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(54) NETWORK NODE, USER DEVICE AND METHODS THEREOF BASED ON SUPERPOSITION TRANSMISSION

(71) Applicant: **Huawei Technologies Co., Ltd.**, Shenzhen (CN)

(72) Inventors: **Pablo SOLDATI**, Kista (SE); **Alberto Giuseppe PEROTTI**, Segrate (IT)

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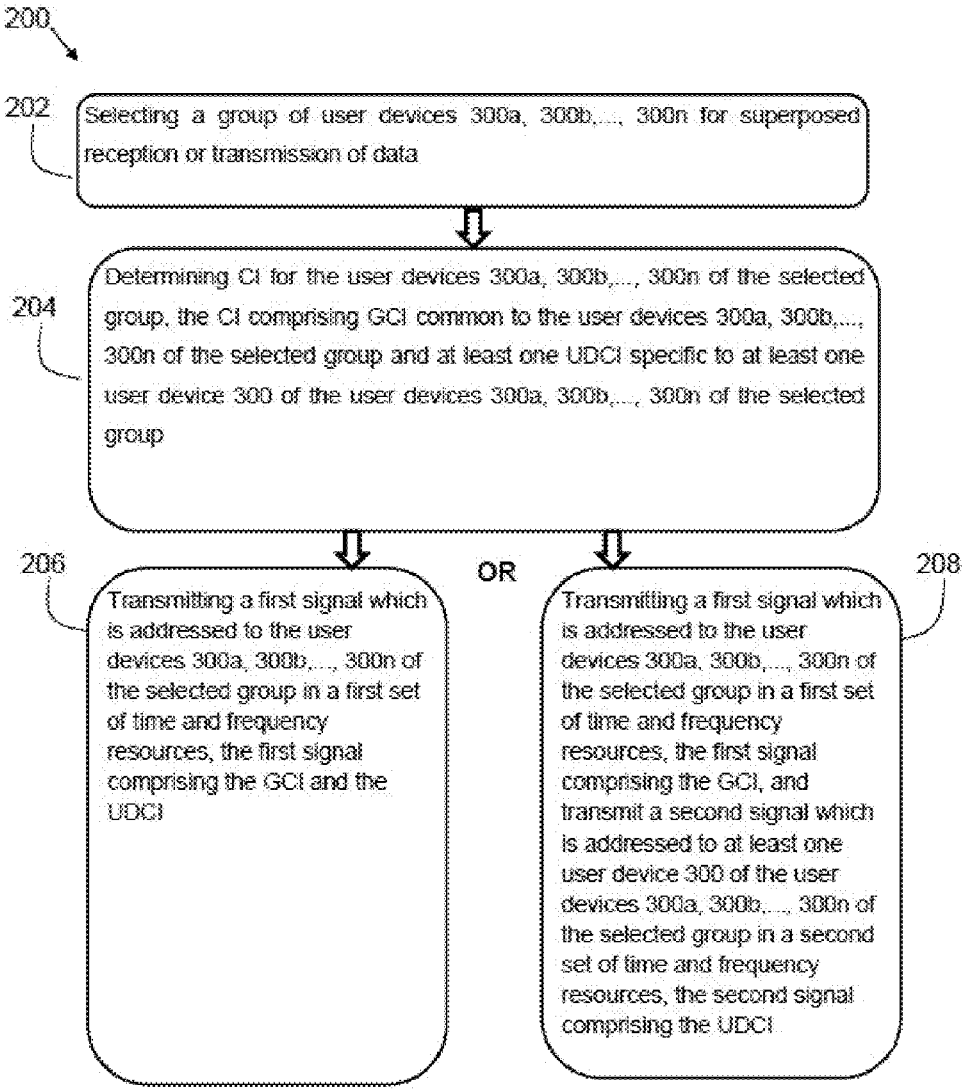
(57) **ABSTRACT**

The present disclosure relates to a network node, a user device and corresponding methods for transmitting information from a network node to a group of user devices selected for transmission or reception of data in the same or partially overlapping set of radio resources comprising group control information common to the selected group of user devices and user device control information specific to individual user devices.



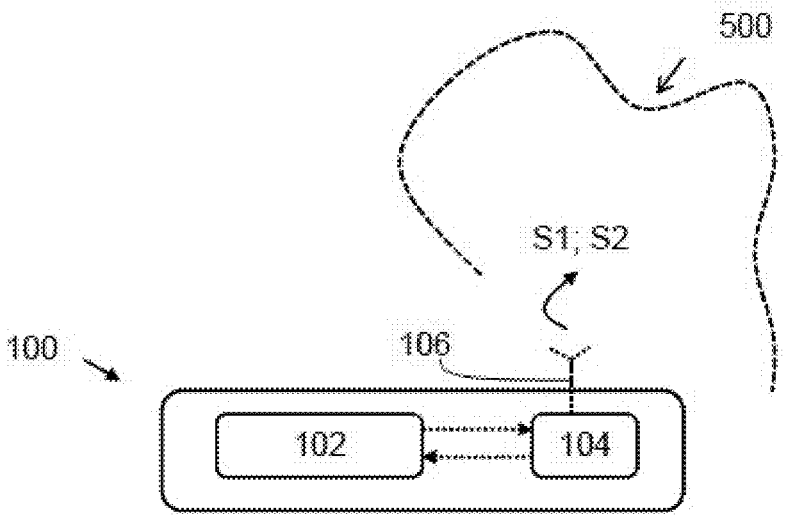


Fig. 1

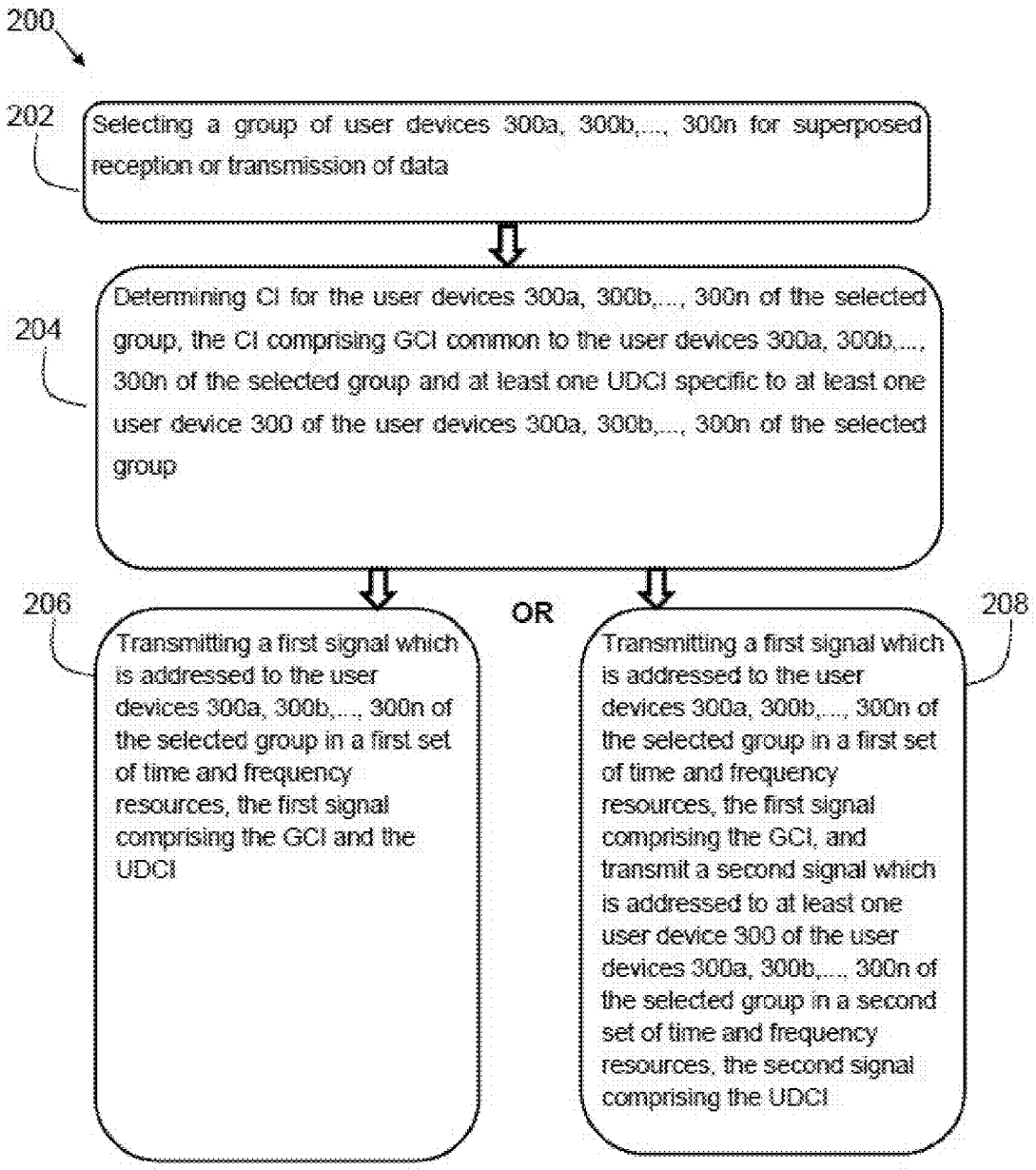

200
202
Selecting a group of user devices 300a, 300b,..., 300n for superposed reception or transmission of data
204
Determining CI for the user devices 300a, 300b,..., 300n of the selected group, the CI comprising GCI common to the user devices 300a, 300b,..., 300n of the selected group and at least one UDCI specific to at least one user device 300 of the user devices 300a, 300b,..., 300n of the selected group
206
Transmitting a first signal which is addressed to the user devices 300a, 300b,..., 300n of the selected group in a first set of time and frequency resources, the first signal comprising the GCI and the UDCI
OR
208
Transmitting a first signal which is addressed to the user devices 300a, 300b,..., 300n of the selected group in a first set of time and frequency resources, the first signal comprising the GCI, and transmit a second signal which is addressed to at least one user device 300 of the user devices 300a, 300b,..., 300n of the selected group in a second set of time and frequency resources, the second signal comprising the UDCI

Fig. 2

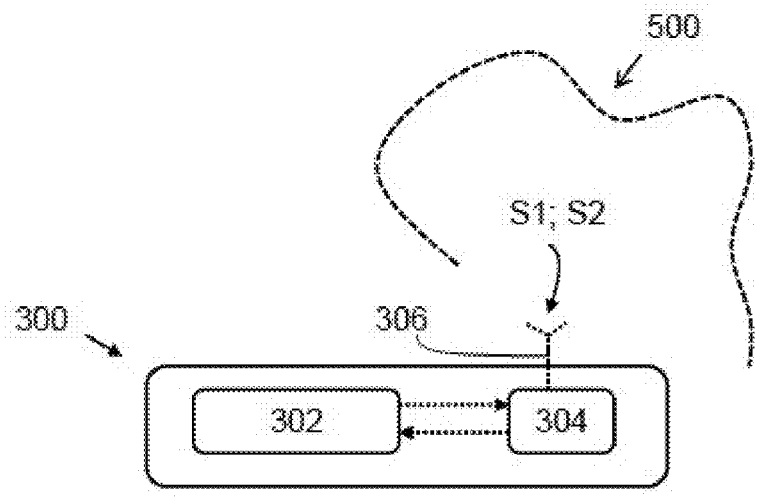


Fig. 3

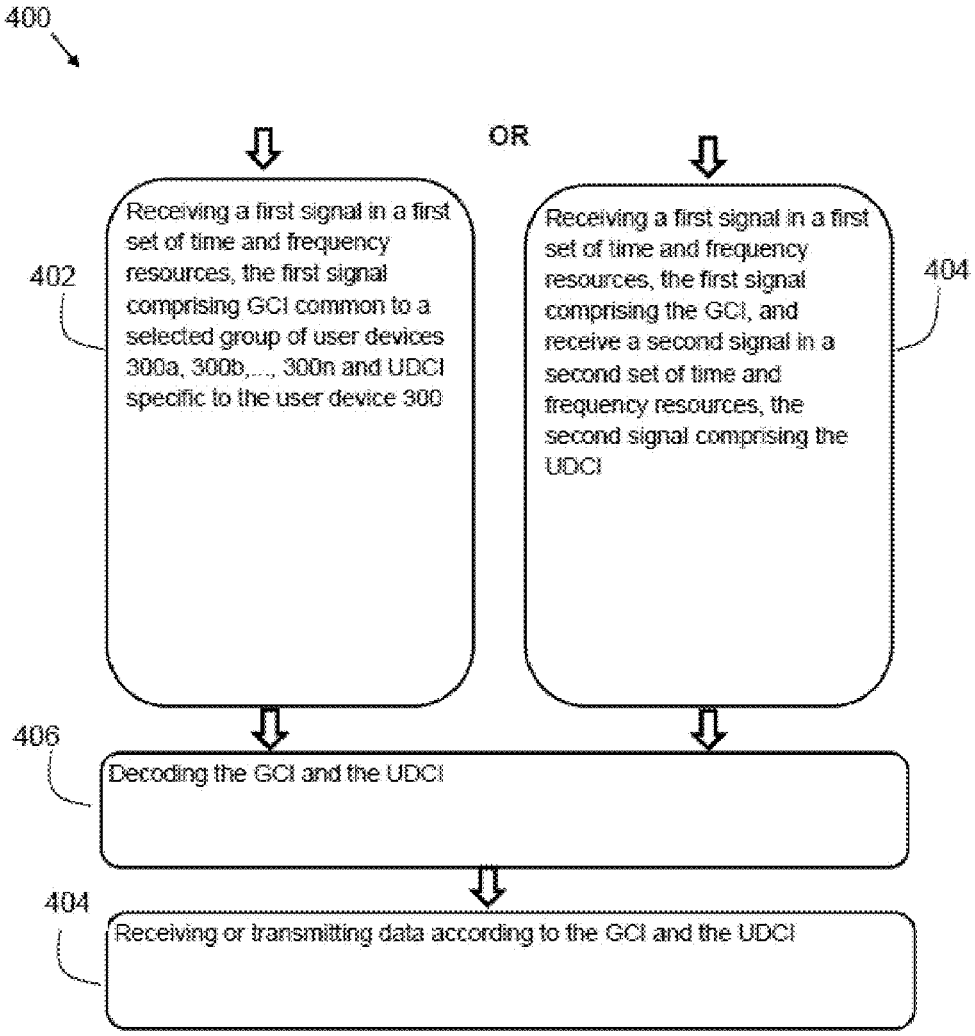

400
OR
Receiving a first signal in a first set of time and frequency resources, the first signal comprising GCI common to a selected group of user devices 300a, 300b,..., 300n and UDCI specific to the user device 300
402
Receiving a first signal in a first set of time and frequency resources, the first signal comprising the GCI, and receive a second signal in a second set of time and frequency resources, the second signal comprising the UDCI
404
406
Decoding the GCI and the UDCI
404
Receiving or transmitting data according to the GCI and the UDCI

Fig. 4

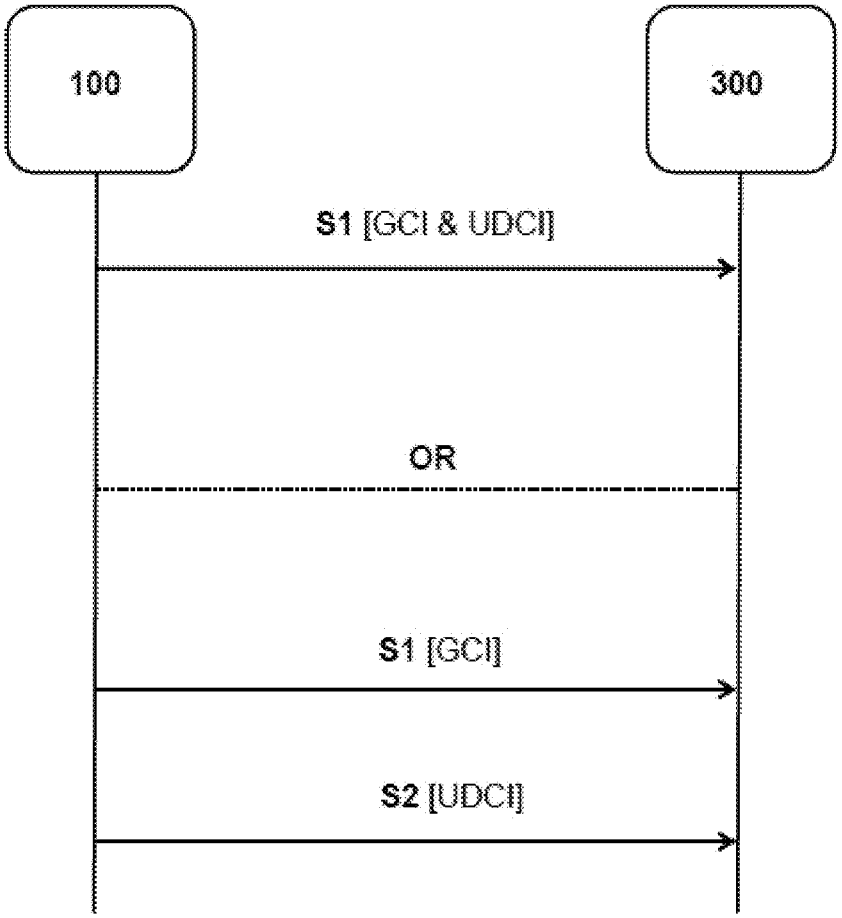


Fig. 5

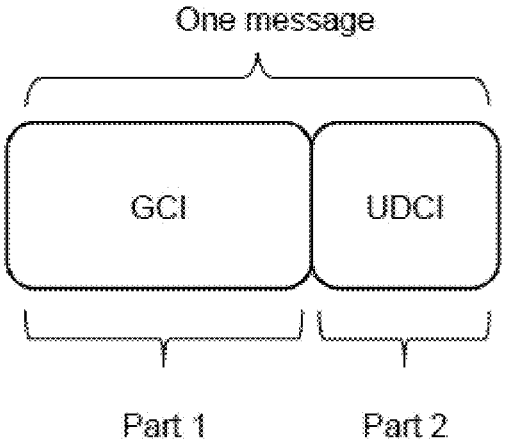


Fig. 6

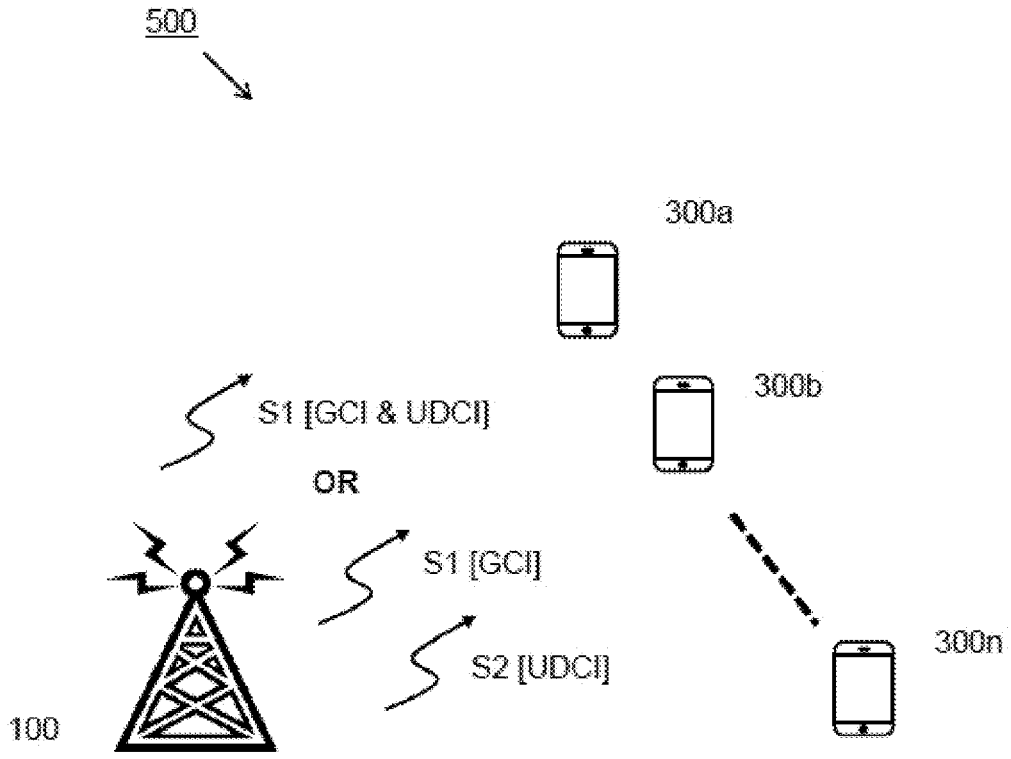


Fig. 7

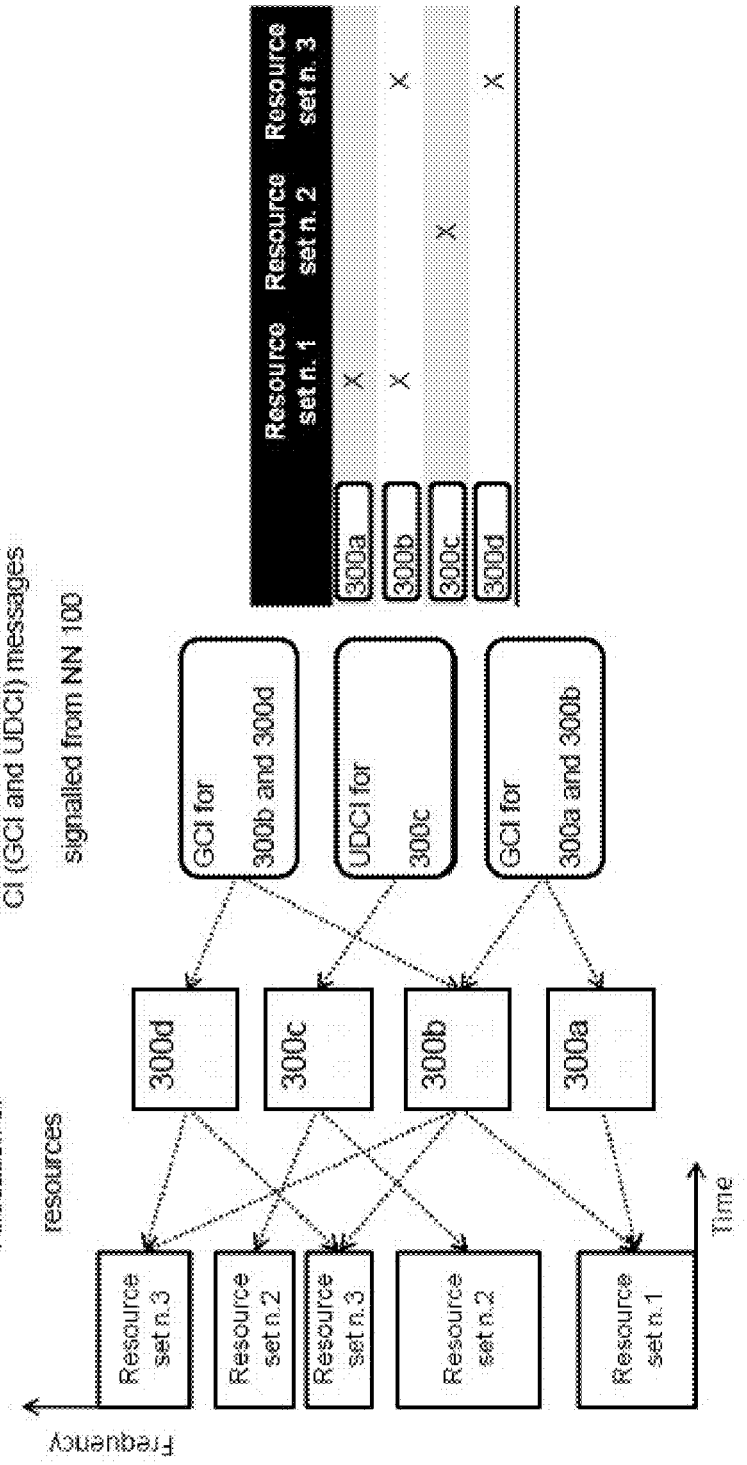

8/8
CI (GCI and UDCI) messages
signalled from NN 100
Allocation of
resources
Frequency
Time
Resource set n.3
Resource set n.2
Resource set n.3
Resource set n.2
Resource set n.1
300d
300c
300b
300a
GCI for 300b and 300d
UDCI for 300c
GCI for 300a and 300b
Resource set n. 1
Resource set n. 2
Resource set n. 3
300a
300b
300c
300d
X
X
X
X
X

Fig. 8

NETWORK NODE, USER DEVICE AND METHODS THEREOF BASED ON SUPERPOSITION TRANSMISSION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International Application No. PCT/EP2015/060617, filed on May 13, 2015, the disclosure of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to a network node and a user device. Furthermore, the present disclosure also relates to corresponding methods and non-transitory computer readable mediums.

BACKGROUND

[0003] The downlink of the 3GPP Long Term Evolution (LTE) cellular communication system is based on Orthogonal Frequency Division Multiplex (OFDM) transmission, which uses time and frequency resource units for transmission. The smallest time-frequency resource unit, called Resource Element (RE), consists of a single complex sinusoid frequency (sub-carrier) in an OFDM symbol. For the purpose of scheduling transmissions to the different User Equipments (UEs), the resource elements are grouped into larger units called Physical Resource Blocks (PRBs). A PRB occupies a half of a subframe, called "slot", consisting of six or seven consecutive OFDM symbol intervals in time domain (0.5 milliseconds in total), and twelve consecutive sub-carrier frequencies in the frequency domain (180 kHz in total).

[0004] Downlink and uplink transmissions in LTE occur in an orthogonal manner, i.e., in each downlink (/uplink) subframe users are scheduled to receive (/transmit) in orthogonal radio resources by being granted access to non-overlapping sets of physical resource blocks. The downlink of the 3GPP LTE-A system also supports Multi-User Multiple-Input-Multiple-Output (MU-MIMO) transmission, where a set of users are orthogonally multiplexed in different antenna spatial layers (corresponding to orthogonal radio channels) while being granted access to the same or overlapping sets of time-frequency resources. In this way, more users can be simultaneously served by the base station. Downlink and uplink scheduling information, containing all the necessary parameters for receiving the downlink physical data shared channel or transmitting the uplink physical data shared channel, respectively, are transmitted to the UEs as Downlink Control Information (DCI) in a physical downlink control channel. The control information may include downlink or uplink resource assignments, user identity, transport format information (modulation, coding, payload size, etc.) Hybrid Automatic Repeat Request (HARD) information, and MIMO information for the user device (e.g., precoding vector/matrix indicators, etc).

[0005] The LTE Rel-8/10 specifies a Physical Downlink Control Channel (PDCCH) as a signal carrying DCI for a user equipment device. The PDCCH is transmitted in a control region that can occupy up to three OFDM symbols at the beginning of each subframe, whereas the remaining part of the subframe forms the data region used for the transmission of the Physical Downlink Shared Channel (PDSCH).

[0006] The LTE Rel-11 introduced a new control channel, the Enhanced Physical Downlink Control Channel (EPDCCH), to increase the control channel capacity and to support transmission beam-forming, improved spatial reuse, and frequency-domain interference coordination, while taking into account the coexistence with the legacy PDCCH. To this end, the EPDCCH consists of a user device specific search-space configured via higher layer Radio Resource Control (RRC) signalling within the PDSCH resources (i.e., PRB pairs), and has the distinct characteristic of using demodulation reference signals for demodulation. A UE configured to use EPDCCH monitors the EPDCCH UE-specific search space instead of the PDCCH UE-specific search space. The PDCCH common search space is monitored regardless of whether and EPDCCH has been configured or not.

[0007] Recent advances in radio communications have revived the interest in superposed non-orthogonal Multiple Access (MA) schemes, where groups of user devices are selected in each Transmission Time Interval (TTI) to receive (in downlink) or to transmit (in uplink) data streams in the same set of time-frequency resources (i.e., Resource Blocks (RB), groups of resource blocks (RBG), sub-band) or in partially overlapping sets thereof. Examples of these techniques include Low-Density Spread (LDS) multiple access, Constellation Expansion Multiple Access (CEMA) and its version with adaptive rate (RA-CEMA), Semi-Orthogonal Multiple Access (SOMA), the NTT Non-Orthogonal Multiple Access (NOMA) scheme, etc.

[0008] The introduction of superposed non-orthogonal MA schemes in a system designed for orthogonal MA of users can severely impact the capacity of the downlink control channel due to the larger number of scheduled user devices per TTI.

[0009] In the related art 3GPP LTE system, one PDCCH/EPDCCH carries one DCI message using one of the available DCI formats. As the system may schedule multiple user devices, both in downlink and uplink, the LTE downlink control channel should be able to transmit multiple DCI messages within each subframe (at least one per scheduled user). Each DCI message is transmitted in a separate PDCCH/EPDCCH, resulting in multiple simultaneous PDCCH/EPDCCH transmissions within each cell in a subframe. In addition, scheduling assignments/grants for carrier aggregation are transmitted to the user devices individually per component carrier. A major drawback of this method is that the control signalling overhead is directly proportional to the number of scheduled users (in downlink and uplink), thereby becoming a major limitation for non-orthogonal multiple access schemes.

[0010] The related art 3GPP LTE system also provides MU-MIMO transmission to spatially multiplexed users, thereby transmitting orthogonal downlink data signals to multiple users in the same or partially overlapping time-frequency resources. To support this feature, the LTE system transmits separate downlink control information to each individual user according to the DCI format 1D. With this approach, downlink control information that is common to all user devices spatially multiplexed in the same time-frequency resources has to be transmitted over the air as many times as the number of user devices multiplexed.

[0011] An alternative conventional solution proposes a method for processing downlink MU-MIMO transmission based upon receiving, at the user device, a separate control channel, in addition to the user-specific control channel, carrying downlink control information that is common to all user devices spatially multiplexed in the same time-frequency resources for MU-MIMO transmission. While this solution may achieve the goal of reducing control signalling overhead for enabling MU-MIMO transmission by transmitting the common control information only once, the user device specific MIMO control information is still transmitted in a separate user device specific control channel or transmitted implicitly with user specific reference signals. In both cases, additional signalling overhead is required for user device specific control information.

[0012] The introduction of non-orthogonal multiple access schemes in downlink and/or uplink poses similar limitations to the capacity of the downlink control channel as MU-MIMO transmission. Also in this case, the number of scheduling assignments/grants per transmission time interval can significantly increase with the number of users non-orthogonally multiplexed for data transmission in the same time-frequency resources. Thereby, solutions that overcome the limitation of conventional solutions are needed.

SUMMARY

[0013] An objective of embodiments of the present disclosure is to provide a solution which mitigates or solves the drawbacks and problems of conventional solutions.

[0014] Another objective of embodiments of the present disclosure is to provide methods and devices for transmitting downlink control signals to a large number of user devices with reduced signalling overhead in a wireless communication system.

[0015] An "or" in this description and the corresponding claims is to be understood as a mathematical OR which covers "and" and "or", and is not to be understood as an XOR (exclusive OR).

[0016] The above objectives are solved by the subject matter of the independent claims. Further advantageous implementation forms of the present disclosure can be found in the dependent claims.

[0017] According to a first aspect of the disclosure, the above mentioned and other objectives are achieved with a network node for a wireless communication system, the network node comprising:

a processor configured to

[0018] select a group of user devices for superposed reception or transmission of data,

[0019] determine control information for (or specific to) the user devices of the selected group, the control information comprising group control information common to the user devices of the selected group and at least one user device control information specific to at least one user device of the user devices of the selected group; and

a transceiver configured to

[0020] transmit a first (single) signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information and the user device control information; or

[0021] transmit a first (single) signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information, and transmit a second signal which is addressed to (the) at least one user device of the user devices of the selected group in a second set of time and frequency resources, the second signal comprising the user device control information.

[0022] A number of advantages are provided by a network node according to the first aspect. An advantage over conventional solutions is to transmit group common control information and user device specific control information into a single control information message (the first signal), thereby reducing signalling overhead in the case of superposed transmission or reception of data as in the case of non-orthogonal multiple access of user devices to a common pool of radio resources of a physical downlink or uplink shared data channel.

[0023] In a first possible implementation form of the network node according to the first aspect, the user devices of the selected group share at least one common time and frequency resource for the superposed reception or transmission of data.

[0024] An advantage with this possible implementation form is that user devices selected to share at least one common time and frequency resource for the superposed reception or transmission of data can be addressed with a single control message comprising group control information common to the user devices, thereby reducing control signalling overhead.

[0025] In a second possible implementation form of the network node according to the first possible implementation form of the first aspect or to the first aspect as such, the first signal is transmitted in at least one control channel.

[0026] An advantage with this possible implementation form is that control information addressing a group of user devices selected to share at least one common time and frequency resource for the superposed reception or transmission of data can be dynamically transmitted on a transmission time interval basis.

[0027] In a third possible implementation form of the network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such, the control information comprises user device control information for each user device of the selected group.

[0028] An advantage with this possible implementation form is that control signalling overhead is further reduced when addressing a group of user devices selected to share at least one common time and frequency resource for the superposed reception or transmission of data.

[0029] According to a second aspect of the disclosure, the above mentioned and other objectives are achieved with a user device for a wireless communication system, the user device comprising:

a transceiver configured to

[0030] receive a first signal in a first set of time and frequency resources, the first signal comprising group control information common to a selected group of user devices and user device control information specific to the user device; or

[0031] receive a first signal in a first set of time and frequency resources, the first signal comprising the group control information, and receive a second signal

in a second set of time and frequency resources, the second signal comprising the user device control information; and

a processor configured to

[0032] decode the group control information and the user device control information; and

[0033] wherein the transceiver further is configured to receive or transmit data according to the group control information and the user device control information.

[0034] A number of advantages are provides by a user device according to the second aspect. An advantage over conventional solutions is to receive group common control information and user device specific control information into a single control information message, thereby reducing signalling overhead in the case of superposed transmission or reception of data as in the case of non-orthogonal multiple access of user devices to a common pool of radio resources of a physical downlink or uplink shared data channel.

[0035] In a fourth possible implementation form of a network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such or in a first possible implementation form of a user device according to the second aspect, the group control information indicates one or more in the group comprising: scheduling assignment information; multiple input multiple output, MIMO, transmission information; transport format information; number of scheduled user device information, multiple access mode information; and user device power allocation information.

[0036] An advantage with this possible implementation form is that a number of superposed non-orthogonal multiple access schemes for data transmission in the downlink or uplink can be realized with reduced control signalling overhead. A further advantage with this possible implementation form is that MIMO transmission techniques and superposed orthogonal multiple access schemes can be combined with reduced control signalling overhead.

[0037] In a fifth possible implementation form of a network node according to the fourth possible implementation form of the first aspect or in a second possible implementation form of a user device according to the first possible implementation form of the second aspect, the scheduling assignment information indicates a set of time and frequency resources assigned to the user devices of the selected group or a subset of time and frequency resources shared by the user devices of the selected group.

[0038] An advantage with this possible implementation form is that scheduling assignments for a group of user devices selected to share at least one common time and frequency resource for the superposed reception or transmission of data can be transmitted to all user devices in the group with a single multicast control message comprising group control information common to the user devices, thereby reducing control signalling overhead.

[0039] In a sixth possible implementation form of a network node according to the fourth possible implementation form of the first aspect or in a third possible implementation form of a user device according to the first possible implementation form of the second aspect, the MIMO transmission information indicates one or more in the group comprising: a MIMO pre-coding matrix index or pre-coding vector index common to the user devices of the selected group; a common number of data streams or layers available to the user devices of the selected group.

[0040] An advantage with this possible implementation form is that user devices can be configured with control information for MIMO transmission techniques and superposed non-orthogonal multiple access schemes with reduced control signalling overhead.

[0041] In a seventh possible implementation form of a network node according to the fourth possible implementation form of the first aspect or in a fourth possible implementation form of a user device according to the first possible implementation form of the second aspect, the multiple access mode information comprises an indication of one or more in the group comprising: non-orthogonal multiple access, semi-orthogonal multiple access; constellation expansion multiple access, rate adaptive constellation expansion multiple access, multiuser superposed transmission; and multi-user MIMO multiple access.

[0042] An advantage with this possible implementation form is that a number of superposed non-orthogonal multiple access schemes for data transmission in the downlink or uplink can be realized with reduced control signalling overhead.

[0043] In an eighth possible implementation form of a network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such or in a fifth possible implementation form of a user device according to any of the preceding possible implementation forms of the second aspect or to the second aspect as such, the group control information indicates one or more in the group comprising: a common MIMO pre-coding matrix index or pre-coding vector index; a common number of data streams or layers available to the user devices of the selected group; and a set of common time and frequency resources assigned to the user devices of the selected group or a subset of time and frequency resources shared by the user devices of the selected group.

[0044] An advantage with this possible implementation form is that user devices can be configured with control information for MIMO transmission techniques and superposed non-orthogonal multiple access schemes with reduced control signalling overhead.

[0045] In a ninth possible implementation form of a network node according to the eight possible implementation form of the first aspect or in a sixth possible implementation form of a user device according to the fifth possible implementation form of the second aspect, the group control information further indicates a common modulation format.

[0046] An advantage with this possible implementation form is that multiple users can be configured for superposed transmission or reception of data with reduced control signalling overhead when using superposition schemes with common modulation format.

[0047] In a tenth possible implementation form of a network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such or in a seventh possible implementation form of a user device according to any of the preceding possible implementation forms of the second aspect or to the second aspect as such, the user device control information indicates one or more in the group comprising: user device identity information; transport format information; hybrid automatic repeat request, HARQ, information; and user device power allocation information.

[0048] An advantage with this possible implementation form is that a number of superposed non-orthogonal mul-

tiple access schemes can be configured with user device specific control information while reducing the control signalling overhead.

[0049] In an eleventh possible implementation form of a network node according to the fourth possible implementation forms of the first aspect or in a eight possible implementation form of a user device according to the seventh possible implementation form of the second aspect, the user device power allocation information comprises one or more in the group comprising: downlink power allocation to least one user device of the user devices of the selected group; and uplink power allocation to least one user device of the user devices of the selected group.

[0050] An advantage with this possible implementation form is that user devices in the group of user devices selected for superposed transmission of reception of data can be configured to operate with different transmission power.

[0051] In a twelfth possible implementation form of a network node according to the fourth possible implementation forms of the first aspect or in a ninth possible implementation form of a user device according to the seventh possible implementation form of the second aspect, the transport format information comprises a common modulation format to the user devices of the selected group or a modulation and coding scheme indicator.

[0052] An advantage with this possible implementation form is that control signalling overhead can be reduced.

[0053] In a thirteenth possible implementation form of a network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such or in a eight possible implementation form of a user device according to any of the preceding possible implementation forms of the second aspect or to the second aspect as such, the user device control information indicates a channel code rate; and a multiuser interleaving scheme.

[0054] An advantage with this possible implementation form is that the code rate and the multiuser interleaving scheme are signalled only to the receiver that needs such information for performing reception of data.

[0055] In a fourteenth possible implementation form of a network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such or in a ninth possible implementation form of a user device according to any of the preceding possible implementation forms of the second aspect or to the second aspect as such, the user device control information indicates user device power allocation; a modulation scheme and a channel code rate or a modulation and coding scheme indicator; a user device specific MIMO pre-coding matrix index or pre-coding vector index.

[0056] An advantage with this possible implementation form is that the modulation scheme and power allocation, which are user device-specific in some of the aforementioned superposition schemes, are signalled only to the receiver that needs such information for performing reception of data.

[0057] In a fifteenth possible implementation form of a network node according to the thirteenth or fourteenth possible implementation forms of the first aspect or to the first aspect as such or in a tenth possible implementation form of a user device according to the eighth or ninth possible implementation forms of the second aspect or to the second aspect as such, the user device control information further indicates number of user device specific data streams or layers available to the user devices of the selected group.

[0058] An advantage with this possible implementation form is that user devices can be configured with control information for MIMO transmission techniques and superposed non-orthogonal multiple access schemes with reduced control signalling overhead.

[0059] In a sixteenth possible implementation form of a network node according to any of the preceding possible implementation forms of the first aspect or to the first aspect as such or in an eleventh possible implementation form of a user device according to any of the preceding possible implementation forms of the second aspect or to the second aspect as such, the control information is comprised in a single downlink control information format.

[0060] An advantage with this possible implementation form is an efficient downlink signalling scheme for superposed non-orthogonal multiple access transmission schemes comprising a multicast transmission of common control information to a group of user devices and user device-specific control information to each user device in the group.

[0061] According to a third aspect of the disclosure, the above mentioned and other objectives are achieved with a method in a network node, the method comprising:

[0062] selecting a group of user devices for superposed reception or transmission of data;

[0063] determining control information for (or specific to) the user devices of the selected group, the control information comprising group control information common to the user devices of the selected group and at least one user device control information specific to at least one user device of the user devices of the selected group;

[0064] transmitting a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information and the user device control information; or

[0065] transmitting a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information, and transmitting a second signal which is addressed to at least one user device of the user devices of the selected group in a second set of time and frequency resources, the second signal comprising the user device control information.

[0066] In a first possible implementation form of the method according to third aspect, the user devices of the selected group share at least one common time and frequency resource for the superposed reception or transmission of data.

[0067] In a second possible implementation form of the method according to the first possible implementation form of the third aspect or to the third aspect as such, the first signal is transmitted in at least one control channel.

[0068] In a third possible implementation form of the method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such, the control information comprises user device control information for each user device of the selected group.

[0069] According to a fourth aspect of the disclosure, the above mentioned and other objectives are achieved with a method in a user device comprising:

[0070] receiving a first signal in a first set of time and frequency resources, the first signal comprising group control information common to a selected group of user devices and user device control information specific to the user device; or

[0071] receiving a first signal in a first set of time and frequency resources, the first signal comprising the group control information, and receiving a second signal in a second set of time and frequency resources, the second signal comprising the user device control information;

[0072] decoding the group control information and the user device control information;

[0073] receiving or transmitting data according to the group control information and the user device control information.

[0074] In a fourth possible implementation form of a method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such or in a first possible implementation form of a method according to the fourth aspect, the group control information indicates one or more in the group comprising: scheduling assignment information; multiple input multiple output, MIMO, transmission information; transport format information; number of scheduled user device information, multiple access mode information; and user device power allocation information.

[0075] In a fifth possible implementation form of a method according to the fourth possible implementation form of the third aspect or in a second possible implementation form of a method according to the first possible implementation form of the fourth aspect, the scheduling assignment information indicates a set of time and frequency resources assigned to the user devices of the selected group or a subset of time and frequency resources shared by the user devices of the selected group.

[0076] In a sixth possible implementation form of a method according to the fourth possible implementation form of the third aspect or in a third possible implementation form of a method according to the first possible implementation form of the fourth aspect, the MIMO transmission information indicates one or more in the group comprising: a MIMO pre-coding matrix index or pre-coding vector index common to the user devices of the selected group; a common number of data streams or layers available to the user devices of the selected group.

[0077] In a seventh possible implementation form of a method according to the fourth possible implementation form of the third aspect or in a fourth possible implementation form of a method according to the first possible implementation form of the fourth aspect, the multiple access mode information comprises an indication of one or more in the group comprising: non-orthogonal multiple access, semi-orthogonal multiple access; constellation expansion multiple access, rate adaptive constellation expansion multiple access, multiuser superposed transmission; and multi-user MIMO multiple access.

[0078] In an eighth possible implementation form of a method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such or in a fifth possible implementation form of a method according to any of the preceding possible implementation forms of the fourth aspect or to the fourth aspect as such, the group control information indicates one or more in the group comprising: a common MIMO pre-coding matrix index or pre-coding vector index; a common number of data streams or layers available to the user devices of the selected group; and a set of common time and frequency resources assigned to the user devices of the selected group or a subset of time and frequency resources shared by the user devices of the selected group.

[0079] In a ninth possible implementation form of a method according to the eight possible implementation form of the third aspect or in a sixth possible implementation form of a method according to the fifth possible implementation form of the fourth aspect, the group control information further indicates a common modulation format.

[0080] In a tenth possible implementation form of a method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such or in a seventh possible implementation form of a method according to any of the preceding possible implementation forms of the fourth aspect or to the fourth aspect as such, the user device control information indicates one or more in the group comprising: user device identity information; transport format information; hybrid automatic repeat request, HARQ, information; and user device power allocation information.

[0081] In an eleventh possible implementation form of a method according to the fourth possible implementation forms of the third aspect or in a eight possible implementation form of a method according to the seventh possible implementation form of the fourth aspect, the user device power allocation information comprises one or more in the group comprising: downlink power allocation to least one user device of the user devices of the selected group; and uplink power allocation to least one user device of the user devices of the selected group.

[0082] In a twelfth possible implementation form of a method according to the fourth possible implementation forms of the third aspect or in a ninth possible implementation form of a method according to the seventh possible implementation form of the fourth aspect, the transport format information comprises a common modulation format to the user devices of the selected group or a modulation and coding scheme indicator.

[0083] In a thirteenth possible implementation form of a method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such or in a eight possible implementation form of a method according to any of the preceding possible implementation forms of the fourth aspect or to the fourth aspect as such, the user device control information indicates a channel code rate; and a multiuser interleaving scheme.

[0084] In a fourteenth possible implementation form of a method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such or in a ninth possible implementation form of a method according to any of the preceding possible implementation forms of the fourth aspect or to the fourth aspect as such, the user device control information indicates user device power allocation; a modulation scheme and a channel code rate or a modulation and coding scheme indicator; a user device specific MIMO pre-coding matrix index or pre-coding vector index.

[0085] In a fifteenth possible implementation form of a method according to the thirteenth or fourteenth possible implementation forms of the third aspect or to the third

aspect as such or in a tenth possible implementation form of a method according to the eighth or ninth possible implementation forms of the fourth aspect or to the fourth aspect as such.

[0086] In a sixteenth possible implementation form of a method according to any of the preceding possible implementation forms of the third aspect or to the third aspect as such or in an eleventh possible implementation form of a method according to any of the preceding possible implementation forms of the fourth aspect or to the fourth aspect as such, the control information is comprised in a single downlink control information format.

[0087] The advantages of the methods according to the third aspect or the fourth aspect are the same as those for the corresponding device claims according to the first and second aspects.

[0088] The present disclosure also relates to a computer program, characterized in code means, which when run by processing means causes said processing means to execute any method according to the present disclosure. Further, the disclosure also relates to a computer program product comprising a computer readable medium and said mentioned computer program, wherein said computer program is included in the computer readable medium, and comprises of one or more from the group: ROM (Read-Only Memory), PROM (Programmable ROM), EPROM (Erasable PROM), Flash memory, EEPROM (Electrically EPROM) and hard disk drive.

[0089] Further applications and advantages of the present disclosure will be apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0090] The appended drawings are intended to clarify and explain different embodiments of the present disclosure, in which:

[0091] FIG. **1** shows a network node according to an embodiment of the present disclosure;

[0092] FIG. **2** shows a method according to an embodiment of the present disclosure;

[0093] FIG. **3** shows a user device according to an embodiment of the present disclosure;

[0094] FIG. **4** shows another method according to an embodiment of the present disclosure;

[0095] FIG. **5** illustrates signalling according to an embodiment of the present disclosure;

[0096] FIG. **6** shows an exemplary message format according to an embodiment of the present disclosure;

[0097] FIG. **7** shows a wireless communication system according to an embodiment of the present disclosure; and

[0098] FIG. **8** illustrates the transmission of group control information and user device specific control information according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0099] In a wireless communication system **500** (as shown for example on page **7**) with superposed non-orthogonal data transmission, groups of user devices can be selected in each transmission time unit (e.g., a subframe in LTE) to receive (in downlink) or to transmit (in uplink) using data channels in the same or partially overlapping time-frequency resources, i.e., Resource Blocks (RB), groups of resource blocks (RBG), sub-bands, etc. It is therefore a problem to transmit downlink control information efficiently to a large number of user devices in each transmission time unit with reduced signaling.

[0100] Therefore, embodiments of the present disclosure disclose to transmit control information, e.g. by means of a multicast control signal, from a network node to a group of user devices selected for transmission or reception of data in the same or partially overlapping set of radio resources, by e.g. means of a Downlink Control Information (DCI) format comprising group control information common to the selected group of user devices and user device control information specific to individual user devices.

[0101] FIG. **1** shows a network node **100** according to an embodiment of the present disclosure. The network node **100** has the capabilities to communicate with other communication devices (not shown in FIG. **1**) in the wireless communication system **500**. In this respect the network node **100** comprises a transceiver **104** which in this embodiment is coupled to an antenna unit **106**. The transceiver **104** is further communicably coupled to a processor **102** of the network node **100**.

[0102] The processor **102** of the network node **100** is configured to select a group of user devices **300***a*, **300***b*, . . . , **300***n* (see FIG. **8**) for superposed reception or transmission of data. The processor **102** is further configured to determine Control Information (CI) for, or specific to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group. The CI comprises Group Control Information (GCI) common to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group and at least one User Device Control Information (UDCI) specific to at least one user device of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group. In detail the network node **100** may determine a separate UDCI for each user device **300***a*, **300***b*, . . . , **300***n* of the selected group.

[0103] The transceiver **104** of the network node **100** is configured to transmit a first signal **S1** which is addressed to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group in a first set of time and frequency resources. In other words, all user device **300***a*, **300***b*, . . . , **300***n* of the selected group read the first signal **S1**. The first signal **S1** comprises the GCI and the UDCI. Alternatively or additionally (e.g. in a different configuration) the transceiver **104** of the network node **100** is configured to transmit a first signal **S1** which is addressed to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group in a first set of time and frequency resources. In other words, all user device **300***a*, **300***b*, . . . , **300***n* of the selected group read the first signal **S1**. The first signal **S1** comprises the GCI. The transceiver **104** of the network node **100** is according to this aspect further configured to transmit a second signal **S2** which is addressed to at least one user device of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group in a second set of time and frequency resources. The second signal **S2** comprises the UDCI. In detail the network node **100** may send to each of the In detail the network node **100** may send to each of the user device **300***a*, **300***b*, . . . , **300***n* of the selected group a respective signal **S2** in the second set of time frequency resources comprising the UDCI corresponding to the respective user device **300***a*, **300***b*, . . . , **300***n*.

[0104] FIG. **5** illustrates the signalling between the network node **100** and a user device **300** according to an embodiment of the present disclosure. As mentioned above, the network node **100** determines the GCI and the UDCI. In

one aspect as shown in the upper part of FIG. **5**, a first signal **S1** is transmitted to the user device **300**. The first signal **S1** indicates the GCI and the UDCI. However, in another aspect shown in the lower part of FIG. **5** the network node **100** transmits a first signal **S1** and a second signal **S2** to the user device **300**. The first signal **S1** indicates the GCI and the second signal **S2** indicates the UDCI to the user device **300**. It should also be noted that the first signal **S1** and second signal **S2** are transmitted/signalled in different sets of time and frequency resources.

[0105] FIG. **2** shows a method **200** according to an embodiment of the present disclosure. The method **200** may be executed in a network node **100**, such as the one shown in FIG. **1**. The method **200** comprises the step of selecting **202** a group of user devices **300***a*, **300***b*, . . . , **300***n* for superposed reception or transmission of data. The method **200** further comprises the step of determining **204** CI for the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group, the CI comprising GCI common to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group and at least one UDCI specific to at least one user device **300** of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group. The method **200** further comprises the step of transmitting **206** a first signal **S1** which is addressed to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group in a first set of time and frequency resources, the first signal comprising the GCI and the UDCI. Or, the method **200** further comprises the step of transmitting **208** a first signal **S1** which is addressed to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group in a first set of time and frequency resources, the first signal **S1** comprising the GCI, and transmit a second signal **S2** which is addressed to at least one user device **300** of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group in a second set of time and frequency resources, the second signal **S2** comprising the UDCI.

[0106] FIG. **3** shows a user device **300** according to an embodiment of the present disclosure. The user device **300** comprises a processor **302** communicably coupled to a transceiver **304**. In this example, the user device **300** also comprises an antenna unit **306** coupled to the transceiver **304**. The transceiver **304** of the user device **300** is configured to receive a first signal **S1** in a first set of time and frequency resources, the first signal **S1** comprising GCI common to a selected group of user devices **300***a*, **300***b*, . . . , **300***n* and UDCI specific to the user device **300**. Or, the transceiver **304** of the user device **300** is configured to receive a first signal **S1** in a first set of time and frequency resources, the first signal **S1** comprising the GCI, and receive a second signal **S2** in a second set of time and frequency resources, the second signal **S2** comprising the UDCI. The processor **302** of the user device **300** is configured to decode the GCI and the UDCI. The transceiver **304** of the user device **300** further is configured to receive or transmit data according to the GCI and the UDCI.

[0107] FIG. **4** shows a corresponding method **400** according to an embodiment of the present disclosure. The method **400** may be executed in a user device **300**, such as the one shown in FIG. **3**. The method **400** comprises the step of receiving **402** a first signal **S1** in a first set of time and frequency resources, the first signal **S1** comprising GCI common to a selected group of user devices **300***a*, **300***b*, . . . , **300***n* and UDCI specific to the user device **300**. Or, the method **400** comprises the step of receiving **404** a first signal **S1** in a first set of time and frequency resources, the first signal **S1** comprising the GCI, and further to receive a second signal **S2** in a second set of time and frequency resources, the second signal **S2** comprising the UDCI. The method **400** further comprises the step of decoding **406** the GCI and the UDCI. The method **400** further comprises the step of receiving or transmitting data **408** according to the GCI and the UDCI. Therefore, upon the step of receiving **402** a first signal **S1** or the step of receiving **404** a first signal **S1** and a second signal **S2**, the user device **300** receives CI necessary for further receiving data in a downlink data channel or for transmitting data in an uplink data channel.

[0108] According to an embodiment of the present disclosure, the first signal **S1** and the second signal **S2** are transmitted in at least one control channel. Therefore, the GCI may be multicast to the intended group of user devices scheduled in a certain TTI through the PDCCH or EPDCCH. In addition, the UDCI may be unicast to each user devices scheduled in a certain TTI through the PDCCH or EPDCCH.

[0109] According to another embodiment of the present disclosure, the CI is comprised in a single (multicast) downlink control information format. FIG. **6** illustrates such an embodiment in which the single (multicast) downlink control information format comprises of two parts. The first part comprising the GCI and the second part comprises the UDCI. The multicast downlink control information format may be a control message transmitted by the network node **100** to user devices according known control protocols. It should be noted that the two parts need not be separated in the control message and may e.g. be interleaved in the control message.

[0110] FIG. **7** illustrates a wireless communication system **500** according to an embodiment of the present disclosure. In this example the network node **100** is a radio network base station which transmits the first **S1** and/or the second signal **S2** in the downlink to a number of selected user devices **300***a*, **300***b*, . . . , **300***n*. The network node **100** transmits a first signal comprising the GCI and the UDCI; or the network node transmits a first signal **S1** comprising the CGI and a second signal **S2** comprising the UDCI. The user devices **300***a*, **300***b*, . . . , **300***n* derives the GCI and the UDCI and transmits and/or receives according to the GCI and the UDCI.

[0111] FIG. **8** illustrates an example of transmission of a GCI message and a UDCI message to dynamically allocate radio resources to user devices within a TTI. The x-axis represents time and the y-axis frequency. In this example, four user devices **300***a*, **300***b*, **300***c*, **300***d* are assigned multiple sets of possible non-contiguous time-frequency resources (in time or frequency, or both) blocks for data transmission or reception. Each set of time-frequency resources may be assigned to one or more user devices.

[0112] In particular, the group of user devices **300***a* and **300***b* is assigned to use resource set **1**. The Network Node (NN) **100** (not shown in FIG. **8**) determines CI for, or specific to the group of user devices **300***a* and **300***b*. The CI comprises GCI common to the user devices **300***a* and **300***b* of the selected group and at least one UDCI specific to at least one user device of the user devices **300***a* and **300***b* of the selected group.

[0113] Similarly, the group of user devices **300***b* and **300***d* is configured to receive or transmit data in the resource set **3** according to the same method as described above. Hence, the network node **100** determines CI for, or specific to the group of user devices **300***b* and **300***d*. The CI comprises GCI

common to the user devices **300***b* and **300***d* of the selected group and at least one UDCI specific to at least one user device of the user devices **300***b* and **300***d* of the selected group.

[0114] User device **300***c* in FIG. **8** is configured to receive or transmit data in the resource set **2**. No other user devices are assigned to resource set **2**. The network node **100** determines CI for user device **300***c* comprising only UDCI and sends it to user device **300***c*.

[0115] Hence, it can be seen, that per selected group a single control message (the first signal) is sufficient to at least signal group specific control information (GCI) the members (user devices) of the selected group. Furthermore, user device specific control information (UDCI) specific to each user device of a selected group can be sent in the same message or a further message (second signal).

[0116] Therefore, the CI may refer to a scheduling grant for superposed non-orthogonal multiple access of a group of user devices to either the downlink or the uplink the data channel. The advantage of this method over conventional solutions is to transmit GCI and UDCI into a single multicast downlink control information format (i.e., a single multicast control message), thereby reducing signaling overhead in the case of non-orthogonal multiple access of user devices to a common pool of radio resources of a physical downlink or uplink shared data channel. Therefore, all user devices assigned to access the same (downlink or uplink) radio resources receive both GCI and UDCI by receiving the disclosed downlink control information format. This has the advantage to reduce signaling overhead and increase the efficiency of the resource utilization.

[0117] In one embodiment of the present disclosure, the control information specific to individual user devices **300***a*, **300***b*, . . . , **300***n*, i.e. UDCI, in the selected group of user device may, in this case, further be transmitted to the individual user devices with a separate control message i.e., in a separate user-specific control information format. This has the advantage to simplify the design of the downlink control information formats, while still reducing the control signaling overhead compared to the case in which the GCI common to all user devices in the group is transmitted separately to each individual user device scheduled for non-orthogonal multiple access to the same downlink or uplink radio resources.

[0118] In one embodiment of the present disclosure, the GCI for superposed transmission or reception of data in shared or partially overlapping radio resources of a data channel may include one or more information in the group comprising: scheduling assignment information; multiple input multiple output, MIMO, transmission information; transport format information; number of scheduled user device information, multiple access mode information; and user device power allocation information.

[0119] In one embodiment of the present disclosure, the scheduling assignment information indicates or specifies the radio resources (e.g. resource block, group of resource blocks, sub-bands, etc.) of a physical shared data channel (e.g., in downlink or in uplink) to be used by a group of user devices **300***a*, **300***b*, . . . , **300***n* selected for non-orthogonal multiple access. That is, a set of time and frequency resources assigned to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group or a subset of time and frequency resources shared by the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group.

[0120] In one embodiment of the present disclosure, the MIMO transmission information may indicate one or a combination of: a MIMO pre-coding matrix index or pre-coding vector index common to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group; a common number of data streams or layers available to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group.

[0121] In one embodiment of the present disclosure, the number of user devices scheduled for superposed transmission or reception of data in shared or partially overlapping radio resources of a data channel indicates the number of user devices assigned to simultaneously access a common or overlapping set of radio resources in non-orthogonal way. A non-orthogonal multiple access mode indicates the multiple access scheme the user devices should adopt to access the common set of radio resources, such as non-orthogonal multiple access, superposition coding, semi-orthogonal multiple access; constellation expansion multiple access, rate adaptive constellation expansion multiple access, multiuser superposed transmission; multi-user MIMO multiple access, and the like. For the case of downlink multiple access, this information enables each user device **300***a*, **300***b*, . . . , **300***n* of the selected group to identify and decode its own data after joint detection of all data.

[0122] In one embodiment of the present disclosure, the multiple access mode information indicates whether a non-orthogonal multiple access scheme is configured for superposed transmission or reception of data. The non-orthogonal multiple access scheme can refer to one or more in the group comprising: non-orthogonal multiple access, semi-orthogonal multiple access; constellation expansion multiple access, rate adaptive constellation expansion multiple access, multiuser superposed transmission; and multi-user MIMO multiple access. This can e.g. be realized with a one-bit flag in a multicast control information signal.

[0123] In one embodiment of the present disclosure, the user device power allocation information comprises one or more in the group comprising: downlink power allocation to least one user device **300** of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group; and uplink power allocation to least one user device **300** of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group. The user device power allocation information may be used to indicate common power control settings for shared data channel transmission or reference signal transmission with non-orthogonal multiple access. The power settings may refer also to MIMO transmission, such as power settings for all user devices in a MIMO stream or layer in the case of non-orthogonal multiple access with SU-MIMO transmission, or power settings for all user devices per transmission beam in the case of non-orthogonal multiple access with transmission beam-forming or MU-MIMO. This information can further be utilized to enable advanced receiver processing, such as successive interference cancellation/suppression. For the case of uplink multiple access, this information enables each user device to use the proper shared data channel resources and transmission format for multiple access to the data channel.

[0124] In one embodiment of the present disclosure, the GCI indicates one or more in the group comprising: a common MIMO pre-coding matrix index or pre-coding vector index; a common number of data streams or layers available to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group; and a set of common time and frequency

resources assigned to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group or a subset of time and frequency resources shared by the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group.

[0125] In a further embodiment of the present disclosure, the GCI further indicates a common modulation format. This is particularly convenient in non-orthogonal MA systems using a common modulation format shared among the user device signals, e.g. in Rate Adaptive Constellation Expansion MA systems.

[0126] In another embodiment of the present disclosure, the UDCI for non-orthogonal multiple access to downlink or uplink shared data channel resources may include information in the group comprising: user device identity information; transport format information; hybrid automatic repeat request, HARQ, information; and user device power allocation information.

[0127] In one embodiment of the present disclosure, the user device identity information indicates which user devices the group-specific downlink control information format is intended for, thereby enabling group of user devices dynamically scheduled, for instance, on a TTI basis to receive and decode control information for non-orthogonal multiple access to shared downlink or uplink radio resources. The order in which user device identities appear in the downlink control information format can further enable the corresponding user devices to identify the associated additional user device specific control information within the control signal format. In one example, the order in which user specific information appears in a field can be mapped implicitly or explicitly to the order in which the user identities appear in the user identity field of the control information format.

[0128] In one embodiment of the present disclosure, depending on the adopted non-orthogonal multiple access scheme the transport format information may indicate parts or all transport format information intend for a user device. Transport format information common to all scheduled user devices (if any common information exists) can be transmitted as part of the common downlink control information, whilst user device specific transport format information can be transmitted in a separate field of the control signal format.

[0129] In one embodiment of the present disclosure, the transport format information comprises a common modulation format to the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group or a modulation and coding scheme indicator.

[0130] In one embodiment of the present disclosure, the HARQ information refers to user device specific information for retransmission of previously failed transmission attempts. The information may comprise number of retransmission attempt(s), transmission format, modulation and coding rate.

[0131] In one embodiment of the present disclosure, the user device power allocation information comprises one or more in the group comprising: downlink power allocation to least one user device **300** of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group; and uplink power allocation to least one user device **300** of the user devices **300***a*, **300***b*, . . . , **300***n* of the selected group. The power allocation information may indicate the fraction of the overall transmission power used to transmit information of each user device within the same pool of shared data radio resources. Power allocation information may further indicate transmission power used for user device specific pilot reference signals within the pool of shared data radio resources assigned for non-orthogonal multiple access. This power allocation information may comprise, e.g., a power offset compared to the data transmission power used for the user device. Power control settings may further be resource specific, i.e., resource block specific, group of resource block specific, or sub-band specific.

[0132] In one embodiment of the present disclosure, the UDCI indicates a channel code rate; and a multiuser interleaving scheme. This embodiment is convenient for non-orthogonal MA schemes that do not require CodeWord-level Interference Cancellation (CWIC), because a user device **300** only needs to know the code rate used to encode its own codewords and the multiuser interleaving scheme.

[0133] In the following description some exemplary embodiments of the present disclosure are described. These embodiments describe exemplary content of the group control information GCI and the user device control information UDCI. It should also be noted that LTE terminology often is used in the present disclosure to describe and explain embodiments of the present disclosure. However, embodiments of the present disclosure are not limited to an LTE system and may be applied in all relevant wireless communication systems.

[0134] In one exemplary embodiment of the present disclosure, the GCI sent to the group of user devices comprises at least one of:

[0135] The set of resources assigned to the group of user devices or the subset of resources shared among said group of users;

[0136] A common modulation format;

[0137] A common MIMO pre-coding matrix index (PMI) or a pre-coding vector index (PVI); and

[0138] A common number of streams (or layers) available to all user devices.

[0139] In this exemplary embodiment the UDCI sent to each of the user devices in the group comprises at least one of:

[0140] The channel code rate; and

[0141] A multiuser interleaving scheme specifying the modulation label bit allocation to user device.

[0142] This exemplary embodiment refers to non-orthogonal multiple access schemes using a common modulation format, like Rate-adaptive constellation Expansion Multiple Access. Here, no power allocation to user devices is performed and the user devices are multiplexed on the codewords domain. The parameters common to all user devices are signaled using the GCI and the user device-specific parameters are signaled using the UDCI.

[0143] In one exemplary embodiment of the present disclosure, the GCI sent to the group of user devices comprises at least one of:

[0144] The set of resources assigned to the group of user devices or the subset of resources shared among said group of users;

[0145] A common MIMO pre-coding matrix index (PMI) or a pre-coding vector index (PVI); and

[0146] A common number of streams (or layers) available to all user device.

[0147] In this exemplary embodiment the UDCI sent to each of the user devices in the group comprises at least one of:

[0148] User device power allocation;

[0149] A modulation scheme and channel code rate, or a modulation and coding scheme indicator; and

[0150] A user device-specific MIMO pre-coding matrix index (PMI) or a pre-coding vector index (PVI).

[0151] This exemplary embodiment refers to non-orthogonal multiple access (MA) schemes performing linear superposition like NOMA and SOMA where power allocation coefficients are specific to each user device. The parameters common to all user devices are signaled using the GCI and the user device-specific parameters are signaled using the UDCI.

[0152] The network node **100** or a radio network node, or base station, e.g. a Radio Base Station (RBS), which in some networks may be referred to as transmitter, "eNB", "eNodeB", "NodeB" or "B node", depending on the technology and terminology used. The radio network nodes may be of different classes such as e.g. macro eNodeB, home eNodeB or pico base station, based on transmission power and thereby also cell size. The radio network node can be a Station (STA), which is any device that contains an IEEE 802.11-conformant Media Access Control (MAC) and Physical Layer (PHY) interface to the Wireless Medium (WM).

[0153] The user device **300** or a User Equipment (UE), mobile station, wireless terminal and/or mobile terminal is enabled to communicate wirelessly in a wireless communication system, sometimes also referred to as a cellular radio system. The User Equipment (UE) may further be referred to as mobile telephones, cellular telephones, computer tablets or laptops with wireless capability. The UEs in the present context may be, for example, portable, pocket-storable, hand-held, computer-comprised, or vehicle-mounted mobile devices, enabled to communicate voice and/or data, via the radio access network, with another entity, such as another receiver or a server. The UE can be a Station (STA), which is any device that contains an IEEE 802.11-conformant Media Access Control (MAC) and Physical Layer (PHY) interface to the Wireless Medium (WM).

[0154] Furthermore, any method according to the present disclosure may be implemented in a computer program, having code means, which when run by processing means causes the processing means to execute the steps of the method. The computer program is included in a computer readable medium of a computer program product. The computer readable medium may comprises of essentially any memory, such as a ROM (Read-Only Memory), a PROM (Programmable Read-Only Memory), an EPROM (Erasable PROM), a Flash memory, an EEPROM (Electrically Erasable PROM), or a hard disk drive.

[0155] Moreover, it is realized by the skilled person that the present first network node and second network node comprises the necessary communication capabilities in the form of e.g., functions, means, units, elements, etc., for performing the present solution. Examples of other such means, units, elements and functions are: processors, memory, buffers, control logic, encoders, decoders, rate matchers, de-rate matchers, mapping units, multipliers, decision units, selecting units, switches, interleavers, de-interleavers, modulators, demodulators, inputs, outputs, antennas, amplifiers, receiver units, transmitter units, DSPs, MSDs, TCM encoder, TCM decoder, power supply units, power feeders, communication interfaces, communication protocols, etc. which are suitably arranged together for performing the present solution.

[0156] Especially, the processors of the present devices may comprise, e.g., one or more instances of a Central Processing Unit (CPU), a processing unit, a processing circuit, a processor, an Application Specific Integrated Circuit (ASIC), a microprocessor, or other processing logic that may interpret and execute instructions. The expression "processor" may thus represent a processing circuitry comprising a plurality of processing circuits, such as, e.g., any, some or all of the ones mentioned above. The processing circuitry may further perform data processing functions for inputting, outputting, and processing of data comprising data buffering and device control functions, such as call processing control, user interface control, or the like.

[0157] Finally, it should be understood that the present disclosure is not limited to the embodiments described above, but also relates to and incorporates all embodiments within the scope of the appended independent claims.

What is claimed is:

1. A network node for a wireless communication system, the network node comprising:

a processor configured to

select a group of user devices for superposed reception or transmission of data,

determine control information (CI) for the user devices of the selected group, the control information (CI) comprising group control information (GCI) common to the user devices of the selected group and at least one user device control information (UDCI) specific to at least one user device of the user devices of the selected group; and

a transceiver configured to

transmit a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information (GCI) and the user device control information (UDCI); or

transmit a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information (GCI), and transmit a second signal which is addressed to at least one user device of the user devices of the selected group in a second set of time and frequency resources, the second signal comprising the user device control information (UDCI).

2. The network node according to claim **1**, wherein the user devices of the selected group share at least one common time and frequency resource for the superposed reception or transmission of data.

3. The network node according to claim **1**, wherein the first signal is transmitted in at least one control channel.

4. The network node according to claim **1**, wherein the control information (CI) comprises user device control information (UDCI) for each user device of the selected group.

5. The network node according to claim **1**, wherein the group control information (GCI) indicates one or more in the group comprising: scheduling assignment information; multiple input multiple output, MIMO, transmission information; transport format information; number of scheduled user device information, multiple access mode information; and user device power allocation information.

6. The network node according to claim 1, wherein the group control information (GCI) indicates one or more in the group comprising: a common MIMO pre-coding matrix index or pre-coding vector index; a common number of data streams or layers available to the user devices of the selected group; and a set of common time and frequency resources assigned to the user devices of the selected group or a subset of time and frequency resources shared by the user devices of the selected group.

7. The network node according to claim 6, wherein the group control information (GCI) further indicates a common modulation format.

8. The network node according to claim 1, wherein the user device control information (UDCI) indicates one or more in the group comprising: user device identity information; transport format information; hybrid automatic repeat request, HARQ, information; and user device power allocation information.

9. The network node according to claim 1, wherein the user device control information (UDCI) indicates a channel code rate; and a multiuser interleaving scheme.

10. The network node or user device according to claim 1, wherein the user device control information (UDCI) indicates user device power allocation; a modulation scheme and a channel code rate or a modulation and coding scheme indicator; a user device specific MIMO pre-coding matrix index or pre-coding vector index.

11. The network node or user device according to claim 9, wherein the user device control information (UDCI) further indicates number of user device specific data streams or layers available to the user devices of the selected group.

12. The network node according to claim 10, wherein the control information (CI) is comprised in a single downlink control information format.

13. A user device for a wireless communication system, the user device comprising:

a transceiver configured to receive a first signal in a first set of time and frequency resources, the first signal comprising group control information (GCI) common to a selected group of user devices and user device control information (UDCI) specific to the user device; or

receive a first signal in a first set of time and frequency resources, the first signal comprising the group control information (GCI), and receive a second signal in a second set of time and frequency resources, the second signal comprising the user device control information (UDCI); and

a processor configured to

decode the group control information (GCI) and the user device control information (UDCI); and

wherein the transceiver further is configured to receive or transmit data according to the group control information (GCI) and the user device control information (UDCI).

14. The network node according to claim 13, wherein the group control information (GCI) indicates one or more in the group comprising: scheduling assignment information; multiple input multiple output, MIMO, transmission information; transport format information; number of scheduled user device information, multiple access mode information; and user device power allocation information.

15. The network node according to claim 13, wherein the group control information (GCI) indicates one or more in the group comprising: a common MIMO pre-coding matrix index or pre-coding vector index; a common number of data streams or layers available to the user devices of the selected group; and a set of common time and frequency resources assigned to the user devices of the selected group or a subset of time and frequency resources shared by the user devices of the selected group.

16. The network node according to claim 15, wherein the group control information (GCI) further indicates a common modulation format.

17. The network node according to claim 13, wherein the user device control information (UDCI) indicates one or more in the group comprising: user device identity information; transport format information; hybrid automatic repeat request, HARQ, information; and user device power allocation information.

18. The network node according to claim 13, wherein the user device control information (UDCI) indicates a channel code rate; and a multiuser interleaving scheme.

19. The network node or user device according to claim 13, wherein the user device control information (UDCI) indicates user device power allocation; a modulation scheme and a channel code rate or a modulation and coding scheme indicator; a user device specific MIMO pre-coding matrix index or pre-coding vector index.

20. The network node or user device according to claim 18, wherein the user device control information (UDCI) further indicates number of user device specific data streams or layers available to the user devices of the selected group.

21. The network node according to claim 19, wherein the control information (CI) is comprised in a single downlink control information format.

22. A method in a network node, the method comprising:

selecting a group of user devices for superposed reception or transmission of data;

determining control information (CI) for the user devices of the selected group, the control information (CI) comprising group control information (GCI) common to the user devices of the selected group and at least one user device control information (UDCI) specific to at least one user device of the user devices of the selected group; and

one of:

transmitting a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information (GCI) and the user device control information (UDCI); and

transmitting a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information (GCI), and transmitting a second signal which is addressed to at least one user device of the user devices of the selected group in a second set of time and frequency resources, the second signal comprising the user device control information (UDCI).

23. A method in a user device, the method comprising:

receiving one of:

a first signal in a first set of time and frequency resources, the first signal comprising group control information (GCI) common to a selected group of user devices and user device control information (UDCI) specific to the user device; and

a first signal in a first set of time and frequency resources, the first signal comprising the group control information (GCI), and receiving a second signal in a second set of time and frequency resources, the second signal comprising the user device control information (UDCI);

decoding the group control information (GCI) and the user device control information (UDCI);

receiving or transmitting data according to the group control information (GCI) and the user device control information (UDCI).

24. A non-transitory computer readable medium having stored thereon computer-executable instructions that when executed by a processor cause the processor to perform operations in a network node, the operations comprising:

selecting a group of user devices for superposed reception or transmission of data;

determining control information (CI) for the user devices of the selected group, the control information (CI) comprising group control information (GCI) common to the user devices of the selected group and at least one user device control information (UDCI) specific to at least one user device of the user devices of the selected group;

transmitting one of

a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information (GCI) and the user device control information (UDCI); and

a first signal which is addressed to the user devices of the selected group in a first set of time and frequency resources, the first signal comprising the group control information (GCI), and transmitting a second signal which is addressed to at least one user device of the user devices of the selected group in a second set of time and frequency resources, the second signal comprising the user device control information (UDCI).

25. A non-transitory computer readable medium having stored thereon computer-executable instructions that when executed by a processor cause the processor to perform operations in a user device, the operations comprising:

receiving one of

a first signal in a first set of time and frequency resources, the first signal comprising group control information (GCI) common to a selected group of user devices and user device control information (UDCI) specific to the user device; and

a first signal in a first set of time and frequency resources, the first signal comprising the group control information (GCI), and receiving a second signal in a second set of time and frequency resources, the second signal comprising the user device control information (UDCI);

decoding the group control information (GCI) and the user device control information (UDCI);

receiving or transmitting data according to the group control information (GCI) and the user device control information (UDCI).

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