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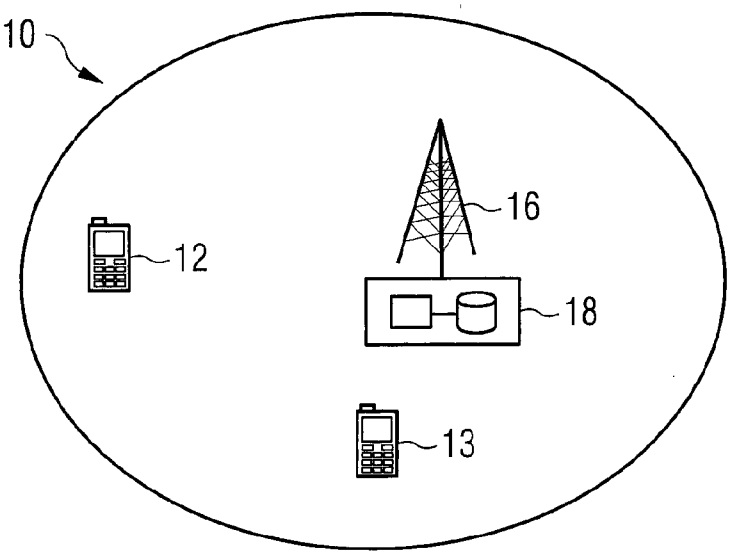
(54) **Title**: CONTROL CHANNEL DISTRIBUTION

FIG 1



(57) **Abstract**: A method and apparatus comprising: defining a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal; selecting from the first set of resources a second set of resources associated with a second control channel; and using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

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DESCRIPTION

Title

Control Channel Distribution

This disclosure relates to control channel distribution for wireless communications, and more particularly to defining distribution and communication of control information.

A communication system can be seen as a facility that enables communication sessions between two or more entities such as fixed or mobile communication devices, machine-type terminals, base stations, servers and/or other communication nodes. A communication system and compatible communicating entities typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. In a wireless communication system at least a part of communications between stations occurs over a wireless link. Examples of wireless systems include public land mobile networks (PLMN) such as cellular networks, satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). A wireless system can be divided into cells or other radio coverage or service areas.

A user can access the communication system by means of an appropriate communication device. A communication device of a user is often referred to as user equipment (UE) or terminal. A communication device is provided with an appropriate signal receiving and transmitting arrangement for enabling communications with other parties. In a wireless system a communication device provides a transceiver station that can communicate with another communication node such as e.g. a base station and/or another user equipment.

An example of communication systems is an architecture that is being standardized by the 3rd Generation Partnership Project (3GPP). This system is often referred to as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. A further development of the LTE is often referred to as LTE-Advanced. The various development stages of the 3GPP LTE specifications are referred to as releases.

Various control channels are possible. For example control channels in the downlink (DL) can be used for signalling HARQ-ACK information related to Physical Uplink Shared Channel (PUSCH) transport blocks. In other words LTE uses a hybrid automatic repeat request (HARQ) scheme for error correction. The eNodeB sends a HARQ indicator to the

UE to indicate a positive acknowledgement (ACK) or negative acknowledgement (NACK) for previous data sent using the uplink shared channel. The channel coded HARQ indicator codeword is transmitted through the Physical Hybrid Automatic Repeat Request Indicator Channel (PHICH).

It has been proposed to use New Carrier Type (NCT) signalling having no Common (Cell Specific) Reference Signals (CRS) available for coherent detection. For example it has been known (such as from LTE Rel-8/9/10/11) that the PHICH (Physical Hybrid ARQ indicator Channel) can be used to convey HARQ-ACKs (in the DL) for the PUSCH data packets. The PHICH is a common physical channel transmitted in every subframe.

Currently NCT operation requires usage of Enhanced Physical Downlink Control Channel (EPDCCH) and UE-specific demodulation reference signals (DM-RS) as there are no CRS available for demodulation. Furthermore there is no definition for the common search space for EPDCCH and therefore legacy PHICH methods are not applicable to NCT operation of the EPHICH either.

A signalling channel carrying the HARQ-ACK in the downlink using the New Carrier Type and / or EPDCCH is denoted here as the EPHICH (Enhanced Physical Hybrid-ARQ Indicator Channel).

There are number of properties for the EPHICH design. These include network energy savings, interference coordination among neighboring cells and support for Heterogeneous networks (HetNet). Furthermore the EPHICH designs should meet or exceed the same basic requirements as the PHICH in terms of performance (10^-3 target BER), capacity (number of scheduled users), overhead and configurability. Additionally the EPHICH designs should demonstrate properties such as smooth coexistence with EPDCCH, CoMP and other advantageous features of the evolving LTE-Advanced standards.

Embodiments of the invention aim to address one or several of the above issues.

According to a first aspect there is provided a method for control channel distribution for wireless communications comprising: defining a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal; selecting from the first set of resources a second set of resources associated with a second control channel; and using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

Selecting from the first set of resources a second set of resources associated with a second control channel may comprise selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

Selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions may comprise selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

Selecting from the first set of resources a second set of resources associated with a second control channel may comprise selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

Selecting from the first set of resources a second set of resources associated with a second control channel may comprise selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

Selecting from the first set of resources a second set of resources associated with a second control channel may comprise mapping at least one of the resources from the set of

resources associated with the first control channel to the set of resources associated with the second control channel.

Mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: determining a number (N) of resources in the first control channel set; determining a number (REP) of repetitions per resource; and generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,..., REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

Mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: determining a number (N) of resources in the first control channel set; determining a number (REP) of repetitions; and generating a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

Generating an index mapping based on the ratio of resources in the first control channel set to repetitions may comprise at least one of: generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,..., REP-1], N \right),$$

where N/REP>=2; generating a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,..., REP-1], N)$, where N/REP<2; and generating a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor REP/N \rfloor * N$ repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

The method may further comprise: embedding information about the selected second set of resources associated with a second control channel into a master information block of system information on a broadcast channel; and transmitting the master information block of system information on the broadcast channel.

The method may further comprise transmitting information about the selected second set of resources associated with a second control channel using a radio resource control protocol.

The method may further comprise transmitting information about the first set of resources associated with the first control channel using the radio resource control protocol.

The method may further comprise defining a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

According to a second aspect there is provided a method comprising: receiving information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources; receiving further information selecting from the first set of resources a second set of resources associated with a second control channel; and using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise receiving information for selecting from the first set of resources the second set of resources which maximise

the frequency diversity for a defined number of code block repetitions of the second control channel.

Receiving further information for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions may comprise receiving information for selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprises receiving information for selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise receiving information for selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

Receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: determining a number (N) of resources in the first control channel set; determining a number (REP) of repetitions per resource; and generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,\ldots, REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

Receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second

control channel may comprise: determining a number (N) of resources in the first control channel set; determining a number (REP) of repetitions; and generating a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

Generating an index mapping based on the ratio of resources in the first control channel set to repetitions may comprise at least one of: generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N\right),$$

where N/REP>=2; generating a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N)$, where N/REP<2; and generating a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor REP/N \rfloor * N$ repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

Receiving further information selecting from the first set of resources a second set of resources associated with a second control channel may further comprise receiving the further information embedded within a master information block of system information on a broadcast channel.

Receiving further information selecting from the first set of resources a second set of resources associated with a second control channel may further comprise receiving the further information in a radio resource control protocol message.

Receiving information defining a first set of resources associated with a first control channel may comprises receiving information about the first set of resources associated with the first control channel in a radio resource control protocol message.

The method may further comprise defining a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

According to a third aspect there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured to with the at least one processor to cause the apparatus to at least: define a first set of resources associated with a first con-

trol channel, the first control channel first set of resources further associated with at least one demodulation reference signal; select from the first set of resources a second set of resources associated with a second control channel; and use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

Selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to select from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

Selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions may cause the apparatus to select the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

Selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to select the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

Selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to select 12/SF resources, where SF is the spreading factor associated with the second control channel.

Selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to map at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

Mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may cause the apparatus to: determine a number (N) of resources in the first control channel set; determine a number (REP) of repetitions per resource; and generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,...,REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

Mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may cause the apparatus to: determine a number (N) of resources in the first control channel set; determine a number (REP) of repetitions; and generate a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

Generating an index mapping based on the ratio of resources in the first control channel set to repetitions may cause the apparatus to perform least one of:

generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N \right),$$

where N/REP>=2;

generate a PRB pair index mapping for the g'th group of the second control channel based on

$EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N)$, where N/REP<2;

and

generate a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor REP/N \rfloor * N$ repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

The apparatus may further be caused to: embed information about the selected second set of resources associated with a second control channel into a master information block of system information on a broadcast channel; and transmit the master information block of system information on the broadcast channel.

The apparatus may further be caused to transmit information about the selected second set of resources associated with a second control channel using a radio resource control protocol.

The apparatus may further be caused to transmit information about the first set of resources associated with the first control channel using the radio resource control protocol.

The apparatus may further be caused to define a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

According to a fourth aspect there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured to with the at least one processor to cause the apparatus to at least: receive information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources; receive further information selecting from the first set of resources a second set of resources associated with a second control channel; and use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to receive information for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

Receiving further information for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions may cause the apparatus to receive information for selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to receive information for selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to receive information for selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

Receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to receive information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

Receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may cause the apparatus to: determine a number (N) of resources in the first control channel set; determine a number (REP) of repetitions per resource; and generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,..., REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

Receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may cause the apparatus to: determine a number (N) of resources in the first control channel set; determine a number (REP) of repetitions; and generate a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

Generating an index mapping based on the ratio of resources in the first control channel set to repetitions may cause the apparatus to perform at least one of: generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,..., REP-1], N \right),$$

where N/REP>=2; generate a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,..., REP-1], N)$, where N/REP<2; and generate a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor REP/N \rfloor$ *N repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

Receiving further information selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to receive the further information embedded within a master information block of system information on a broadcast channel.

Receiving further information selecting from the first set of resources a second set of resources associated with a second control channel may cause the apparatus to receive the further information in a radio resource control protocol message.

Receiving information defining a first set of resources associated with a first control channel may cause the apparatus to receive information about the first set of resources associated with the first control channel in a radio resource control protocol message.

The apparatus may be further caused to define a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

According to a fifth aspect there is provided an apparatus comprising: means for defining a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal; means for selecting from the first set of resources a second set of resources associated with a second control channel; and means for using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

The means for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

The means for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions may comprise means for selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

The means for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

The means for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

The means for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

The means for mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: means for determining a number (N) of resources in the first control channel set; means for determining a number (REP) of repetitions per resource; and means for generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,\ldots, REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

The means for mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: means for determining a number (N) of resources in the first control channel set; means for determining a number (REP) of repetitions; and means for generating a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

The means for generating an index mapping based on the ratio of resources in the first control channel set to repetitions may comprise at least one of: means for generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N\right),$$

where N/REP>=2; means for generating a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N)$, where N/REP<2; and means for generating a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor REP/N \rfloor * N$ repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

The apparatus may further comprise: means for embedding information about the selected second set of resources associated with a second control channel into a master information block of system information on a broadcast channel; and means for transmitting the master information block of system information on the broadcast channel.

The apparatus may comprise means for transmitting information about the selected second set of resources associated with a second control channel using a radio resource control protocol.

The apparatus may comprise means for transmitting information about the first set of resources associated with the first control channel using the radio resource control protocol.

The apparatus may comprise means for defining a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

According to a sixth aspect there is provided an apparatus comprising: means for receiving information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources; means for receiving further information selecting from the first set of resources a second set of resources associated with a second control channel; and means for using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

The means for receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving information for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

The means for receiving further information for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions may comprise means for receiving information for selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

The means for receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving information for selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

The means for receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving information for selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

The means for receiving further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

The means for receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: means for determining a number (N) of resources in the first control channel set; means for determining a number (REP) of repetitions per resource; and means for generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,...,REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

The means for receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel may comprise: means for determining a number (N) of resources in the first control channel set; means for determining a number (REP) of repetitions; and means for generating a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

The means for generating an index mapping based on the ratio of resources in the first control channel set to repetitions may comprise at least one of: means for generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N \right),$$

where N/REP>=2; means for generating a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N)$, where N/REP<2; and means for generating a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor$REP/N$\rfloor$ *N repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

The means for receiving further information selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving the further information embedded within a master information block of system information on a broadcast channel.

The means for receiving further information selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving the further information in a radio resource control protocol message.

The means for receiving information defining a first set of resources associated with a first control channel may comprise means for receiving information about the first set of resources associated with the first control channel in a radio resource control protocol message.

The apparatus may further comprise means for defining a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

According to a seventh aspect there is provided an apparatus comprising: a first channel resource determiner configured to define a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal; a second channel resource determiner configured to select from the first set of resources a second set of resources associated with a second control channel; and a demodulation reference definer configured to use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

The second channel resource determiner may comprise a resource selector configured to select from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

The resource selector may be configured to select the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

The second channel resource determiner may comprise a resource selector configured to select the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

The second channel resource determiner may comprise a resource selector configured to select 12/SF resources, where SF is the spreading factor associated with the second control channel.

The second channel resource determiner may comprise a mapper configured to map at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

The mapper may comprise: a resource determiner configured to determine a number (N) of resources in the first control channel set; a repetition determiner configured to determine a number (REP) of repetitions per resource; and a mapping generator configured to generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,\ldots, REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

The mapper may comprise: a resource determiner configured to determine a number (N) of resources in the first control channel set; a repetition determiner configured to determine a number (REP) of repetitions; and mapping generator configured to generate a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

The mapper may comprise at least one of: a mapping generator configured to generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N \right),$$

where N/REP>=2; a mapping generator configured to generate a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N)$, where N/REP<2; and a mapping generator configured to generate a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor REP/N \rfloor * N$ repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

The apparatus may further comprise: an embedder configured to embed information about the selected second set of resources associated with a second control channel into a master information block of system information on a broadcast channel; and a transmitter configured to transmit the master information block of system information on the broadcast channel.

The apparatus may comprise a transmitter configured to transmit information about the selected second set of resources associated with a second control channel using a radio resource control protocol.

The apparatus may comprise a transmitter configured to transmit information about the first set of resources associated with the first control channel using the radio resource control protocol.

The apparatus may comprise a remaining resource determiner configured to define a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

The apparatus may be base station control apparatus.

According to an eighth aspect there is provided an apparatus comprising: a receiver configured to receive information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources; the receiver further configured to receive further information

selecting from the first set of resources a second set of resources associated with a second control channel; and a demodulator configured to use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

The first control channel may be an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel may be an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

The resources may be physical resource block pairs (PRB).

The first set of resources associated with the first control channel may form a search space within which information on the first control channel is transmitted.

The search space may define at least one of: a common search space for the first control channel; and a user specific search space for the first control channel.

The apparatus may further comprise a resource selector configure to select from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving information for selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

The resource selector may be configured to receive information for selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

The resource selector may be configured to receive information for selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

The resource selector may be configured to receive further information for selecting from the first set of resources a second set of resources associated with a second control channel may comprise means for receiving information for selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

The resource selector may be configured to receive receiving information mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

The resource selector may comprise: a resource determiner for determining a number (N) of resources in the first control channel set; a repetition determiner configured to determine a number (REP) of repetitions per resource; and a mapper configured to generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,..., REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation.

The resource selector may comprise: a resource selector configured to determine a number (N) of resources in the first control channel set; a repetition determiner configured to determine a number (REP) of repetitions; and a mapper configured to generate a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

The mapper may comprise at least one of: a mapper configured to generate a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,..., REP-1], N \right),$$

where N/REP>=2; a mapper configured to generate a PRB pair index mapping for the g'th group of the second control channel based on $EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,..., REP-1], N)$, where N/REP<2; and a mapper configured to generate a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor$REP/N$\rfloor$ *N repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

The receiver may be configured to receive the further information embedded within a master information block of system information on a broadcast channel.

The receiver may be configured to receive the further information in a radio resource control protocol message.

The receiver may be configured to receive information about the first set of resources associated with the first control channel in a radio resource control protocol message.

The apparatus may further comprise a remainder set determiner configured to define a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

The apparatus may be a user equipment.

Nodes implementing the embodiments may be provided. The nodes can include a base station control apparatus and a mobile device.

A computer program comprising program code means adapted to perform the claimed method may also be provided.

Various other aspects and further embodiments are also described in the following detailed description and in the attached claims.

The invention will now be described in detail, by way of example only, with reference to the following examples and accompanying drawings, in which:

Figure 1 shows a schematic diagram of a network according to some embodiments;

Figure 2 shows a schematic diagram of a mobile communication device according to some embodiments;

Figure 3 shows a schematic diagram of a control apparatus according to some embodiments;

Figure 4 shows a flow chart according to some embodiments of the operations at a network element;

Figure 5 shows an example mapping of distributed eCCE to eREG according to some embodiments;

Figure 6 shows an example PRB mapping pattern for different example EPHICH groups according to some embodiments;

Figure 7 shows a flow chart according to some embodiments of the allocation or mapping operations at a network element;

Figure 8 shows an example PRB and eREG mapping pattern for different EPHICH groups for different number of available PRB pairs according to some embodiments;

Figure 9 shows a flow chart according to some embodiments of the allocation or mapping operations at a network element; and

Figure 10 shows an example improved mapping of eREG to EPHICH groups according to some embodiments.

It would be understood that the existing PHICH design (such as defined within the LTE Rel-8 standard) cannot be implemented as an EPHICH design candidate as such as the CRS used in the existing PHICH designs are not available in the NCT.

The existing PDCCH is transmitted on one or several control channel elements (CCEs). In LTE blind decoding a device, for example a user equipment, checks predefined locations, aggregation levels, and downlink control information (DCI) formats and acts on messages satisfying predefined criteria. Carrying out such a 'blind decoding' of all the possible combinations would require the device to make many decoding attempts in every subframe, and thus LTE specifications define that each device has only a limited set of control channel element (CCE) locations where a control channel for that device may be placed. The set of CCE locations where a device may find its control channel can be considered as its 'search space'. A search space can be of a different size for each control channel format. Separate dedicated, user specific and common search spaces can also be defined. In such case a dedicated search space can be configured for each device individually (i.e. user specific) while all devices can be informed of the extent and location of a common search space. Such common search space is typically located in a fixed location such that it is possible to address all user devices within a cell using only one signalling message on the control channel.

The EPDCCH is multiplexed and based on a fixed number of enhanced control channel elements (eCCEs) per a physical resource block (PRB) pair where the size of each eCCE in terms of number of resource elements adapts to the number of resource elements (REs) available in the PRB pair. The adaptation of the eCCE sizes can depend on the presence of legacy signals such as common reference signal (CRS), PDCCH, physical control format indicator channel (PCFICH), and channel state information reference signal (CSI-RS).

There have been design proposals made where EPHICHs are transmitted within a minimum configured set of physical resource block (PRB) pairs for enhanced CCHs (designed to construct EPDCCH). Furthermore the amount of EPHICH resources is configurable with a fine resolution to avoid unnecessary overhead, and the EPHICH mapping unit is an enhanced resource element group (eREG) composed of N REs within a PRB pair (N=9 for

normal cyclic prefic, N=8 for extended cyclic prefix). In these proposed design EPDCCH resources are to be used for EPHICH by granularity of the eREG.

However this design has the following problems. Firstly usage of code division multiplexing (CDM) is difficult to implement as the effective size of eREG varies significantly. For example the effective size of the eREG can vary depending on the presence of other signals (such as channel state information reference signal CSI-RS or NCT tracking RS) and also the subframe type (normal, time division duplex [TDD] special subframe). Moreover, the REs of a single eREG are distributed over a PRB pair as such, which is not very CDM friendly due to time and/or frequency selective channels. Furthermore the performance of EPHICH varies as well according to eREG resource size. Finally these designs have not taken into account recent decisions related to Distributed and Localized Search Spaces for the EPDCCH.

The concept in embodiments as described herein is a method and apparatus for transmitting and receiving HARQ-ACK information in downlink using a New Carrier Type arrangement (in other words having no Common Reference Signals available for coherent detection).

As described herein the concept design for the Enhanced Physical Hybrid ARQ indicator Channel (EPHICH) can be summarised by the following design aspects:

Firstly the EPHICH is embedded into the common search space of EPDCCH, for example in some embodiments the EPHICH is embedded into the common search space of a distributed EPDCCH structure although in some embodiments the EPHICH uses the search space of the localized EPDCCH (for example 1 physical resource block [PRB] pair common search space [CSS] for the smallest system bandwidth [BWs] of 1.4MHz/6PRB pairs).

Secondly the EPHICH detection is based on demodulation reference signal (DM-RS) which are shared with the common search space (CSS). For example in some embodiments EPHICH can be designed to share one or more of the DM-RS antenna ports with EPDCCH.

The EPHICH mapping into the common search space PRB pairs or resources in general is described herein in more detail. However it would be understood that in some embodiments the PRB pairs or resources in general can be part of a user specific search space.

In some embodiments a higher layer parameter can be employed to define the number of EPHICH groups. In some embodiments the number of EPHICH groups can be broadcasted in the master information block (MIB). In some embodiments the information can be broadcast on an enhanced Physical broadcast channel (EPBCH).

In some embodiments code division multiplexing (CDM) is applied within the EPHICH group. The CDM component (which in some circumstances is also known as Spreading Factor) applied defines the number of EPHICH resources available per EPHICH group.

In some embodiments a determined number of code block repetitions is applied for each EPHICH group. The repetitions follow a defined pattern in the CSS of EPDCCH. In such embodiments repetitions of the same code block are located (as much as possible) in different PRB pairs in the CSS in order to exploit as much as possible the benefits from frequency diversity. Furthermore in some embodiments the number of code block repetitions is defined by 12/SF (12 divided by the spreading factor) as this defines that a single EPHICH group uses in total 12 Resource Elements.

In some embodiments EPHICH groups can be mapped into defined resource elements within each PRB pair corresponding to CSS of EPDCCH in a defined order.

In some embodiments the EPDCCH CSS is rate matched around EPHICH, i.e. EPDCCH CSS REs are mapped around EPHICH REs on a given PRB pair. In such a manner all UEs using EPDCCH will have knowledge of the EPHICH location within the CSS of EPDCCH.

In other words the embodiments described a method for control channel distribution for wireless communications comprising: defining a first set of resources (for example resource block pairs) associated with a first control channel (such as for example the EPDCCH), the first control channel first set of resources further associated with at least one demodulation reference signal (for example the DM-RS); selecting from the first set of resources a second set of resources associated with a second control channel (for example the EPHICH); and using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

Furthermore it is noted that the above discussed issues are not limited to any particular communication environment.

In the following certain exemplifying embodiments are explained with reference to a wireless or mobile communication system serving mobile communication devices. Before explaining in detail the exemplifying embodiments, certain general principles of a wireless communication system and mobile communication devices are briefly explained with reference to Figures 1 to 3 to assist in understanding the technology underlying the described examples.

In a wireless communication system mobile communication devices or user equipments (UE) 12, 13 are provided wireless access via at least one base station or similar wireless transmitting and/or receiving node or point. In Figure 1 an access system or radio service area of a cellular system 10 provided by a base station 16 are shown. Each mobile communication device and station may have one or more radio channels open at the same time and may send signals to and/or receive signals from more than one source. It is noted that the radio service area border is schematically shown for illustration purposes only in Figure 1. It shall be understood that the size and/or shape of a radio service area may vary considerably from that of Figure 1.

Base stations are typically controlled by at least one appropriate controller apparatus so as to enable operation thereof and management of mobile communication devices in communication with the base stations. In Figure 1 control apparatus 18 is shown to control the station 16. The control apparatus can be interconnected with other control entities. The control apparatus is typically provided with memory capacity and at least one data processor. The control apparatus and functions may be distributed between a plurality of control units.

A non-limiting example of the recent developments in communication system architectures is the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) that is being standardized by the 3rd Generation Partnership Project (3GPP). As explained above, further development of the LTE is referred to as LTE-Advanced. Non-limiting examples of LTE access nodes are macro level base stations known as enhanced NodeB (eNB) in the vocabulary of the 3GPP specifications. Home eNBs (HeNB), pico eNodeBs (pico-eNB), femto nodes, and radio remote heads (RRH) connected to an eNB. The LTE employs a mobile architecture known as the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). Base stations of such systems (evolved or enhanced Node Bs) provide E-UTRAN features such as user plane Radio Link Control/Medium Access Control/Physical layer protocol (RLC/MAC/PHY) and control plane Radio Resource Control (RRC) protocol terminations towards the user devices. Of these Radio Resource Control (RRC) protocol is used to configure and control the radio resource between eNodeBs and user equipment. For example, RRC is used to configure the RLC/MAC and PHY layer at a user equipment and eNodeB.

Other examples of radio access system include those provided by base stations of systems that are based on technologies such as wireless local area network (WLAN) and/or WiMax (Worldwide Interoperability for Microwave Access).

A possible mobile communication device will now be described in more detail in reference to Figure 2 showing a schematic, partially sectioned view of a communication device 20. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples include a mobile station (MS) such as a mobile phone or what is known as a 'smart phone', a portable computer provided with a wireless interface card or other wireless interface facility, personal data assistant (PDA) provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services include two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. User may also be provided with broadcast or multicast data. Non-limiting examples of the content include downloads, television and radio programs, videos, advertisements, various alerts and other information. The mobile device may receive signals over an air interface 27 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 transceiver apparatus is designated schematically by block 26. The transceiver apparatus 26 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the mobile device.

A mobile device is also typically provided with at least one data processing entity 21, at least one memory 22 and other possible components 23 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 24. The control apparatus of a user equipment can be configured to process information in association with the enhanced Physical Hybrid ARQ indicator Channel (EPHICH) configuration as well as in some embodiments the enhanced physical downlink control channel (EPDCCH) configuration and mapped enhanced control channel elements to enhanced resource element groups received from a base station accordingly.

Figure 3 shows an example of a control apparatus for a communication system, for example to be coupled to and/or for controlling a station of an access system. In some embodiments base stations comprise a separate control apparatus. In other embodiments the

control apparatus can be another network element. The control apparatus 30 can be arranged to provide control on communications in the service area of the system. The control apparatus 30 can be configured to provide control functions in association with the enhanced Physical Hybrid ARQ indicator Channel (EPHICH) and also in some embodiments the enhanced physical downlink control channel (EPDCCH) configuration and mapping enhanced control channel elements to enhanced resource element groups for user equipment in accordance with certain embodiments described below. For this purpose the control apparatus comprises at least one memory 31, at least one data processing unit 32, 33 and an input/output interface 34. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The control apparatus can be configured to execute an appropriate software code to provide the control functions. It shall be appreciated that similar components can be provided in a control apparatus provided elsewhere in the system.

Figure 4 shows a flowchart for operation at for determining EPHICH resources for user equipment.

In some embodiments a network element, for example the eNodeB or other control apparatus can be configured to determine EPHICH configuration information. For example the EPHICH configuration information can comprise the information on the CSS PRBs carrying EPHICH and the parameter configuring the number of EPHICH groups. As described herein it would be understood that in some embodiments the PRBs or resources can be user specific search space (USS) PRBs carrying EPHICH information and as such the EPHICH configuration information can comprise information on the USS PRBs carrying EPHICH.

The operation of determining the information is shown in Figure 4 by step 40.

Furthermore the network element can then in some embodiments embed the determined information in the master information block (MIB) of the system information a broadcast channel. For example a physical broadcast channel (PBCH) or enhanced physical broadcast channel (EPBCH).

The operation of embedding and broadcasting the information is shown in Figure 4 by step 41.

The network element can determine a repetition pattern for EPHICH code blocks in some embodiment by determining a PRB mapping for EPHICH within the CSS of EPDCCH.

There are two main principles to construct PRB mapping for EPDCCH corresponding to a predefined number of code repetitions (the number of repetitions may be defined by 12 divided by the spreading factor). The first principle defines PRB mapping based on the pattern used to construct distributed eCCE structure. The second principle defines PRB mapping based on dedicated EPHICH pattern for the CSS (or USS) of EPDCCH (i.e. not directly linked to distributed eCCE pattern).

For example the 3rd Generation Partnership Project, Technical Specification Group Radio Access Network, Evolved Universal Terrestrial Radio Access (E-UTRA), physical channels and modulation (Release 11) technical standard TS 36.211 v11.0.1 (December 2012) describes the resource element (RE) to eREG mapping in section 6.2.4A as well as the eREG to eCCE mapping for localized and distributed EPDCCH sets in section 6.8.A.

In order to define the first principle, we first illustrate the current eCCE to eREG mapping used to construct distributed eCCE structure in 3GPP Rel. 11 accoring to section 6.8A of TS 36.211 v11.0.1 (December 2012). With respect to Figure 5 a series of distributed eCCE to eREG mappings are shown. For example the left mapping shows a N=8 PRB pairs, $N_{\mathrm{ECCE}}^{\mathrm{EREG}}$=4 eREGs per ECCE mapping according to section 6.8A of TS 36.211 v11.0.1 where the eCCE0 to eCCE31 are mapped into the physical resource block (PRB) pairs versus enhanced resource element group (eREG). Thus eCCE10 701 is mapped to the blocks highlighted 745 at eREG 1 of PRB2, eREG 5 of PRB4, eREG 9 of PRB6 and eREG 13 of PRB0.

The right mapping shows a 8 PRB pair EPDCCH set, $N_{\mathrm{ECCE}}^{\mathrm{EREG}}$ =8 mapping according to section 6.8A of TS 36.211 (v11.0.1) described herein where the eCCE0 to eCCE15 are mapped into the physical resource block (PRB) pairs versus enhanced resource element group (eREG). Thus eCCE10 701 is mapped to the blocks highlighted 715 at eREG 1 of PRB2, eREG 3 of PRB3, eREG 5 of PRB4 , eREG 7 of PRB5, eREG 9 of PRB6, eREG 11 of PRB7, eREG 13 of PRB0 and eREG 15 of PRB1.

Figure 6 shows an example of PRB mapping pattern (or selection criteria) for the EPHICH groups in line with the distributed EPDCCH mapping. In the example shown the CDM is assumed to have a spreading factor = 2 and six repetitions (12/2=6). With this combination there is a comparable link budget with earlier PHICH designs such as LTE-A Rel-8 PHICH.

In the Figure shown the PRB mapping for one of the EPHICH groups (“#1” 601) is highlighted for illustrative purposes. Following this example, six repetitions are distributed

among four PRBs according to a predetermined pattern used to construct distributed eCCE indices of the PHICH groups.

In some embodiments the network element can be configured to perform PRB pair mapping based on a dedicated EPHICH pattern within the CSS of EPDCCH.

For example Figure 7 shows an example method of generating the PRB pair mapping pattern for the EPHICH groups according to some embodiments.

In some embodiments the network element can be configured to determine the number of PRBs in the CSS EPDCCH (N) (or a first control channel).

The operation of determining the number of PRBs in the CSS EPDCCH (N) is shown in Figure 7 by step 70.

Furthermore in some embodiments the network element can be configured to determine the number of repetitions (REP).

The operation of determining the number of repetitions (REP) is shown in Figure 7 by step 71.

The network element can then allocate or generate a mapping of EPHICH resource groups (or g'th group of a second control channel) according to the following PRB pair mapping operation.

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,..., REP-1], N \right)$$ where N corresponds to number of PRBs of the EPDCCH set, REP equals to number of repetitions (three in the example shown in Figure 9 as discussed below), g corresponds to the index of EPHICH group (0, 1, …), mod(a,b) denotes the modulo operation (a modulo b) and $\lfloor \rfloor$ is the floor operation (and $\lceil \rceil$ denotes the ceil operation correspondingly).

With respect to Figure 8 examples of PRB pair mapping patterns for the EPHICH groups are shown where CDM has a spreading factor = 4 and three repetitions (12/4=3).

In the three example mappings for 8 PRB pairs 808, 4 PRB pairs 804 and 2 PRB pairs 802 the EPHICH group "#1" 801 is highlighted for illustrative purposes. It would be understood that neither the figure nor the formula shown herein does exactly describe how the EPHICH is mapped to the REs within each PRB pair, but only illustrates the mapping to PRB pairs.

In some embodiments with a high number of repetitions the mapping as described above may not utilize as many as possible PRB pairs. For example for 6 repetitions and where N=8 then the PRB allocation for the six repetitions corresponds to [0, 6, 4, 2, 0, 6]), as the steps are given by a fixed offset given by the repetition size. The steps given by a fixed offset can for example be generated according to the method described herein with respect to Figure 7.

In some embodiments, such as shown in Figure 9, the network element can be configured to generate a mapping according to the following operations.

The operation of determining the number of PRBs in the CSS EPDCCH (N) is shown in Figure 9 by step 70.

Furthermore in some embodiments the network element can be configured to determine the number of repetitions (REP).

The operation of determining the number of repetitions (REP) is shown in Figure 9 by step 71.

The network element can then in some embodiments determine whether there are more repetitions than half the PRB pairs. In other words the network element in some embodiments can be configured to determine whether the following is correct: Is (N/REP)<2?

The operation of checking the ratio of PRB pairs to repetitions is shown in Figure 9 by step 82.

Where the check is false and N/REP >= 2 then the network element can be configured to generate a PRB pair mapping according to the following expression:

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N \right)$$

The operation of mapping where the check is false is shown in Figure 9 by step 83.

In some embodiments where the check is true and N/REP<2 then the network element can be configured to generate a mapping pattern with "PRB step" of 1.

In some embodiments the PRB step pattern can be:

$$EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N).$$

The operation of mapping where the check is true is shown in Figure 9 by step 84.

In some embodiments further frequency diversity optimization compared to the generic pattern can be achieved also in the case when the number of repetitions is larger than the number of PRB pairs (REP>*N*). An example of such optimization is usage of the pattern with "PRB step" of 1 when (REP>*N*).

Furthermore, it's possible to change the mapping for the predetermined repetitions (e.g. last/first (mod(N,REP)) in order to maximize the frequency diversity over the entire pattern.

This has been shown in Figure 10 where a PRB mapping with REP=6 and N=4 is improved from a first mapping 901 having a fixed step size of 1 to a second mapping 903, where the fixed set size of 1 is only given for the first $\lfloor REP/N \rfloor$ repetitions whereas the remaining mod(REP,N) repetitions is then having a step size maximizing again the frequency diversity by using a step size of $\lceil N/\mathrm{mod}(REP,N) \rceil$.

In some embodiments it would be understood that the 'unused' or unselected resources define a third set of resources which can be associated with the first control channel, the EPDCCH. In other words the EPDCCH can be configured to use the 'third set of resources' (the difference between the first set of resources and the second set of resources).

Furthermore it would be understood that in some embodiments the selected or index mapped resources can be signalled using other signalling paths such as using radio resource control (RRC) protocols. This can be used for example to convey the information for the EPHICH resources but also for the EPDCCH resources.

The required data processing apparatus and functions of a control apparatus for the determinations and control of scheduling of transmission in subframes at a communication device, a base station and any other node or element may be provided by means of one or more data processors. The described functions may be provided by separate processors or by an integrated processor. The data processors may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), gate level circuits and processors based on multi core processor architecture, as non limiting examples. The data processing may be distributed across several data processing modules. A data processor may be provided by means of, for example, at least one chip. Appropriate memory capacity can also be provided in the relevant devices. The memory or memories may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory.

An appropriately adapted computer program code product or products may be used for implementing the embodiments, when loaded or otherwise provided on an appropriate data processing apparatus, for example for selection of appropriate PRB pairs for EPHICH transmission. The program code product for providing the operation may be stored on, provided and embodied by means of an appropriate carrier medium. An appropriate computer program can be embodied on a computer readable record medium. A possibility is to download the program code product via a data network. In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Embodiments of the inventions may thus be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

It is noted that whilst embodiments have been described in relation to LTE-Advanced, similar principles can be applied to any other communication system. Therefore, although certain embodiments were described above by way of example with reference to certain

exemplifying architectures for wireless networks, technologies and standards, embodiments may be applied to any other suitable forms of communication systems than those illustrated and described herein.

The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. For example, a combination of one or more of any of the other embodiments previously discussed can be provided. All such and similar modifications of the teachings of this invention will still fall within the scope of this invention as defined in the appended claims.

Claims:

1. A method for control channel distribution for wireless communications comprising:

defining a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal;

selecting from the first set of resources a second set of resources associated with a second control channel; and

using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

2. The method as claimed in claim 1, wherein the first control channel is an Enhanced Physical Downlink Control Channel (EPDCCH), the second control channel is an Enhanced Physical Hybrid Automatic Repeat Request Indicator Channel (EPHICH).

3. The method as claimed in claims 1 and 2, wherein the resources are physical resource block pairs (PRB).

4. The method as claimed in claims 1 to 3, wherein the first set of resources associated with the first control channel form a search space within which information on the first control channel is transmitted.

5. The method as claimed in claim 4, wherein the search space defines at least one of:

a common search space for the first control channel; and

a user specific search space for the first control channel.

6. The method as claimed in claims 1 to 5, wherein selecting from the first set of resources a second set of resources associated with a second control channel comprises selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions of the second control channel.

7. The method as claimed in claim 6, wherein selecting from the first set of resources the second set of resources which maximise the frequency diversity for a defined number of code block repetitions comprises selecting the second set of resources such that the second set of resources selected comprise the largest number of different physical resource blocks.

8. The method as claimed in claims 1 to 7, wherein selecting from the first set of resources a second set of resources associated with a second control channel comprises selecting the second set of resources such that a selected resource within the second set of resources is not adjacent to a further selected resource within the second set of resources.

9. The method as claimed in claims 1 to 8, wherein selecting from the first set of resources a second set of resources associated with a second control channel comprises selecting 12/SF resources, where SF is the spreading factor associated with the second control channel.

10. The method as claimed in claims 1 to 9, wherein selecting from the first set of resources a second set of resources associated with a second control channel comprises:

mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel.

11. The method as claimed in claim 10, wherein mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel comprises:

determining a number (N) of resources in the first control channel set (70);

determining a number (REP) of repetitions per resource (71); and

generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, REP) + REP^2 \cdot \left\lfloor \frac{g}{REP} \right\rfloor + REP \cdot [0,1,\ldots, REP-1], N \right),$$

$\lfloor \rfloor$ is the floor operation, and mod is the modulo operation (72).

12. The method as claimed in claims 10 to 11, wherein mapping at least one of the resources from the set of resources associated with the first control channel to the set of resources associated with the second control channel comprises:

determining a number (N) of resources in the first control channel set (70);

determining a number (REP) of repetitions (71); and

generating a PRB pair index mapping for the second control channel based on the ratio of resources in the first control channel set to repetitions.

13. The method as claimed in claim 12, wherein generating an index mapping based on the ratio of resources in the first control channel set to repetitions comprises at least one of:

generating a PRB pair index mapping for the g'th group of the second control channel based on

$$EPHICH\_PRBs(g) = \mathrm{mod}\left(\mathrm{mod}(g, \lceil N/REP \rceil) + REP \cdot \left\lceil \frac{N}{REP} \right\rceil \cdot \left\lfloor \frac{g}{REP} \right\rfloor + \left\lceil \frac{N}{REP} \right\rceil \cdot [0,1,...,REP-1], N\right),$$

where N/REP>=2 (83);

generating a PRB pair index mapping for the g'th group of the second control channel based on

$EPHICH\_PRBs(g) = \mathrm{mod}(g \cdot REP + [0,1,...,REP-1], N)$, where N/REP<2 (84);

and

generating a PRB pair index mapping for the second control channel with a fixed step size of 1 for a first $\lfloor$REP/N$\rfloor$ *N repetitions and a larger step size for the remaining mod(REP,N) repetitions where N/REP<1.

14. The method as claimed in claims 1 to 13, further comprising:

embedding information about the selected second set of resources associated with a second control channel into a master information block of system information on a broadcast channel (41); and

transmitting the master information block of system information on the broadcast channel.

15. The method as claimed in claims 1 to 13, further comprising transmitting information about the selected second set of resources associated with a second control channel using a radio resource control protocol.

16. The method as claimed in claim 15, further comprising transmitting information about the first set of resources associated with the first control channel using the radio resource control protocol.

17. The method as claimed in claims 1 to 16, further comprising defining a third set of resources associated with the first control channel, the third set of resources being the difference between the first set of resources and the second set of resources.

18. A method comprising:

receiving information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources;

receiving further information selecting from the first set of resources a second set of resources associated with a second control channel; and

using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

19. An apparatus (30) comprising at least one processor (32, 33) and at least one memory (31) including computer code for one or more programs, the at least one memory (31) and the computer code configured to with the at least one processor to cause the apparatus to at least:

define a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal;

select from the first set of resources a second set of resources associated with a second control channel; and

use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

20. An apparatus (20) comprising at least one processor (21, 23) and at least one memory (22) including computer code for one or more programs, the at least one memory (22) and the computer code configured to with the at least one processor to cause the apparatus to at least:

receive information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources;

receive further information selecting from the first set of resources a second set of resources associated with a second control channel; and

use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

21. An apparatus comprising:

means for defining a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal;

means for selecting from the first set of resources a second set of resources associated with a second control channel; and

means for using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

22. An apparatus comprising:

means for receiving information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources;

means for receiving further information selecting from the first set of resources a second set of resources associated with a second control channel; and

means for using the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

23. An apparatus comprising:

a first channel resource determiner configured to define a first set of resources associated with a first control channel, the first control channel first set of resources further associated with at least one demodulation reference signal;

a second channel resource determiner configured to select from the first set of resources a second set of resources associated with a second control channel; and

a demodulation reference definer configured to use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

24. An apparatus comprising:

a receiver configured to receive information defining a first set of resources associated with a first control channel, and at least one demodulation reference signal associated with the first control channel first set of resources; the receiver further configured to receive further information selecting from the first set of resources a second set of resources associated with a second control channel; and

a demodulator configured to use the at least one demodulation reference signal associated with the first set of resources for the selected second set of resources as the at least one demodulation reference signal associated with the second control channel.

FIG 1

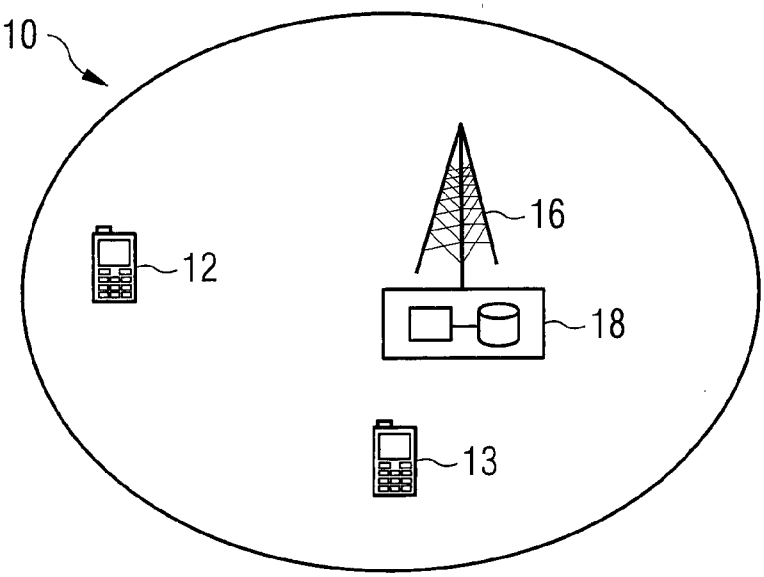


FIG 2

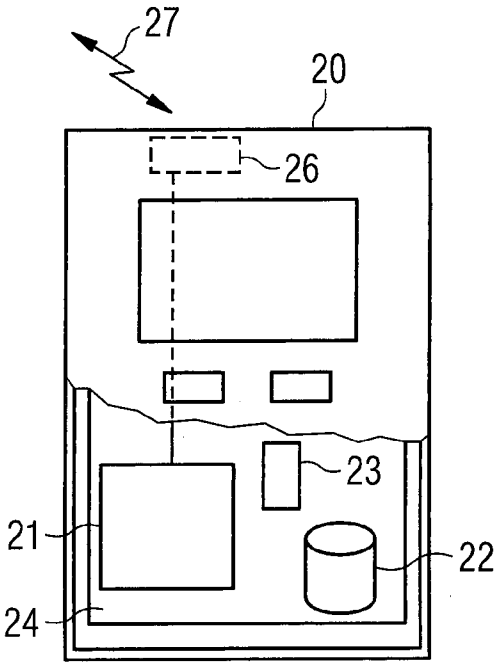


FIG 3

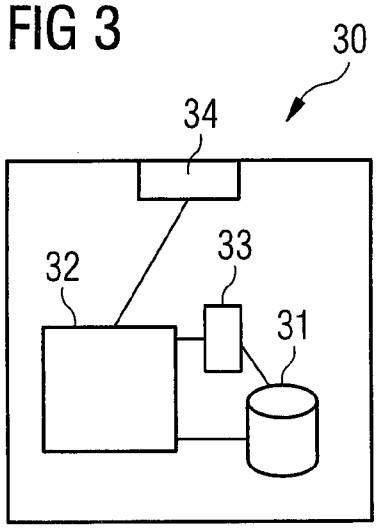

30
34
32
33
31

FIG 4

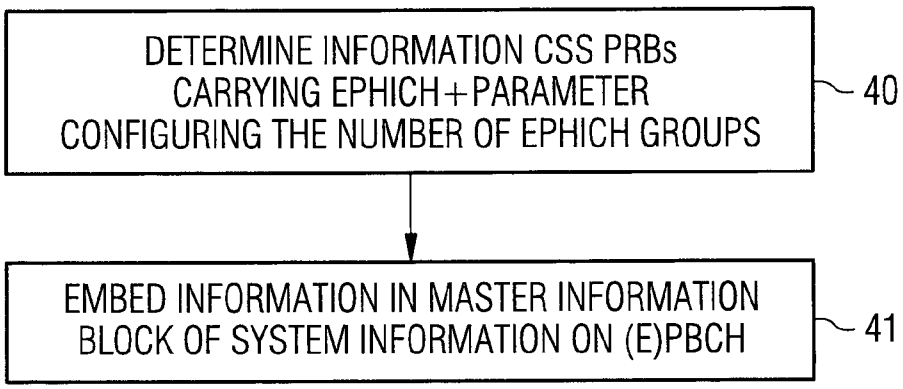

DETERMINE INFORMATION CSS PRBs CARRYING EPHICH+PARAMETER CONFIGURING THE NUMBER OF EPHICH GROUPS
40
EMBED INFORMATION IN MASTER INFORMATION BLOCK OF SYSTEM INFORMATION ON (E)PBCH
41

FIG 5

eREG to ECCE mapping for distributed EPDCCH set of a size of 8 PRB pairs according to TS 36.211 v11.01.

Left: N_{ECCE}^{EREG} =4 eREGS per ECCE. Right: N_{ECCE}^{EREG} =8 eREGS per ECCE.

N_{ECCE}^{EREG} =4, 8 PRB pairs

eREG	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PRB0	0	8	16	24	6	14	22	30	4	12	20	28	2	10	18	26
PRB1	1	9	17	25	7	15	23	31	5	13	21	29	3	11	19	27
PRB2	2	10	18	26	0	8	16	24	6	14	22	30	4	12	20	28
PRB3	3	11	19	27	1	9	17	25	7	15	23	31	5	13	21	29
PRB4	4	12	20	28	2	10	18	26	0	8	16	24	6	14	22	30
PRB5	5	13	21	29	3	11	19	27	1	9	17	25	7	15	23	31
PRB6	6	14	22	30	4	12	20	28	2	10	18	26	0	8	16	24
PRB7	7	15	23	31	5	13	21	29	3	11	19	27	1	9	17	25

745 PRB1 ECCE10 701 745 745

N_{ECCE}^{EREG} =8, 8 PRB pairs

eREG	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PRB0	0	8	7	15	6	14	5	13	4	12	3	11	2	10	1	9
PRB1	1	9	0	8	7	15	6	14	5	13	4	12	3	11	2	10
PRB2	2	10	1	9	0	8	7	15	6	14	5	13	4	12	3	11
PRB3	3	11	2	10	1	9	0	8	7	15	6	14	5	13	4	12
PRB4	4	12	3	11	2	10	1	9	0	8	7	15	6	14	5	13
PRB5	5	13	4	12	3	11	2	10	1	9	0	8	7	15	6	14
PRB6	6	14	5	13	4	12	3	11	2	10	1	9	0	8	7	15
PRB7	7	15	6	14	5	13	4	12	3	11	2	10	1	9	0	8

715 715 715 715 701 ECCE10 715

FIG 6

Exemplary PRB mapping pattern for EPHICH groups (8 PRB pairs).

	PHICH group					
PRB0	0	6	4	2	0	6
PRB1	1	7	5	3	1	7
PRB2	2	0	6	4	2	0
PRB3	3	1	7	5	3	1
PRB4	4	2	0	6	4	2
PRB5	5	3	1	7	5	3
PRB6	6	4	2	0	6	4
PRB7	7	5	3	1	7	5

601

FIG 7

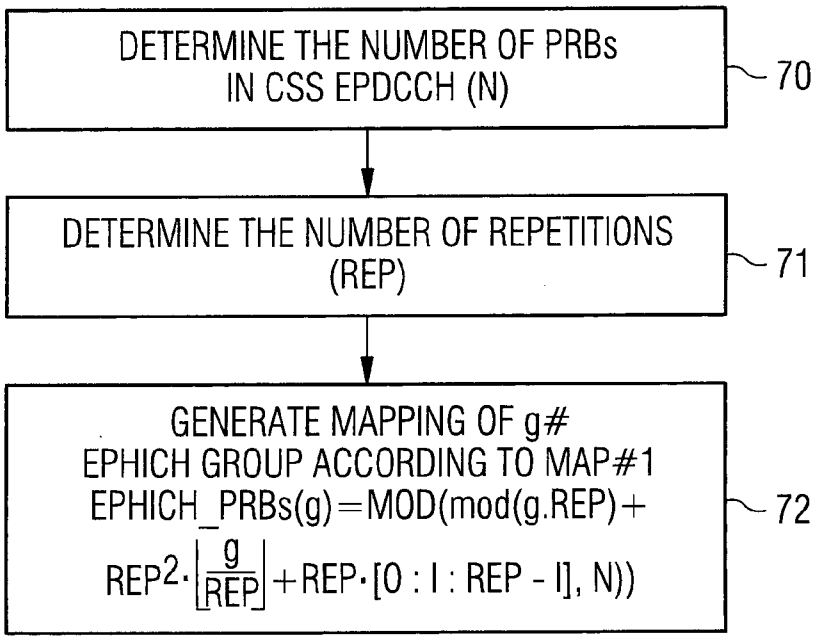


FIG 8

Exemplary PRB mapping pattern for 8, 4 and 2 PRB pairs.

EPHICH group									
PRB0	0	2	4	6	11	13	15	20	22
PRB1	1	3	5	7	9	14	16	18	23
PRB2	2	4	6	8	10	12	17	19	21
PRB3	0	5	7	9	11	13	15	20	22
PRB4	1	3	8	10	12	14	16	18	23
PRB5	2	4	6	11	13	15	17	19	21
PRB6	0	5	7	9	14	16	18	20	22
PRB7	1	3	8	10	12	17	19	21	23

808

PRB0	0	1	2	3	4	7	5	9	10
PRB1	1	2	3	4	5	5	6	10	8
PRB2	2	0	4	5	5	6	7	8	9
PRB3	0	1	5	3	6	7	8	9	10

804

PRB0	0	2	1	0	2	4	3	5	4
PRB1	1	0	2	1	3	5	4	3	5

802

801

FIG 9

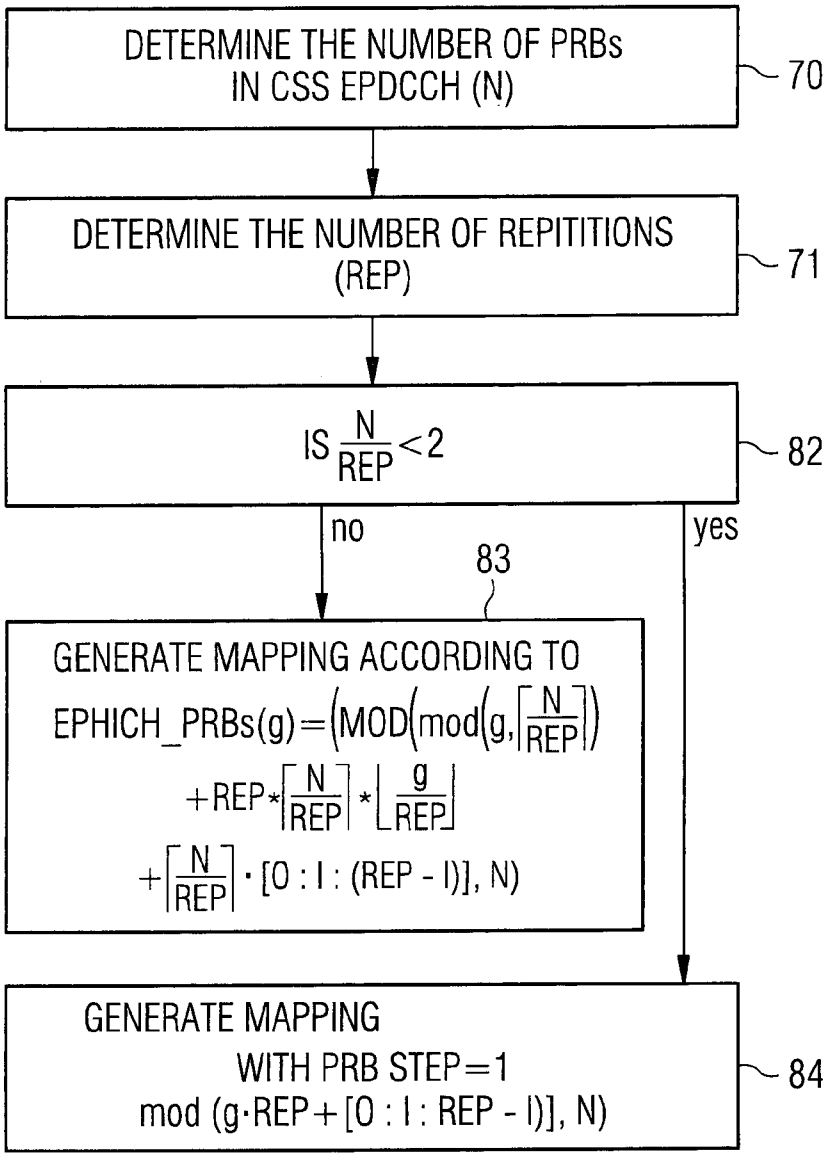
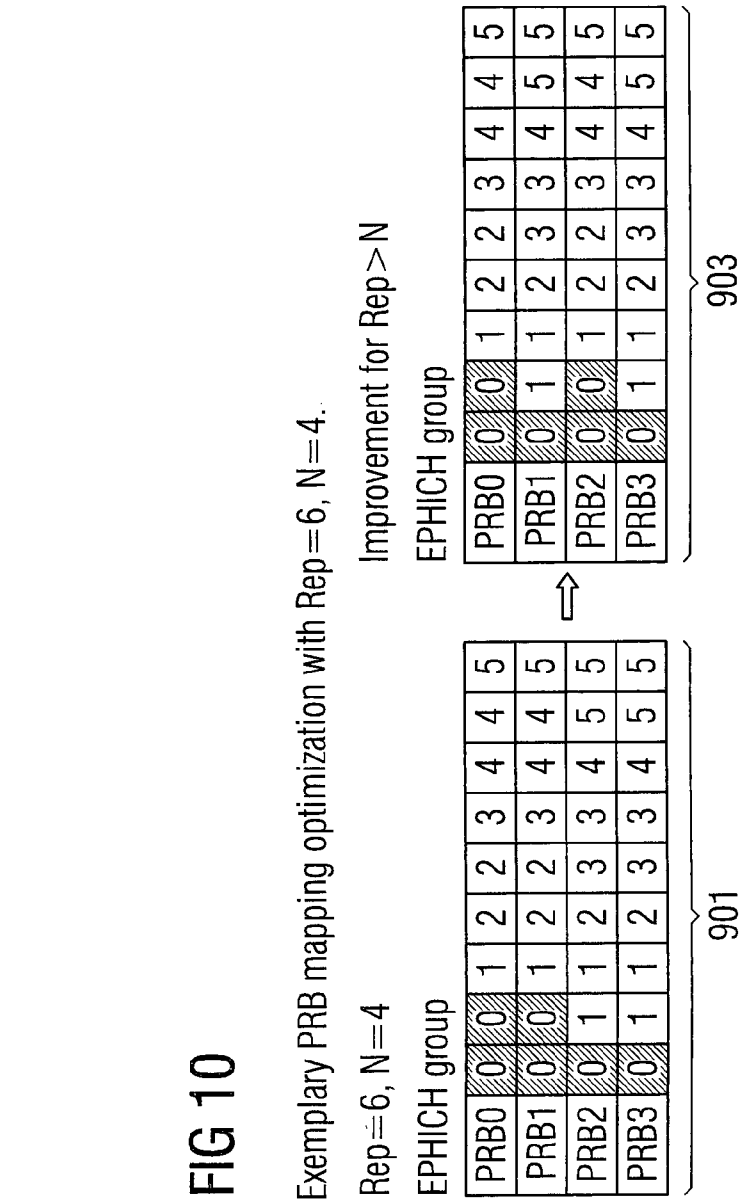

DETERMINE THE NUMBER OF PRBs IN CSS EPDCCH (N)
70
DETERMINE THE NUMBER OF REPITITIONS (REP)
71
IS $\frac{N}{REP} < 2$
82
no
yes
83
GENERATE MAPPING ACCORDING TO
$EPHICH\_PRBs(g) = \left(MOD\left(mod\left(g, \left\lceil \frac{N}{REP} \right\rceil\right)\right.\right.$
$+ REP * \left\lceil \frac{N}{REP} \right\rceil * \left\lfloor \frac{g}{REP} \right\rfloor$
$+ \left\lceil \frac{N}{REP} \right\rceil \cdot [0 : 1 : (REP - 1)], N)$
GENERATE MAPPING
WITH PRB STEP=1
mod (g·REP+[0 : 1 : REP - 1)], N)
84

FIG 10


Exemplary PRB mapping optimization with Rep=6, N=4.
Rep=6, N=4
EPHICH group
PRB0 0 0 1 2 2 3 4 4 5
PRB1 0 0 1 2 2 3 4 4 5
PRB2 0 1 1 2 3 3 4 5 5
PRB3 0 1 1 2 3 3 4 5 5
901
Improvement for Rep>N
EPHICH group
PRB0 0 0 1 2 2 3 4 4 5
PRB1 0 1 1 2 3 3 4 5 5
PRB2 0 0 1 2 2 3 4 4 5
PRB3 0 1 1 2 3 3 4 5 5
903

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/052870

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/08 H04L5/00
ADD. H04W72/02

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W H04L

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/019960 A2 (RESEARCH IN MOTION LTD [CA]; RESEARCH IN MOTION CORP [US]; SONG YI [US) 17 February 2011 (2011-02-17) the whole document	1,18-24
A	US 2012/008556 A1 (NOH MINSEOK [KR] ET AL) 12 January 2012 (2012-01-12) the whole document	1,18-24
A	US 2013/034070 A1 (SEO HAN BYUL [KR] ET AL) 7 February 2013 (2013-02-07) the whole document	1,18-24
A	EP 2 448 143 A2 (LG ELECTRONICS INC [KR]) 2 May 2012 (2012-05-02) the whole document	1,18-24

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 December 2013	18/12/2013

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

2

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SAMSUNG: "ePHICH design for Rel-11", 3GPP DRAFT; R1-122258 EPHICH DESIGN FINAL, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Prague, Czech Republic; 20120521 - 20120525, 12 May 2012 (2012-05-12), XP050600521, [retrieved on 2012-05-12] the whole document --- ERICSSON ET AL: "Reference signals for enhanced control channels", 3GPP DRAFT; R1-113678, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. San Francisco; 20111114 - 20111118, 8 November 2011 (2011-11-08), XP050561814, [retrieved on 2011-11-08] the whole document ---	1,18-24 1,18-24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2013/052870

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