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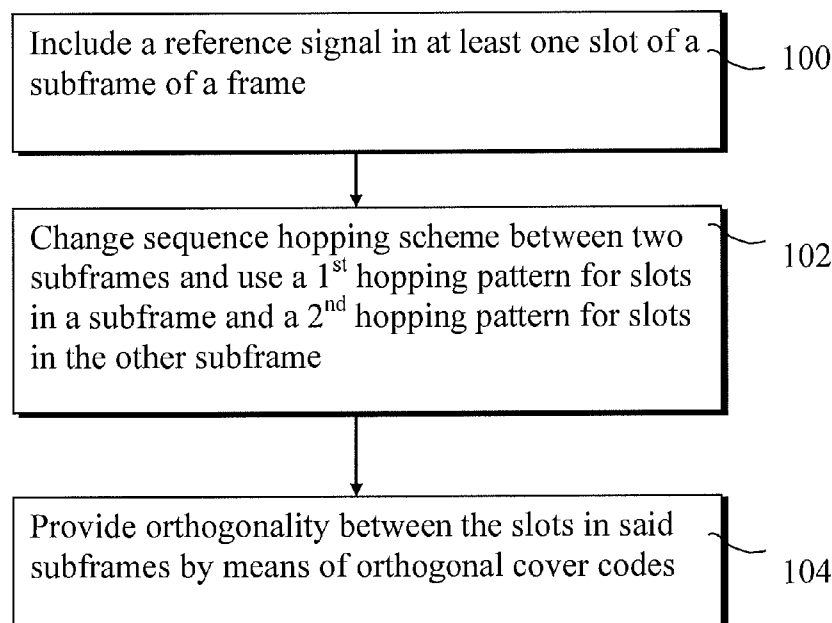
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(54) Title: SEQUENCE HOPPING IN A COMMUNICATION SYSTEM



(57) Abstract: A method and apparatus for communication of signals in a slotted communication system is disclosed. The slots are arranged into subframes of frames such that each subframe comprises at least two slots. A reference signal can be included in at least one slot of a subframe. A sequence hopping scheme is changed between at least two subframes such that a first hopping pattern is used for slots in the earlier subframe and a second hopping pattern is used for slots in the latter subframe of said at least two subframes. Orthogonal cover codes are used between the slots in said subframes.

Fig. 5

### Sequence hopping in a communication system

The invention relates to sequence hopping, and more particularly but not  
5 exclusively to sequence hopping in communication of demodulation reference  
signals in a system where communications may occur via multiple input multiple  
output antennae.

A communication system can be seen as a facility that enables communication  
10 sessions between two or more entities such as mobile communication devices,  
base stations and/or other communication points. 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. For example,  
15 the standards, specifications and protocols can define the manner how and  
based on which access technology communication devices can access the  
communication system and how communication shall be implemented between  
communicating devices, the elements of a communication network and/or other  
communication devices. In a wireless communication system at least a part of  
20 the communication between at least two 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, and are therefore is often referred to as  
25 a cellular system.

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  
30 appropriate signal receiving and transmitting arrangement for enabling  
communications with other parties. Typically a communication device is used for  
enabling the users thereof to receive and transmit communications such as  
speech and data. In wireless systems a communication devices provides a

transceiver station that can communicate with e.g. a base station of an access network providing at least one cell and/or another communications device. Depending on the context, a communication device may also be considered as being a part of a communication system. In certain applications, for example in  
5    ad hoc networks, the communication system can be based on use of a plurality of user equipment capable of communicating with each other.

An example of communications systems is an architecture that is being standardized by the 3<sup>rd</sup> Generation Partnership Project (3GPP) and is known as  
10    the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. The LTE technology aims to achieve various improvements, for example reduced latency, higher user data rates, improved system capacity and coverage, reduced cost for the operator and so on. A further development of the LTE is often referred to as LTE-Advanced. The  
15    various development stages of the 3GPP LTE specifications are referred to as releases. Backward compatibility of later versions for a standard with earlier versions of the standard is typically desired. For this reason, backward-compatibility of later versions with the existing LTE compatible devices and stations would be desired. Thus for example a release 8 compatible  
20    communication device should be able to work in a radio network that is configured in accordance with later releases and vice versa.

Transmission of signals by communicating entities is known to interfere with other communications links. Thermal noise may also degrade the performance.  
25    Coherent detection of data signals can be utilized to mitigate the effect of interference and to provide more efficient transmission. In coherent detection, the carrier phase of the received signal is detected at the receiver. It is common to add a reference signal to a payload signal so that the signal may be received coherently at a receiver. For example, constant amplitude zero autocorrelation  
30    waveform (CAZAC) sequences can be used as reference signals. Other sequences may also be used, such as computer searched Zero-Autocorrelation (ZAC) sequences. The base station needs some source of known data symbols to facilitate the coherent detection. For example, in LTE uplink, reference signals

can be used as demodulation reference signals (DM RS) on physical uplink control channels (PUCCH) and physical uplink shared channels (PUSCH). Demodulation reference signals can be used for channel estimation needed for coherent detection and demodulation. Demodulation reference signal typically  
5 has the same bandwidth as the uplink data transmission. There is typically one demodulation reference signal in every 0.5 ms slot on PUSCH, whereas on PUCCH there are two to three reference signals per slot depending on the used PUCCH format.

10 Cyclic shifts can be used to multiplex reference signals from different user equipments within a cell, whereas different sequence groups can be used in neighbouring cells. Different hopping methods can be used to randomize inter-cell interference for reference signals. The pseudorandom hopping patterns can be cell specific and can be derived from the physical layer cell identity. For  
15 example, the LTE supports for PUSCH and PUCCH sequence group hopping and sequence hopping. Sequence group hopping or sequence hopping can be disabled, thus facilitating sequence planning.

Sequence group hopping pattern is composed of a group of hopping patterns  
20 and a sequence shift. The same group hopping pattern can be applied to a cluster of 30 cells. To differentiate cells within a cluster, a cell specific sequence shift can be added on top of the group hopping pattern. With this arrangement, the occasional use of the same sequence group simultaneously on neighbouring cells can be avoided within the cell cluster. Sequence groups hop for every slot,  
25 i.e. every 0.5 ms.

Sequence hopping in turn means hopping between two sequences within a sequence group. Sequence hopping can be applied for resource allocation larger than five resource blocks if sequence group hopping is disabled and sequence  
30 hopping is enabled.

It is possible to configure cyclic shift hopping and sequence group hopping patterns so that the same patterns are used on neighbouring cells. Thus same

sequence group can be used on neighbouring cells. Use of an orthogonal cover code applied over two symbols, for example DM RS single carrier frequency division multiple access (SC-FDMA) symbols, in a subframe is considered as a feasible complementary DM RS multiplexing scheme. Orthogonal cover codes have been proposed to be used between the DM RS of the two slots within the subframe to provide a possibility to multiplex users with different bandwidths. Orthogonal cover codes can be Walsh codes of length-2, i.e. [1, 1] and [1, -1]. In the case of sequence hopping and sequence group hopping, DM RS sequence used in the cell changes from slot to slot and the orthogonal cover code does not remain orthogonal between DM RS with different bandwidths. If multiplexed DM RS have different bandwidth, orthogonal cover code (OCC) remains orthogonal if the same DM RS sequences are used on both slots. However, although this can work with sequence planning, it does not necessarily provide satisfactory results if sequence hopping and/or sequence group hopping are used.

15

Due to the requirement of backwards compatibility any solution for later releases should take LTE release 8 compatible equipment also into account. In particular, the frequency of DM RS sequence group collisions between neighbouring cells should be minimized. In LTE release 8 and release 9 it can be guaranteed, if so configured, that the same DM RS sequence group is not used simultaneously in cells sharing the same group hopping pattern. Such cells have the same  $\left\lfloor \frac{N_{ID}^{cell}}{30} \right\rfloor$

20

value, and can be referred to as a cell group. It is noted that although the term cell group is used in this description to denote this feature, other terms may be used for the same feature elsewhere.

25

Systems where demodulation reference signal multiplexing is based on cyclic shifts can have some limitations. For example, the orthogonality can become degraded with a large number of simultaneous cyclic shifts in respect to channel delay spread. Also, orthogonality may be achieved only if the reference signals have the same sequence, bandwidth and frequency position. This can be relevant for example in multi-user multiple input multiple output (MU-MIMO) pairing because of potential for causing scheduling restrictions.

30

It is noted that the above discusses only examples, and the issues are not limited to any particular communication environment, standard, specification and so forth, but may occur in any appropriate communication system where  
5 communications to multiple points may take place.

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

In accordance with an embodiment there is provided a method for  
10 communication of signals in a slotted communication system where slots are arranged into subframes of frames such that each subframe comprises at least two slots, the method comprising using a reference signal in at least one slot of a subframe, changing a sequence hopping scheme between at least two subframes such that a first hopping pattern is used for slots in the earlier  
15 subframe and a second hopping pattern is used for slots in the latter subframe of said at least two subframes, and using orthogonal cover codes between the slots in said subframes.

In accordance with another embodiment there is provided a control apparatus for  
20 controlling communication of signals in a slotted communication system where slots are arranged into subframes of frames such that each subframe comprises at least two slots, the control apparatus comprising at least one processor, and at least one memory including computer program code, wherein the at least one memory and the computer program code are configured, with the at least one  
25 processor, to control communications of a reference signal in at least one slot of a subframe, to control changing of a sequence hopping scheme between at least two subframes such that a first hopping pattern is used for slots in the earlier subframe and a second hopping pattern is used for slots in the latter subframe of said at least two subframes, and to use orthogonal cover codes between the  
30 slots in said subframes.

In accordance with a more detailed embodiment the change in the sequence hopping scheme comprises change in a sequence group hopping pattern.

A hopping offset can be used in certain embodiments. The hopping offset can be changed between subframes. A hopping offset can be used for all cells sharing a hopping pattern.

5

A sequence group can be defined for a subframe based on a sequence group used for a first slot of the subframe and a sequence group for another subframe can be defined based on a sequence group used for the second slot of the other subframe. The sequence groups of the first slot and the second slot can be  
10 based on sequence group hopping in accordance with 3GPP LTE release 8.

The change in the sequence hopping scheme can comprise change in a sequence hopping pattern.

15 The signals can comprise reference signals in a multiple input multiple output communication system. The reference signals can comprise demodulation reference signals.

In accordance with an embodiment the minimum interval for changing the  
20 hopping pattern is one millisecond. The hopping pattern can be changed once in a frame. The sequence group of a slot of a subframe can be used for each slot of the subframe. Two different hopping patterns can be used in a cell.

In accordance with an embodiment a sequence group is defined from a hopping  
25 pattern for a cell group.

A variable can be used for selecting a sequence group. The variable can be a pseudo-random variable. According to an alternative the variable has been defined deterministically.

30

A communication device and/or base station comprising a control apparatus configured to provide at least one of the embodiments can also be provided. The communication device may comprise a mobile user equipment.

A computer program comprising program code means adapted to perform the herein described methods may also be provided. In accordance with further embodiments apparatus and/or computer program product that can be embodied on a computer readable medium for providing at least one of the above methods is provided.

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

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

- Figure 1 shows an example of a communication system wherein below described examples of the invention may be implemented;
- Figure 2 shows an example of a communication device;
- Figure 3 shows an example of controller apparatus for a base station;
- Figure 4 shows a MIMO arrangement;
- Figure 5 is a flowchart illustrating an embodiment;
- Figures 6A, 6B, 7A, 7B, 8A, and 8B show examples for hopping patterns.

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 and 2 to assist in understanding the technology underlying the described examples.

A communication device 1 can be used for accessing various services and/or applications provided via a communication system. The 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  
5 may also be provided broadcast or multicast data. Non-limiting examples of the content include downloads, television and radio programs, videos, advertisements, various alerts and other information.

A mobile communication device 1 is typically provided wireless access via at  
10 least one base station 12 or similar wireless transmitter and/or receiver node of an access system. In figure 1 three access systems 16, 17 and 18 are shown. However, it is noted that instead of three access systems, any number of access systems may be provided in a communication system. An access system may be provided by a cell of a cellular system or another system enabling a  
15 communication device to access a communication system. A base station site 12 can provide one or more cells of the plurality of cells of a cellular communication system. A base station can be configured to provide a cell, but a base station can also provide, for example, three sectors, each sector providing a cell. Each mobile communication device 1 and base station 12 may have one or  
20 more radio channels open at the same time and may send signals to and/or receive signals from more than one source.

A base station 12 is typically controlled by at least one appropriate controller so as to enable operation thereof and management of mobile communication  
25 devices 1 in communication with the base station. The control apparatus can be interconnected with other control entities. In Figure 1 a controller apparatus is shown to be provided by block 13. A base station control apparatus is typically provided with memory capacity 15 and at least one data processor 14. It shall be understood that the control apparatus and functions may be distributed between  
30 a plurality of control units.

The cell borders or edges are schematically shown for illustration purposes only by the dashed lines in Figure 1. It shall be understood that the sizes and shapes

of the cells may vary considerably from the similarly sized circles of Figure 1. The cell areas typically overlap. Thus signals transmitted in a cell can interfere with communications in another cell.

- 5 The communication devices 1 can access the communication system based on various access techniques, such as code division multiple access (CDMA), or wideband CDMA (WCDMA). Other examples include time division multiple access (TDMA), frequency division multiple access (FDMA) and various schemes thereof such as the interleaved frequency division multiple access  
10 (IFDMA), single carrier frequency division multiple access (SC-FDMA) and orthogonal frequency division multiple access (OFDMA), space division multiple access (SDMA) and so on.

A non-limiting example of the recent developments in communication systems is  
15 the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) that is being standardized by the 3<sup>rd</sup> Generation Partnership Project (3GPP). As explained above, further development of the LTE is referred to as LTE-Advanced. Non-limiting examples of appropriate access nodes are a base station of a cellular system, for example what is known as NodeB (NB) in  
20 the vocabulary of the 3GPP specifications. The LTE employs a mobile architecture known as the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). Base stations of such systems are known as evolved Node Bs (eNBs) and may provide E-UTRAN features such as user plane Radio Link Control/Medium Access Control/Physical layer protocol (RLC/MAC/PHY) and  
25 control plane Radio Resource Control (RRC) protocol terminations towards the user devices. 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).

30

In Figure 1 example the base stations of the access systems are connected to a wider communications network 20. A controller 21 may be provided in the network 20 for coordinating the operation of the access systems. Although not

shown, a gateway function may also be provided to connect to another network via the network 20. The other network may be any appropriate network, for example another communication network, a packet data network and so on. A wider communication system may thus be provided by one or more interconnect  
5 networks and the elements thereof, and one or more gateways may be provided for interconnecting various networks.

Figure 2 shows a schematic, partially sectioned view of a communication device 1 that a user can use for communication with a communication system. Such a  
10 communication device is often referred to as user equipment (UE). 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  
15 interface facility, personal data assistant (PDA) provided with wireless communication capabilities, or any combinations of these or the like. A wireless mobile communication device is often referred to as a user equipment (UE). A mobile communication device may be used for voice and video calls, for accessing service applications and so on. The mobile device 1 may receive  
20 signals over an air interface 11 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 a transceiver is designated schematically by block 7. The transceiver may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally  
25 to the mobile device.

A mobile device is also typically provided with at least one data processing entity 3, at least one memory 4 and other possible components 9 for use in software aided execution of tasks it is designed to perform, including control of access to  
30 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 6.

The user may control the operation of the mobile device by means of a suitable user interface such as key pad 2, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 5, a speaker and a microphone are also typically provided. Furthermore, a mobile communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

Figure 3 shows an example of a control apparatus 30 for a communication system, for example to be coupled to and/or for controlling a station of an access system. The control apparatus 30 can be arranged to provide control on communications by mobile communication devices that are in the area of the system. The control apparatus 30 can be configured to facilitate use of hopping patterns as 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 30 can be configured to execute an appropriate software code to provide the control functions as explained below in more detail.

A way to extend usability of orthogonal cover code (OCC) in demodulation reference signal (DM RS) orthogonalisation is described in the following non-limiting exemplifying embodiments. The embodiments are described with reference to 3GPP LTE, and more particularly with reference to LTE releases 8, 9 and 10 in the context of LTE release 10 compatible Multiple Input / Multiple Output (MIMO) system and uplink (UL) multiple antenna transmissions.

Multiple Input / Multiple Output (MIMO) systems as such are known. MIMO systems use multiple antennas at the transmitter and receiver (of e.g. base stations) along with advanced digital signal processing to improve link quality and capacity. Multi-user MIMO enhances the communication capabilities of individual stations by using multiple independent stations, antennas or other transmitting

and/or receiving elements. More data can be received and/or sent where there are more antennae elements. A base station may comprise an array of multiple antennae. The antennae can be arranged to cover transmission and reception in a plurality of sectors. MIMO can be employed in any system where  
5 communications between multiple points of communication is provided.

Figure 4 shows an example of multi-user multiple input multiple output (MU-MIMO). In Figure 4 MU-MIMO arrangement is provided by means of the plurality of antennas 41, 42 of eNode B (eNB) 40. A user equipment can communicate  
10 with more than one of the antennas, as illustrated by the arrows between user equipments UE1 and UE2 the eNode B 40. The eNB and the user equipment can communicate via a various different channels, PDCCH and PUSCH being shown in Figure 4. The user equipments can be paired for the MU-MIMO. A non-limiting example of access techniques that can be used to facilitate MU-MIMO is space-  
15 division multiple access (SDMA) which allows a communication device to transmit and/or receive signal to and/or from multiple users in the same band simultaneously. Multi-user MIMO can thus leverage multiple users as spatially distributed transmission resources.

20 To support single-user multiple input multiple output (SU-MIMO) or multi-user MIMO (MU-MIMO), each spatial layer requires its own orthogonal demodulation reference signal (DM RS). In 3GPP LTE release 8, orthogonal cyclic shifts of demodulation reference signal base sequence are used for orthogonalization of the orthogonal demodulation reference signals. Cyclic shifts, however, can have  
25 some inherent limitations. For example, orthogonality can become degraded if a large number of simultaneous cyclic shifts take place in respect to channel delay spread. This can be relevant for example in high rank MIMO transmissions, in particular SU-MIMO. Also, orthogonality may be achieved only if orthogonal demodulation reference signals have the same sequence, bandwidth and  
30 frequency position. This can become relevant for example in view of MU-MIMO pairing because of the possibility of causing scheduling restrictions.

The below described embodiments provide a demodulation reference signal (DM RS) sequence group hopping pattern and/or a sequence hopping pattern. Both patterns can be used with multi user multiple input multiple output (MU-MIMO) and/or single-user multiple input multiple output (SU-MIMO) systems where  
5 demodulation reference signal (DM RS) orthogonality is provided by means of an orthogonal cover code (OCC). Certain embodiments provide backward compatibility of 3GPP release 10 and later system with 3GPP LTE release 8 and 9 compatible user equipment.

10 An embodiment for communication of signals in a slotted communication system is shown in the flowchart of Figure 5. The slots are arranged into subframes of frames such that each subframe comprises at least two slots. In accordance with the method a reference signal is included in at least one slot of a subframe at 100. A sequence hopping scheme can be changed between at least two  
15 subframes of a frame at 102 such that a first hopping pattern is used for slots in the earlier subframe and a second hopping pattern is used for slots in the latter subframe of said at least two subframes. Orthogonal cover codes are used at 104 between the slots in said subframes to provide orthogonality. The transmitting and receiving apparatus can process the communications  
20 accordingly.

Certain examples for different group hopping patterns are shown in Figures 6 to 8. A radio frame can be divided into subframes, and the 10 ms 3GPP LTE radio frame 60 of Figures 6 to 8 can be considered as being divided into ten one  
25 millisecond long subframes 62. The length of the frame 60 can be considered as the length of a hopping period. Each subframe in turn comprises two half a millisecond slots, Figures 6 to 8 showing slots #0 to #19. In Figures 6A, 7A and 8A the hopping sequences follow the definitions of LTE release 8, i.e. the sequences change per each slot.

30

Figure 6A shows LTE release 8 / 9 group hopping pattern for five cells and Figure 6B shows a group hopping patterns for five cells in similar environment in accordance with an embodiment. In the embodiment shown in Figure 6B the LTE

release 8 / 9 base sequence for the second slot of a subframe is used as a base sequence for the entire subframe and the hopping sequence changes only between the subframes. That is, in the example slots #0 and #1 use hopping sequence of LTE release 8 / 9 slot #1, slots #2 and #3 use the hopping pattern of  
5 LTE release 8 / 9 slot #3, and so forth.

Figures 7B and 8B, in turn, shown possible hopping patterns for a cell group consisting of thirty cell identities. It is noted that although the hopping pattern can change between each subframe, it is not necessary to change it after each  
10 subframe.

In accordance with an embodiment a hopping pattern can be provided such that demodulation reference signal (DM RS) sequence group changes at 1 ms rate. That is, the sequence group is changed from subframe to subframe. Similarly,  
15 the hopping sequence can be changed per subframe rather than per slot. This is different from e.g. LTE release 8 where the change takes place from slot to slot. Demodulation reference signal sequence or sequence group used for a subframe can be defined based on sequence or sequence group used either in first or in second slot of the relevant subframe. Thus, a first hopping pattern and a second  
20 hopping pattern can be defined, respectively. The sequence or sequence group hopping of the slot can be based on any appropriate definitions, for example the definitions of 3GPP LTE release 8 technical specification 36.211 v8.6.0, section 5.5.1.

25 For example according the definitions of 3GPP LTE release 8, a sequence group contains a demodulation reference signal (DM RS) base sequence for each possible number of physical resource blocks that can be allocated to a user equipment. It is also defined that in a sequence group, there is only one DM RS base sequence corresponding for each possible number of physical resource  
30 blocks (PRBs) less than six, and two DM RS base sequences corresponding for each possible number of PRBs more than five. Furthermore, according to the definitions of 3GPP LTE release 8, if parameter  $v$  corresponds to the number of available base sequences of a particular length within the group and  $v$  can be 0

or 1 for DM RS allocations greater than five PRBs, sequences corresponding to  $v = 0$  are used with sequence group hopping.

In accordance with an embodiment a sequence corresponding to a predefined  
5 base sequence can be used in the case of sequence group hopping and  
resource allocation for transmission arrangements where more than five physical  
resource blocks (PRBs) are used. For example, if there are two available base  
sequences ( $v = 0, 1$ ) for DM RS allocations greater than five PRBs, it can be defined  
that  $v=1$ . Similarly, if there are more available base sequences, a sequence other  
10 that the first available sequence is selected. In other words, base sequences that  
are not used in sequence group hopping according to the definitions of 3GPP LTE  
release 8 can be selected for use in the sequence group hopping according to  
the embodiment when more than one base sequence is available. This can be  
beneficial in certain situations for sequence group hopping as these sequences  
15 are not used in 3GPP LTE release 8 sequence group hopping and thus use of  
same sequence in neighboring cells within cell group can be avoided when  
allocating resources over five physical resource blocks.

Additionally, in the case of sequence group hopping, a new sequence group  
20 hopping offset can be introduced. This offset can change from subframe to  
subframe. The offset can be the same for all cells sharing the same sequence  
group hopping pattern. Possible offset parameters are explained later in  
connection with the detailed examples.

25 A sequence group for whole subframe can be made equal with a sequence  
group either in first slot or second slot of subframe. For example Figure 8B  
shows such a change between slots #9 and #10 of subsequent subframes. The  
dependency on either the first slot or second slot can be changed once or more  
during a ten millisecond frame. For example, a sequence group for a subframe  
30 may be defined by LTE release 8 sequence group used in first slot of that  
subframe during some subframes, and by LTE release 8 sequence group used in  
second slot of that subframe during the remaining subframes. Thus a cell group  
and subframe specific rule for defining sequence group from a hopping pattern



may be introduced. This can be used to reduce the number of slots where the same sequence group is used by a particular cell pair.

In accordance with an embodiment two different sequence group hopping /  
 5 sequence hopping patterns are provided in a cell. The used hopping pattern can be determined as a part of transmission mode configuration of a user equipment. According to a possibility the hopping pattern is determined as a part of higher layer demodulation reference signal configuration by introducing a specific parameter for hopping pattern. It is also possible to use dynamic signalling either  
 10 explicitly or implicitly by linking hopping pattern e.g. to explicit orthogonal cover code signalling. For example, Physical Downlink Control Channel (PDCCH) signalling may be used for this purpose. It is also possible that sequence group hopping / sequence hopping with for example 1 ms rate or a rate which is dependent on multiples of the subframes is made a default mode of operation. In  
 15 this case additional configuration signaling is not necessary.

In the following a more detailed examples for sequence group hopping are presented. Before explaining the example a brief explanation of group hopping and sequence hopping in accordance with 3GPP LTE release 8 is given to assist  
 20 in understanding the examples. In accordance with 3GPP LTE release 8 specification 36.211 V8.2.0 of March 2008, paragraph 5.5.1.3 the sequence-group number  $u$  in each slot  $n_s$  can be defined by a group hopping pattern  $f_{gh}(n_s)$  and a sequence-shift pattern  $f_{ss}$  according to

$$25 \quad u = (f_{gh}(n_s) + f_{ss}) \bmod 30$$

Seventeen different hopping patterns and thirty different sequence-shift patterns are available. PUCCH and PUSCH have the same group hopping pattern but may have different sequence-shift patterns. The group-hopping pattern  $f_{gh}(n_s)$  is  
 30 the same for PUSCH and PUCCH and is given by

$$f_{gh}(n_s) = \begin{cases} 0 & \text{if group hopping is disabled} \\ \left( \sum_{i=0}^7 c(8n_s + i) \cdot 2^i \right) \bmod 30 & \text{if group hopping is enabled} \end{cases}$$

where  $c(i)$  is a pseudo-random sequence.

5 The pseudo-random sequence generator for group hopping can be initialized with

$$c_{init} = \left\lfloor \frac{N_{ID}^{cell}}{30} \right\rfloor$$

at the beginning of each radio frame.

The sequence-shift pattern  $f_{ss}$  definition differs between PUCCH and PUSCH.

10 For PUCCH, the sequence-shift pattern  $f_{ss}^{PUCCH}$  is given by

$$f_{ss}^{PUCCH} = N_{ID}^{cell} \bmod 30.$$

For PUSCH, the sequence-shift pattern  $f_{ss}^{PUSCH}$  is given by

15 
$$f_{ss}^{PUSCH} = (f_{ss}^{PUCCH} + \Delta_{ss}) \bmod 30,$$

where  $\Delta_{ss} \in \{0, 1, \dots, 29\}$  is configured by higher layers.

In accordance with said 3GPP LTE release 8 specification 36.211, paragraph 5.5.1.4 sequence hopping only applies for reference-signals of length  $M_{sc}^{RS} \geq 6N_{sc}^{RB}$ .

20 For reference-signals of length  $M_{sc}^{RS} < 6N_{sc}^{RB}$ , the base sequence number  $v$  within the base sequence group is given by  $v = 0$ . For reference-signals of length  $M_{sc}^{RS} \geq 6N_{sc}^{RB}$ , the base sequence number  $v$  within the base sequence group in slot  $n_s$  is defined by

$$v = \begin{cases} c(n_s) & \text{if group hopping is disabled and sequence hopping is enabled} \\ 0 & \text{otherwise} \end{cases}$$

25 where  $c(i)$  is a pseudo-random sequence given.

Pseudo-random sequence generator for sequence hopping can be initialized with

$$c_{\text{init}} = \left\lfloor \frac{N_{\text{ID}}^{\text{cell}}}{30} \right\rfloor \cdot 2^5 + f_{\text{ss}}^{\text{PUSCH}}$$

at the beginning of each radio frame.

The sequence group hopping in accordance with an embodiment is defined by:

$$5 \quad u = (f_{\text{gh}}(n_s + 1) + f_{\text{ss}}) \bmod 30, \text{ if } n_s \text{ is even or zero}$$

$$u = (f_{\text{gh}}(n_s) + f_{\text{ss}}) \bmod 30, \text{ if } n_s \text{ is odd,}$$

where  $n_s$  is the slot,

$u$  is the sequence-group number in each slot  $n_s$

$f_{\text{gh}}(n_s)$  is the group-hopping pattern, and

$$10 \quad f_{\text{ss}} \text{ is the sequence-shift pattern.}$$

An additional sequence group offset,  $f_{\text{ss}2}$ , can be taken into account in the sequence group definition e.g. by:

$$15 \quad u = (f_{\text{gh}}(n_s + 1) + f_{\text{ss}} + f_{\text{ss}2}(n_s + 1)) \bmod 30, \text{ if } n_s \text{ is even or zero}$$

$$u = (f_{\text{gh}}(n_s) + f_{\text{ss}} + f_{\text{ss}2}(n_s)) \bmod 30, \text{ if } n_s \text{ is odd}$$

Additional time-varying sequence group offset may be a pseudo-random sequence or it may be a deterministic. However, it can be same for all cells sharing the same group hopping pattern, i.e., it may depend on physical cell ID and in particular in the form of the initialization parameter  $\left\lfloor \frac{N_{\text{ID}}^{\text{cell}}}{30} \right\rfloor$ . In the case of pseudo-random sequence, cell ID may be used in the sequence generator initialization.

25 The sequence group derivation from the 3GPP LTE release 8 hopping pattern can be defined in a subframe and cell dependent manner for example by:

$$u = (f_{\text{gh}}(n_s + \alpha) + f_{\text{ss}}) \bmod 30 \text{ if } n_s \text{ is even or zero}$$

$$u = (f_{\text{gh}}(n_s + \alpha - 1) + f_{\text{ss}}) \bmod 30 \text{ if } n_s \text{ is odd}$$

where  $\alpha$  is a variable used for selecting sequence group according to the LTE release 8 sequence group defined either for the first slot or the second slot of the subframe.

Variable  $\alpha$  can be pseudo-random or it can be defined in a deterministic way, for example:

$$\alpha = \left(1 + \lfloor n_s/10 \rfloor \left(1 + \lfloor N_{ID}^{cell}/30 \rfloor + \lfloor N_{ID}^{cell}/360 \rfloor\right)\right) \bmod 2$$

Sequence hopping can be defined e.g. by:

$$v = \begin{cases} c(n_s) & \text{if group hopping is disabled and sequence hopping is enabled} \\ 0 & \text{otherwise} \end{cases}$$

if  $n_s$  is even or zero

$$v = \begin{cases} c(n_s - 1) & \text{if group hopping is disabled and sequence hopping is enabled} \\ 0 & \text{otherwise} \end{cases}$$

if  $n_s$  is odd

15

It is recognised that some user equipment in an area may follow LTE release 8 hopping pattern and some user equipment may follow the above described hopping pattern. Thus it is possible that same sequence group may be used in neighbouring cells within a cell group in some subframes even when sequence group hopping is employed. More particularly, within a cell group, all 30 available sequence groups can be used in each slot. As mentioned above, the LTE release 8 hopping pattern changes from slot to slot whilst in the above described embodiments the hopping pattern changes from subframe to subframe, and thus the same sequence group may be allocated to different cells within a cell group.

20

However, as the cells are not likely to be neighbouring cells, this can be tolerated and no further functionality, such as use of cell identities is needed. If the purpose of group hopping is to simplify cell planning, it may not even be desirable to identify neighbouring cells based on cell identity. Nevertheless, the number of slots where the same sequence group may be used by a particular cell pair can be minimized.

30

In Figures 7A and 7B, sequence group collisions between release 8 and hopping patterns based on subframes are highlighted for cell ID 0. It can be noted that cell ID 0 in Figure 7B (subframe based hopping pattern) uses same sequence group as cell 22 of Figure 7A (LTE release 8 hopping pattern) in 3 slots out of 20 and twice with cell ID 5. Better randomization can be achieved if the same sequence group is used only once by a particular cell pair.

Optimization of time-varying sequence group offset can be provided by various means. For example, improved randomization can be obtained by using cell group and subframe varying relation to LTE release 8 hopping pattern for example such that a sequence group is used at maximum only twice by a particular cell pair with the exemplary calculation of  $\alpha$  given above. An example for the resulting hopping pattern is shown in Figure 8A and 8B. For cell ID 0, sequence group collisions occur now only twice with cell ID 22. This can be considered acceptable in various applications.

The required data processing apparatus and functions of a base station apparatus as well as appropriate communication devices 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 managing the sequence hopping and controlling communications between the various nodes and/or other control operations. 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.

The embodiments where sequence group or sequence can change per subframe can provide advantage for example because of the sequences can remain the same over a subframe. This in turn assist in that demodulation reference signal orthogonality can be achieved with orthogonal cover code (OCC) while sequence group hopping / sequence hopping is supported.

In certain embodiments the hopping pattern can follow the 3GPP LTE release 8 hopping pattern for the first or second slot in a subframe. For sequence group hopping thus can be beneficial as the hopping pattern can maintain the structure of LTE release 8 hopping pattern. That is, different demodulation reference signal (DM RS) sequence groups can be used within cell group having the same

$$\left\lfloor \frac{N_{ID}^{cell}}{30} \right\rfloor \text{ value.}$$

30

Same sequence group may also be used in neighbouring cells even within the cell group when some of the user equipments follow 3GPP LTE release 8

hopping pattern and some user equipments follow the hopping pattern proposed in here. However, by following partially release 8 hopping pattern, sequence group collisions can be avoided at least for every second slot.

- 5 In the case of sequence hopping, it should be noted that sequence hopping does not alter the sequence group allocated to a cell.

10 It is noted that whilst embodiments have been described in relation to communications system such as those based on the LTE and 3GPP based systems, similar principles can be applied to any other communication system where reference signals are used. Also, instead of communications between base station and communication devices the communications may be provided directly between two or more communication devices. For example, this may be the case in application where no fixed station equipment is provided but a  
15 communication system is provided by means of a plurality of user equipment, for example in adhoc networks. Also, the above described principle can also be used in networks where relay nodes are employed for relaying transmissions between other stations. Therefore, although certain embodiments were described above by way of example with reference to certain exemplifying architectures for  
20 wireless networks, technologies and standards, embodiments may be applied to any other suitable forms of communication systems than those illustrated and described herein.

25 It is also noted herein that while the above describes exemplifying embodiments of the invention, there are several variations and modifications which may be made to the disclosed solution without departing from the spirit and scope of the present invention.

## Claims

1. A method for communication of signals in a slotted communication system where slots are arranged into subframes of frames such that each subframe  
5 comprises at least two slots, comprising:
  - using a reference signal in at least one slot of a subframe;
  - changing a sequence hopping scheme between at least two subframes such that a first hopping pattern is used for slots in the earlier subframe and a second hopping pattern is used for slots in the latter subframe of said at least two  
10 subframes; and
    - using orthogonal cover codes between the slots in said subframes.
2. A method as claimed in claim 1, wherein the change in the sequence hopping scheme comprises change in a sequence group hopping pattern.  
15
3. A method as claimed in claim 1 or 2, comprising using a hopping offset.
4. A method as claimed in claim 3, comprising changing the hopping offset between subframes.  
20
5. A method as claimed in claim 2 or 3, comprising using the same hopping offset for all cells sharing a hopping pattern.
6. A method as claimed in any preceding claim, comprising:  
25
  - defining a sequence group for a subframe of the frame based on a sequence group used for a first slot of the subframe, and
    - defining a sequence group for another subframe of the frame based on a sequence group used for the second slot of the other subframe.
- 30 7. A method as claimed in claim 6, wherein the sequence groups of the first slot and the second slot are based on sequence group hopping in accordance with 3GPP LTE release 8.



8. A method as claimed in any preceding claim, wherein the change in the sequence hopping scheme comprises change in a sequence hopping pattern.
9. A method as claimed in any preceding claim, wherein communication  
5 signals comprises communication of reference signals in a multiple input multiple output communication system.
10. A method as claimed in any preceding claim, wherein the reference signals comprise demodulation reference signals.
- 10 11. A method as claimed in any preceding claim, wherein the minimum interval for changing the hopping pattern is one millisecond.
12. A method as claimed in any preceding claim, wherein the hopping pattern  
15 is changed once in a frame.
13. A method as claimed in any preceding claim, wherein the sequence group of a slot of a subframe is used for each slot of the subframe.
- 20 14. A method as claimed in any preceding claim, comprising using a predefined base sequence  $v$  of available base sequences 0 to  $n$  for sequence group hopping when the number of physical resource blocks is greater than five, the predefined base sequence  $v$  being selected from  $v = 1$  to  $n$ .
- 25 15. A method as claimed in any preceding claim, comprising using two different hopping patterns in a cell.
16. A method as claimed in any preceding claim comprising defining a sequence group from a hopping pattern for a cell group.
- 30 17. A method as claimed in any preceding claim, comprising using a variable for selecting a sequence group.

18. A method as claimed in claim 17, wherein the variable is a pseudo-random variable or a variable that has been defined deterministically.

19. A control apparatus for controlling communication of signals in a slotted  
5 communication system where slots are arranged into subframes of frames such  
that each subframe comprises at least two slots, the control apparatus  
comprising at least one processor, and at least one memory including computer  
program code, wherein the at least one memory and the computer program  
code are configured, with the at least one processor, to  
10 control communications of a reference signal in at least one slot of a  
subframe,  
control changing of a sequence hopping scheme between at least two  
subframes such that a first hopping pattern is used for slots in the earlier  
subframe and a second hopping pattern is used for slots in the latter subframe of  
15 said at least two subframes, and  
use orthogonal cover codes between the slots in said subframes.

20. A control apparatus as claimed in claim 19, configured to process a change  
in a sequence group hopping pattern.

20

21. A control apparatus as claimed in claim 19 or 20, configured to use a  
hopping offset.

22. A control apparatus as claimed in claim 21, configured to change the  
25 hopping offset between subframes.

23. A control apparatus as claimed in claim 21 or 22, configured to use a  
hopping offset for all cells sharing a hopping pattern.

30 24. A control apparatus as claimed in any of claims 19 to 23, configured to  
define a sequence group for a subframe of the frame based on a sequence  
group used for a first slot of the subframe and to define a sequence group for

another subframe of the frame based on a sequence group used for the second slot of the other subframe.

25. A control apparatus as claimed in any of claims 19 to 24, wherein the  
5 change in the sequence hopping scheme comprises change in a sequence hopping pattern.

26. A control apparatus as claimed in any of claims 19 to 25, configured to  
10 control communication of reference signals in a multiple input multiple output communication system.

27. A control apparatus as claimed in any of claims 19 to 26, wherein the reference signals comprise demodulation reference signals.

15 28. A control apparatus as claimed in any of claims 19 to 27, configured to use the sequence group of a slot of a subframe for each slot of the subframe.

29. A communication device comprising a control apparatus in accordance with  
20 any of claims 19 to 28.

30. A communication device as claimed in claim 29, comprising a mobile user equipment.

31. A base station apparatus comprising a comprising a control apparatus in  
25 accordance with any of claims 19 to 28.

32. A computer program comprising program code means adapted to perform  
the steps of any of claims 1 to 18 when the program is run on a data processing  
30 apparatus.

33. A communication system comprising a control apparatus, a communication device and/or base station in accordance with any of claims 19 to 31.

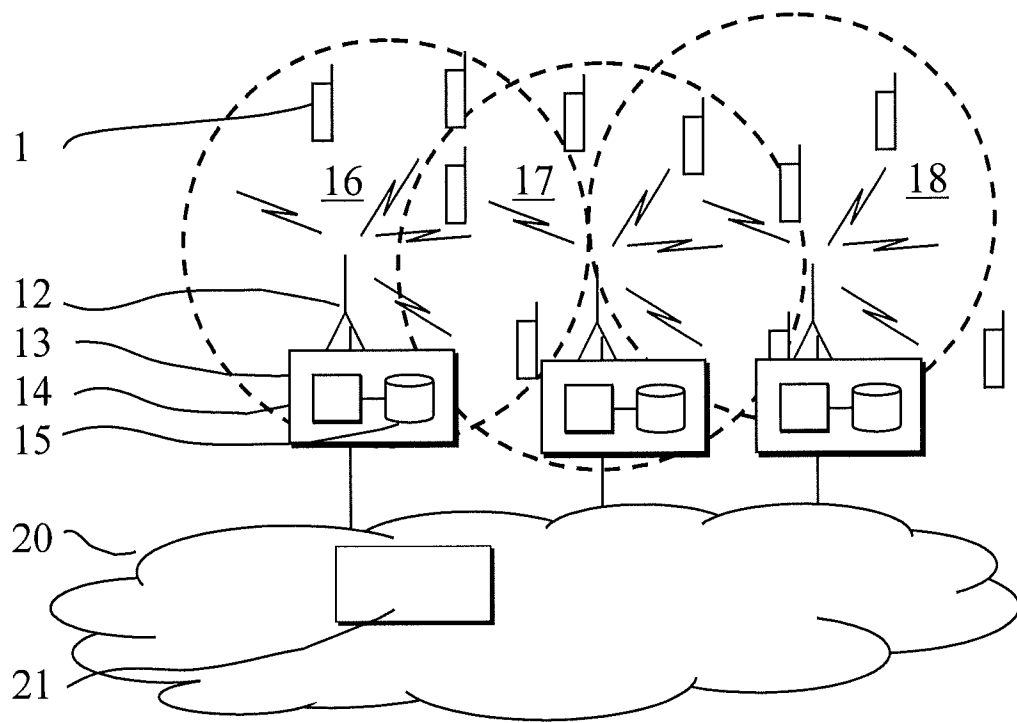


Fig. 1

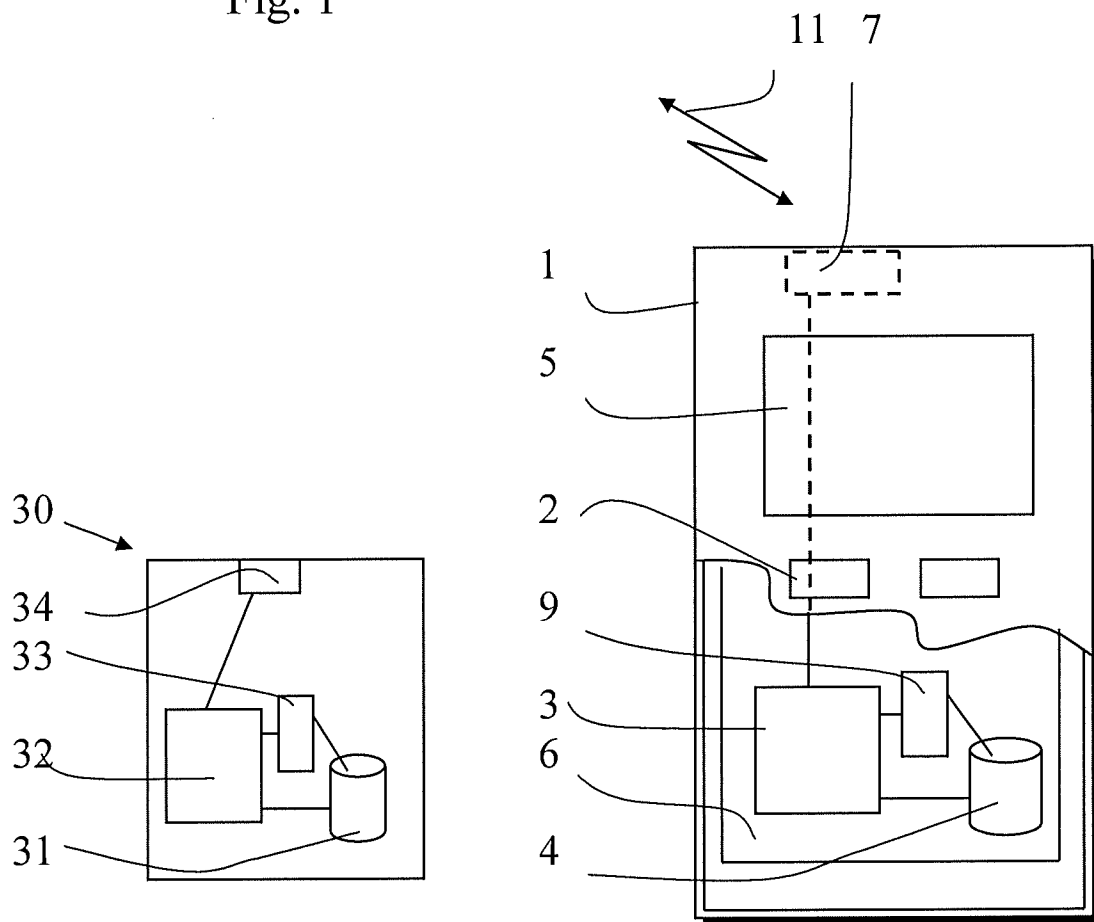


Fig. 3

Fig. 2

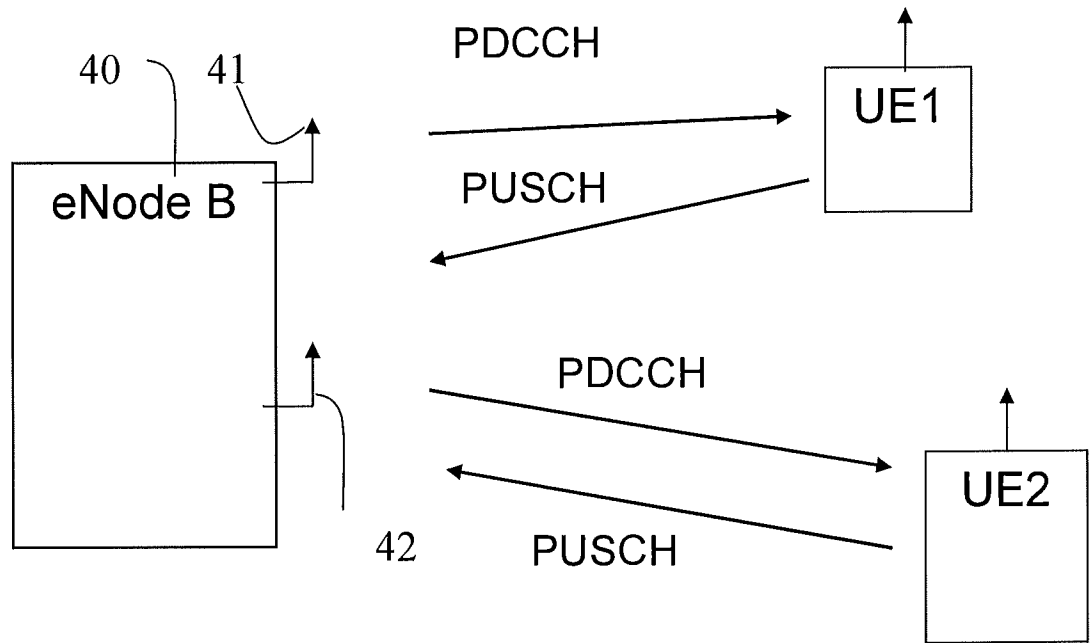


Fig. 4

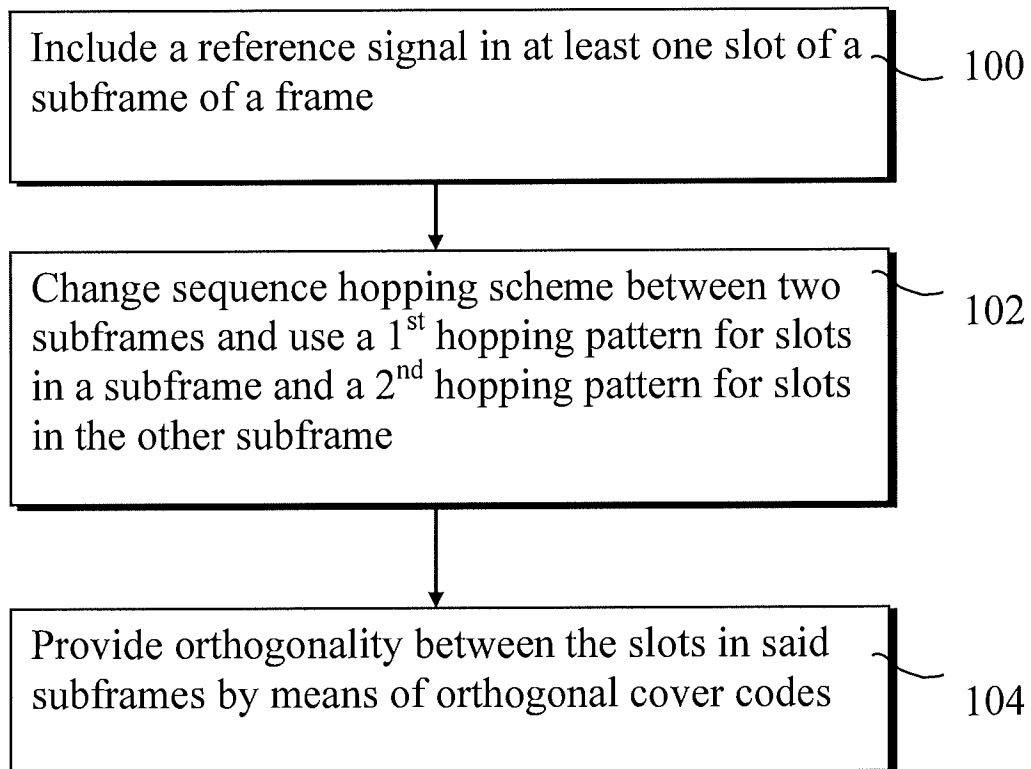


Fig. 5

|         |     | Rel'8/Rel9 Group hopping pattern |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |      |      |
|---------|-----|----------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|
| Slot    |     |                                  |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |      |      |
| Cell ID | # 0 | # 1                              | # 2 | # 3 | # 4 | # 5 | # 6 | # 7 | # 8 | # 9 | # 10 | # 11 | # 12 | # 13 | # 14 | # 15 | # 16 | # 17 | # 18 | # 19 |
| 0       | 4   | 28                               | 12  | 4   | 14  | 19  | 12  | 16  | 12  | 4   | 24   | 29   | 12   | 24   | 8    | 22   | 24   | 9    | 4    | 26   |
| 1       | 5   | 29                               | 13  | 5   | 15  | 20  | 13  | 17  | 13  | 5   | 25   | 0    | 13   | 25   | 9    | 23   | 25   | 10   | 5    | 27   |
| 2       | 6   | 0                                | 14  | 6   | 16  | 21  | 14  | 18  | 14  | 6   | 26   | 1    | 14   | 26   | 10   | 24   | 26   | 11   | 6    | 28   |
| 3       | 7   | 1                                | 15  | 7   | 17  | 22  | 15  | 19  | 15  | 7   | 27   | 2    | 15   | 27   | 11   | 25   | 27   | 12   | 7    | 29   |
| 4       | 8   | 2                                | 16  | 8   | 18  | 23  | 16  | 20  | 16  | 8   | 28   | 3    | 16   | 28   | 12   | 26   | 28   | 13   | 8    | 0    |
| 5       | 9   | 3                                | 17  | 9   | 19  | 24  | 17  | 21  | 17  | 9   | 29   | 4    | 17   | 29   | 13   | 27   | 29   | 14   | 9    | 1    |

Fig.6a

|         |    | Group hopping pattern |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |
|---------|----|-----------------------|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|         |    | Slot                  |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |
| Cell ID | #0 | #1                    | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 | #14 | #15 | #16 | #17 | #18 | #19 |
| 0       | 28 | 28                    | 4  | 4  | 19 | 19 | 16 | 16 | 4  | 4  | 29  | 29  | 24  | 24  | 22  | 22  | 9   | 9   | 26  | 26  |
| 1       | 29 | 29                    | 5  | 5  | 20 | 20 | 17 | 17 | 5  | 5  | 0   | 0   | 25  | 25  | 23  | 23  | 10  | 10  | 27  | 27  |
| 2       | 0  | 0                     | 6  | 6  | 21 | 21 | 18 | 18 | 6  | 6  | 1   | 1   | 26  | 26  | 24  | 24  | 11  | 11  | 28  | 28  |
| 3       | 1  | 1                     | 7  | 7  | 22 | 22 | 19 | 19 | 7  | 7  | 2   | 2   | 27  | 27  | 25  | 25  | 12  | 12  | 29  | 29  |
| 4       | 2  | 2                     | 8  | 8  | 23 | 23 | 20 | 20 | 8  | 8  | 3   | 3   | 28  | 28  | 26  | 26  | 13  | 13  | 0   | 0   |
| 5       | 3  | 3                     | 9  | 9  | 24 | 24 | 21 | 21 | 9  | 9  | 4   | 4   | 29  | 29  | 27  | 27  | 14  | 14  | 1   | 1   |

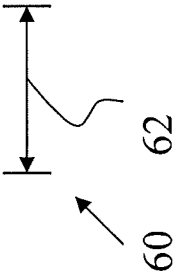


Fig. 6

Fig.6b

Rel'8/Rel9 Group hopping pattern

| Cell ID | #0 | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 | #14 | #15 | #16 | #17 | #18 | #19 |
|---------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0       | 4  | 28 | 12 | 4  | 14 | 19 | 12 | 16 | 12 | 4  | 24  | 29  | 12  | 24  | 8   | 22  | 24  | 9   | 4   | 26  |
| 1       | 5  | 29 | 13 | 5  | 15 | 20 | 13 | 17 | 13 | 5  | 25  | 0   | 13  | 25  | 9   | 23  | 25  | 10  | 5   | 27  |
| 2       | 6  | 0  | 14 | 6  | 16 | 21 | 14 | 18 | 14 | 6  | 26  | 1   | 14  | 26  | 10  | 24  | 26  | 11  | 6   | 28  |
| 3       | 7  | 1  | 15 | 7  | 17 | 22 | 15 | 19 | 15 | 7  | 27  | 2   | 15  | 27  | 11  | 25  | 27  | 12  | 7   | 29  |
| 4       | 8  | 2  | 16 | 8  | 18 | 23 | 16 | 20 | 16 | 8  | 28  | 3   | 16  | 28  | 12  | 26  | 28  | 13  | 8   | 0   |
| 5       | 9  | 3  | 17 | 9  | 19 | 24 | 17 | 21 | 17 | 9  | 29  | 4   | 17  | 29  | 13  | 27  | 29  | 14  | 9   | 1   |
| 6       | 10 | 4  | 18 | 10 | 20 | 25 | 18 | 22 | 18 | 10 | 0   | 5   | 18  | 0   | 14  | 28  | 0   | 15  | 10  | 2   |
| 7       | 11 | 5  | 19 | 11 | 21 | 26 | 19 | 23 | 19 | 11 | 1   | 6   | 19  | 1   | 15  | 29  | 1   | 16  | 11  | 3   |
| 8       | 12 | 6  | 20 | 12 | 22 | 27 | 20 | 24 | 20 | 12 | 2   | 7   | 20  | 2   | 16  | 0   | 2   | 17  | 12  | 4   |
| 9       | 13 | 7  | 21 | 13 | 23 | 28 | 21 | 25 | 21 | 13 | 3   | 8   | 21  | 3   | 17  | 1   | 3   | 18  | 13  | 5   |
| 10      | 14 | 8  | 22 | 14 | 24 | 29 | 22 | 26 | 22 | 14 | 4   | 9   | 22  | 4   | 18  | 2   | 4   | 19  | 14  | 6   |
| 11      | 15 | 9  | 23 | 15 | 25 | 0  | 23 | 27 | 23 | 15 | 5   | 10  | 23  | 5   | 19  | 3   | 5   | 20  | 15  | 7   |
| 12      | 16 | 10 | 24 | 16 | 26 | 1  | 24 | 28 | 24 | 16 | 6   | 11  | 24  | 6   | 20  | 4   | 6   | 21  | 16  | 8   |
| 13      | 17 | 11 | 25 | 17 | 27 | 2  | 25 | 29 | 25 | 17 | 7   | 12  | 25  | 7   | 21  | 5   | 7   | 22  | 17  | 9   |
| 14      | 18 | 12 | 26 | 18 | 28 | 3  | 26 | 0  | 26 | 18 | 8   | 13  | 26  | 8   | 22  | 6   | 8   | 23  | 18  | 10  |
| 15      | 19 | 13 | 27 | 19 | 29 | 4  | 27 | 1  | 27 | 19 | 9   | 14  | 27  | 9   | 23  | 7   | 9   | 24  | 19  | 11  |
| 16      | 20 | 14 | 28 | 20 | 0  | 5  | 28 | 2  | 28 | 20 | 10  | 15  | 28  | 10  | 24  | 8   | 10  | 25  | 20  | 12  |
| 17      | 21 | 15 | 29 | 21 | 1  | 6  | 29 | 3  | 29 | 21 | 11  | 16  | 29  | 11  | 25  | 9   | 11  | 26  | 21  | 13  |
| 18      | 22 | 16 | 0  | 22 | 2  | 7  | 0  | 4  | 0  | 22 | 12  | 17  | 0   | 12  | 26  | 10  | 12  | 27  | 22  | 14  |
| 19      | 23 | 17 | 1  | 23 | 3  | 8  | 1  | 5  | 1  | 23 | 13  | 18  | 1   | 13  | 27  | 11  | 13  | 28  | 23  | 15  |
| 20      | 24 | 18 | 2  | 24 | 4  | 9  | 2  | 6  | 2  | 24 | 14  | 19  | 2   | 14  | 28  | 12  | 14  | 29  | 24  | 16  |
| 21      | 25 | 19 | 3  | 25 | 5  | 10 | 3  | 7  | 3  | 25 | 15  | 20  | 3   | 15  | 29  | 13  | 15  | 0   | 25  | 17  |
| 22      | 26 | 20 | 4  | 26 | 6  | 11 | 4  | 8  | 4  | 26 | 16  | 21  | 4   | 16  | 0   | 14  | 16  | 1   | 26  | 18  |
| 23      | 27 | 21 | 5  | 27 | 7  | 12 | 5  | 9  | 5  | 27 | 17  | 22  | 5   | 17  | 1   | 15  | 17  | 2   | 27  | 19  |
| 24      | 28 | 22 | 6  | 28 | 8  | 13 | 6  | 10 | 6  | 28 | 18  | 23  | 6   | 18  | 2   | 16  | 18  | 3   | 28  | 20  |
| 25      | 29 | 23 | 7  | 29 | 9  | 14 | 7  | 11 | 7  | 29 | 19  | 24  | 7   | 19  | 3   | 17  | 19  | 4   | 29  | 21  |
| 26      | 0  | 24 | 8  | 0  | 10 | 15 | 8  | 12 | 8  | 0  | 20  | 25  | 8   | 20  | 4   | 18  | 20  | 5   | 0   | 22  |
| 27      | 1  | 25 | 9  | 1  | 11 | 16 | 9  | 13 | 9  | 1  | 21  | 26  | 9   | 21  | 5   | 19  | 21  | 6   | 1   | 23  |
| 28      | 2  | 26 | 10 | 2  | 12 | 17 | 10 | 14 | 10 | 2  | 22  | 27  | 10  | 22  | 6   | 20  | 22  | 7   | 2   | 24  |
| 29      | 3  | 27 | 11 | 3  | 13 | 18 | 11 | 15 | 11 | 3  | 23  | 28  | 11  | 23  | 7   | 21  | 23  | 8   | 3   | 25  |
| 30      | 4  | 13 | 12 | 16 | 2  | 29 | 11 | 11 | 11 | 1  | 24  | 25  | 24  | 15  | 22  | 22  | 16  | 12  | 19  | 18  |
| 31      | 5  | 14 | 13 | 17 | 3  | 0  | 12 | 12 | 12 | 2  | 25  | 26  | 25  | 16  | 23  | 23  | 17  | 13  | 20  | 19  |

Fig. 7A

1st cell group

| Group hopping pattern |    |    |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |
|-----------------------|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Slot                  |    | #0 | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 | #14 | #15 | #16 | #17 | #18 | #19 |
| Cell ID               | #0 | 28 | 28 | 4  | 4  | 19 | 19 | 16 | 16 | 4  | 4  | 29  | 29  | 24  | 24  | 22  | 22  | 9   | 9   | 26  | 26  |
| 1                     | 29 | 29 | 5  | 5  | 20 | 20 | 17 | 17 | 17 | 5  | 5  | 0   | 0   | 25  | 25  | 23  | 23  | 10  | 10  | 27  | 27  |
| 2                     | 0  | 0  | 6  | 6  | 21 | 21 | 18 | 18 | 18 | 6  | 6  | 1   | 1   | 26  | 26  | 24  | 24  | 11  | 11  | 28  | 28  |
| 3                     | 1  | 1  | 7  | 7  | 22 | 22 | 19 | 19 | 19 | 7  | 7  | 2   | 2   | 27  | 27  | 25  | 25  | 12  | 12  | 29  | 29  |
| 4                     | 2  | 2  | 8  | 8  | 23 | 23 | 20 | 20 | 20 | 8  | 8  | 3   | 3   | 28  | 28  | 26  | 26  | 13  | 13  | 0   | 0   |
| 5                     | 3  | 3  | 9  | 9  | 24 | 24 | 21 | 21 | 21 | 9  | 9  | 4   | 4   | 29  | 29  | 27  | 27  | 14  | 14  | 1   | 1   |
| 6                     | 4  | 4  | 10 | 10 | 25 | 25 | 22 | 22 | 22 | 10 | 10 | 5   | 5   | 0   | 0   | 28  | 28  | 15  | 15  | 2   | 2   |
| 7                     | 5  | 5  | 11 | 11 | 26 | 26 | 23 | 23 | 23 | 11 | 11 | 6   | 6   | 1   | 1   | 29  | 29  | 16  | 16  | 3   | 3   |
| 8                     | 6  | 6  | 12 | 12 | 27 | 27 | 24 | 24 | 24 | 12 | 12 | 7   | 7   | 2   | 2   | 0   | 0   | 17  | 17  | 4   | 4   |
| 9                     | 7  | 7  | 13 | 13 | 28 | 28 | 25 | 25 | 25 | 13 | 13 | 8   | 8   | 3   | 3   | 1   | 1   | 18  | 18  | 5   | 5   |
| 10                    | 8  | 8  | 14 | 14 | 29 | 29 | 26 | 26 | 26 | 14 | 14 | 9   | 9   | 4   | 4   | 2   | 2   | 19  | 19  | 6   | 6   |
| 11                    | 9  | 9  | 15 | 15 | 0  | 0  | 27 | 27 | 27 | 15 | 15 | 10  | 10  | 5   | 5   | 3   | 3   | 20  | 20  | 7   | 7   |
| 12                    | 10 | 10 | 16 | 16 | 1  | 1  | 28 | 28 | 28 | 16 | 16 | 11  | 11  | 6   | 6   | 4   | 4   | 21  | 21  | 8   | 8   |
| 13                    | 11 | 11 | 17 | 17 | 2  | 2  | 29 | 29 | 29 | 17 | 17 | 12  | 12  | 7   | 7   | 5   | 5   | 22  | 22  | 9   | 9   |
| 14                    | 12 | 12 | 18 | 18 | 3  | 3  | 0  | 0  | 0  | 18 | 18 | 13  | 13  | 8   | 8   | 6   | 6   | 23  | 23  | 10  | 10  |
| 15                    | 13 | 13 | 19 | 19 | 4  | 4  | 1  | 1  | 1  | 19 | 19 | 14  | 14  | 9   | 9   | 7   | 7   | 24  | 24  | 11  | 11  |
| 16                    | 14 | 14 | 20 | 20 | 5  | 5  | 2  | 2  | 2  | 20 | 20 | 15  | 15  | 10  | 10  | 8   | 8   | 25  | 25  | 12  | 12  |
| 17                    | 15 | 15 | 21 | 21 | 6  | 6  | 3  | 3  | 3  | 21 | 21 | 16  | 16  | 11  | 11  | 9   | 9   | 26  | 26  | 13  | 13  |
| 18                    | 16 | 16 | 22 | 22 | 7  | 7  | 4  | 4  | 4  | 22 | 22 | 17  | 17  | 12  | 12  | 10  | 10  | 27  | 27  | 14  | 14  |
| 19                    | 17 | 17 | 23 | 23 | 8  | 8  | 5  | 5  | 5  | 23 | 23 | 18  | 18  | 13  | 13  | 11  | 11  | 28  | 28  | 15  | 15  |
| 20                    | 18 | 18 | 24 | 24 | 9  | 9  | 6  | 6  | 6  | 24 | 24 | 19  | 19  | 14  | 14  | 12  | 12  | 29  | 29  | 16  | 16  |
| 21                    | 19 | 19 | 25 | 25 | 10 | 10 | 7  | 7  | 7  | 25 | 25 | 20  | 20  | 15  | 15  | 13  | 13  | 0   | 0   | 17  | 17  |
| 22                    | 20 | 20 | 26 | 26 | 11 | 11 | 8  | 8  | 8  | 26 | 26 | 21  | 21  | 16  | 16  | 14  | 14  | 1   | 1   | 18  | 18  |
| 23                    | 21 | 21 | 27 | 27 | 12 | 12 | 9  | 9  | 9  | 27 | 27 | 22  | 22  | 17  | 17  | 15  | 15  | 2   | 2   | 19  | 19  |
| 24                    | 22 | 22 | 28 | 28 | 13 | 13 | 10 | 10 | 10 | 28 | 28 | 23  | 23  | 18  | 18  | 16  | 16  | 3   | 3   | 20  | 20  |
| 25                    | 23 | 23 | 29 | 29 | 14 | 14 | 11 | 11 | 11 | 29 | 29 | 24  | 24  | 19  | 19  | 17  | 17  | 4   | 4   | 21  | 21  |
| 26                    | 24 | 24 | 0  | 0  | 15 | 15 | 12 | 12 | 12 | 0  | 0  | 25  | 25  | 20  | 20  | 18  | 18  | 5   | 5   | 22  | 22  |
| 27                    | 25 | 25 | 1  | 1  | 16 | 16 | 13 | 13 | 13 | 1  | 1  | 26  | 26  | 21  | 21  | 19  | 19  | 6   | 6   | 23  | 23  |
| 28                    | 26 | 26 | 2  | 2  | 17 | 17 | 14 | 14 | 14 | 2  | 2  | 27  | 27  | 22  | 22  | 20  | 20  | 7   | 7   | 24  | 24  |
| 29                    | 27 | 27 | 3  | 3  | 18 | 18 | 15 | 15 | 15 | 3  | 3  | 28  | 28  | 23  | 23  | 21  | 21  | 8   | 8   | 25  | 25  |
| 30                    | 13 | 13 | 16 | 16 | 29 | 29 | 11 | 11 | 11 | 1  | 1  | 25  | 25  | 15  | 15  | 22  | 22  | 12  | 12  | 18  | 18  |
| 31                    | 14 | 14 | 17 | 17 | 0  | 0  | 12 | 12 | 12 | 2  | 2  | 26  | 26  | 16  | 16  | 23  | 23  | 13  | 13  | 19  | 19  |

Fig. 7B



Rel'8/Rel9 Group hopping pattern

| Slot    |    | #0 | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 | #14 | #15 | #16 | #17 | #18 | #19 |
|---------|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Cell ID |    | #0 | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 | #14 | #15 | #16 | #17 | #18 | #19 |
| 0       | 4  | 28 | 12 | 4  | 4  | 14 | 19 | 12 | 16 | 12 | 4  | 24  | 29  | 12  | 24  | 8   | 22  | 24  | 9   | 4   | 26  |
| 1       | 5  | 29 | 13 | 5  | 5  | 15 | 20 | 13 | 17 | 13 | 5  | 25  | 0   | 13  | 25  | 9   | 23  | 25  | 10  | 5   | 27  |
| 2       | 6  | 0  | 14 | 6  | 6  | 16 | 21 | 14 | 18 | 14 | 6  | 26  | 1   | 14  | 26  | 10  | 24  | 26  | 11  | 6   | 28  |
| 3       | 7  | 1  | 15 | 7  | 7  | 17 | 22 | 15 | 19 | 15 | 7  | 27  | 2   | 15  | 27  | 11  | 25  | 27  | 12  | 7   | 29  |
| 4       | 8  | 2  | 16 | 8  | 8  | 18 | 23 | 16 | 20 | 16 | 8  | 28  | 3   | 16  | 28  | 12  | 26  | 28  | 13  | 8   | 0   |
| 5       | 9  | 3  | 17 | 9  | 9  | 19 | 24 | 17 | 21 | 17 | 9  | 29  | 4   | 17  | 29  | 13  | 27  | 29  | 14  | 9   | 1   |
| 6       | 10 | 4  | 18 | 10 | 10 | 20 | 25 | 18 | 22 | 18 | 10 | 0   | 5   | 18  | 0   | 14  | 28  | 0   | 15  | 10  | 2   |
| 7       | 11 | 5  | 19 | 11 | 11 | 21 | 26 | 19 | 23 | 19 | 11 | 1   | 6   | 19  | 1   | 15  | 29  | 1   | 16  | 11  | 3   |
| 8       | 12 | 6  | 20 | 12 | 12 | 22 | 27 | 20 | 24 | 20 | 12 | 2   | 7   | 20  | 2   | 16  | 0   | 2   | 17  | 12  | 4   |
| 9       | 13 | 7  | 21 | 13 | 13 | 23 | 28 | 21 | 25 | 21 | 13 | 3   | 8   | 21  | 3   | 17  | 1   | 3   | 18  | 13  | 5   |
| 10      | 14 | 8  | 22 | 14 | 14 | 24 | 29 | 22 | 26 | 22 | 14 | 4   | 9   | 22  | 4   | 18  | 2   | 4   | 19  | 14  | 6   |
| 11      | 15 | 9  | 23 | 15 | 15 | 25 | 0  | 23 | 27 | 23 | 15 | 5   | 10  | 23  | 5   | 19  | 3   | 5   | 20  | 15  | 7   |
| 12      | 16 | 10 | 24 | 16 | 16 | 26 | 1  | 24 | 28 | 24 | 16 | 6   | 11  | 24  | 6   | 20  | 4   | 6   | 21  | 16  | 8   |
| 13      | 17 | 11 | 25 | 17 | 17 | 27 | 2  | 25 | 29 | 25 | 17 | 7   | 12  | 25  | 7   | 21  | 5   | 7   | 22  | 17  | 9   |
| 14      | 18 | 12 | 26 | 18 | 18 | 28 | 3  | 26 | 0  | 26 | 18 | 8   | 13  | 26  | 8   | 22  | 6   | 8   | 23  | 18  | 10  |
| 15      | 19 | 13 | 27 | 19 | 19 | 29 | 4  | 27 | 1  | 27 | 19 | 9   | 14  | 27  | 9   | 23  | 7   | 9   | 24  | 19  | 11  |
| 16      | 20 | 14 | 28 | 20 | 20 | 0  | 5  | 28 | 2  | 28 | 20 | 10  | 15  | 28  | 10  | 24  | 8   | 10  | 25  | 20  | 12  |
| 17      | 21 | 15 | 29 | 21 | 21 | 1  | 6  | 29 | 3  | 29 | 21 | 11  | 16  | 29  | 11  | 25  | 9   | 11  | 26  | 21  | 13  |
| 18      | 22 | 16 | 0  | 22 | 22 | 2  | 7  | 0  | 4  | 0  | 22 | 12  | 17  | 0   | 12  | 26  | 10  | 12  | 27  | 22  | 14  |
| 19      | 23 | 17 | 1  | 23 | 23 | 3  | 8  | 1  | 5  | 1  | 23 | 13  | 18  | 1   | 13  | 27  | 11  | 13  | 28  | 23  | 15  |
| 20      | 24 | 18 | 2  | 24 | 24 | 4  | 9  | 2  | 6  | 2  | 24 | 14  | 19  | 2   | 14  | 28  | 12  | 14  | 29  | 24  | 16  |
| 21      | 25 | 19 | 3  | 25 | 25 | 5  | 10 | 3  | 7  | 3  | 25 | 15  | 20  | 3   | 15  | 29  | 13  | 15  | 0   | 25  | 17  |
| 22      | 26 | 20 | 4  | 26 | 26 | 6  | 11 | 4  | 8  | 4  | 26 | 16  | 21  | 4   | 16  | 0   | 14  | 16  | 1   | 26  | 18  |
| 23      | 27 | 21 | 5  | 27 | 27 | 7  | 12 | 5  | 9  | 5  | 27 | 17  | 22  | 5   | 17  | 1   | 15  | 17  | 2   | 27  | 19  |
| 24      | 28 | 22 | 6  | 28 | 28 | 8  | 13 | 6  | 10 | 6  | 28 | 18  | 23  | 6   | 18  | 2   | 16  | 18  | 3   | 28  | 20  |
| 25      | 29 | 23 | 7  | 29 | 29 | 9  | 14 | 7  | 11 | 7  | 29 | 19  | 24  | 7   | 19  | 3   | 17  | 19  | 4   | 29  | 21  |
| 26      | 0  | 24 | 8  | 0  | 0  | 10 | 15 | 8  | 12 | 8  | 0  | 20  | 25  | 8   | 20  | 4   | 18  | 20  | 5   | 0   | 22  |
| 27      | 1  | 25 | 9  | 1  | 1  | 11 | 16 | 9  | 13 | 9  | 1  | 21  | 26  | 9   | 21  | 5   | 19  | 21  | 6   | 1   | 23  |
| 28      | 2  | 26 | 10 | 2  | 2  | 12 | 17 | 10 | 14 | 10 | 2  | 22  | 27  | 10  | 22  | 6   | 20  | 22  | 7   | 2   | 24  |
| 29      | 3  | 27 | 11 | 3  | 3  | 13 | 18 | 11 | 15 | 11 | 3  | 23  | 28  | 11  | 23  | 7   | 21  | 23  | 8   | 3   | 25  |
| 30      | 4  | 13 | 12 | 16 | 16 | 2  | 29 | 11 | 11 | 11 | 1  | 24  | 25  | 24  | 15  | 22  | 22  | 22  | 12  | 19  | 18  |
| 31      | 5  | 14 | 13 | 17 | 17 | 3  | 0  | 12 | 12 | 12 | 2  | 25  | 26  | 25  | 16  | 23  | 23  | 23  | 13  | 20  | 19  |

1st cell group

Fig. 8A

| Group hopping pattern |    |    |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |  |
|-----------------------|----|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| Slot                  |    | #0 | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | #11 | #12 | #13 | #14 | #15 | #16 | #17 | #18 | #19 |  |
| Cell ID               |    | 28 | 28 | 4  | 4  | 19 | 19 | 16 | 16 | 4  | 4  | 24  | 24  | 12  | 12  | 8   | 8   | 24  | 24  | 4   | 4   |  |
| 0                     | 28 | 29 | 29 | 5  | 5  | 20 | 20 | 17 | 17 | 5  | 5  | 25  | 25  | 13  | 13  | 9   | 9   | 25  | 25  | 5   | 5   |  |
| 1                     | 29 | 0  | 0  | 6  | 6  | 21 | 21 | 18 | 18 | 6  | 6  | 26  | 26  | 14  | 14  | 10  | 10  | 26  | 26  | 6   | 6   |  |
| 2                     | 0  | 0  | 1  | 7  | 7  | 22 | 22 | 19 | 19 | 7  | 7  | 27  | 27  | 15  | 15  | 11  | 11  | 27  | 27  | 7   | 7   |  |
| 3                     | 1  | 1  | 2  | 8  | 8  | 23 | 23 | 20 | 20 | 8  | 8  | 28  | 28  | 16  | 16  | 12  | 12  | 28  | 28  | 8   | 8   |  |
| 4                     | 2  | 2  | 3  | 9  | 9  | 24 | 24 | 21 | 21 | 9  | 9  | 29  | 29  | 17  | 17  | 13  | 13  | 29  | 29  | 9   | 9   |  |
| 5                     | 3  | 3  | 4  | 10 | 10 | 25 | 25 | 22 | 22 | 10 | 10 | 0   | 0   | 18  | 18  | 14  | 14  | 0   | 0   | 10  | 10  |  |
| 6                     | 4  | 4  | 5  | 11 | 11 | 26 | 26 | 23 | 23 | 11 | 11 | 1   | 1   | 19  | 19  | 15  | 15  | 1   | 1   | 11  | 11  |  |
| 7                     | 5  | 5  | 6  | 12 | 12 | 27 | 27 | 24 | 24 | 12 | 12 | 2   | 2   | 20  | 20  | 16  | 16  | 2   | 2   | 12  | 12  |  |
| 8                     | 6  | 6  | 7  | 13 | 13 | 28 | 28 | 25 | 25 | 13 | 13 | 3   | 3   | 21  | 21  | 17  | 17  | 3   | 3   | 13  | 13  |  |
| 9                     | 7  | 7  | 8  | 14 | 14 | 29 | 29 | 26 | 26 | 14 | 14 | 4   | 4   | 22  | 22  | 18  | 18  | 4   | 4   | 14  | 14  |  |
| 10                    | 8  | 8  | 9  | 15 | 15 | 0  | 0  | 27 | 27 | 15 | 15 | 5   | 5   | 23  | 23  | 19  | 19  | 5   | 5   | 15  | 15  |  |
| 11                    | 9  | 9  | 10 | 16 | 16 | 1  | 1  | 28 | 28 | 16 | 16 | 6   | 6   | 24  | 24  | 20  | 20  | 6   | 6   | 16  | 16  |  |
| 12                    | 10 | 10 | 11 | 17 | 17 | 2  | 2  | 29 | 29 | 17 | 17 | 7   | 7   | 25  | 25  | 21  | 21  | 7   | 7   | 17  | 17  |  |
| 13                    | 11 | 11 | 12 | 18 | 18 | 3  | 3  | 0  | 0  | 18 | 18 | 8   | 8   | 26  | 26  | 22  | 22  | 8   | 8   | 18  | 18  |  |
| 14                    | 12 | 12 | 13 | 19 | 19 | 4  | 4  | 1  | 1  | 19 | 19 | 9   | 9   | 27  | 27  | 23  | 23  | 9   | 9   | 19  | 19  |  |
| 15                    | 13 | 13 | 14 | 20 | 20 | 5  | 5  | 2  | 2  | 20 | 20 | 10  | 10  | 28  | 28  | 24  | 24  | 10  | 10  | 20  | 20  |  |
| 16                    | 14 | 14 | 15 | 21 | 21 | 6  | 6  | 3  | 3  | 21 | 21 | 11  | 11  | 29  | 29  | 25  | 25  | 11  | 11  | 21  | 21  |  |
| 17                    | 15 | 15 | 16 | 22 | 22 | 7  | 7  | 4  | 4  | 22 | 22 | 12  | 12  | 0   | 0   | 26  | 26  | 12  | 12  | 22  | 22  |  |
| 18                    | 16 | 16 | 17 | 23 | 23 | 8  | 8  | 5  | 5  | 23 | 23 | 13  | 13  | 1   | 1   | 27  | 27  | 13  | 13  | 23  | 23  |  |
| 19                    | 17 | 17 | 18 | 24 | 24 | 9  | 9  | 6  | 6  | 24 | 24 | 14  | 14  | 2   | 2   | 28  | 28  | 14  | 14  | 24  | 24  |  |
| 20                    | 18 | 18 | 19 | 25 | 25 | 10 | 10 | 7  | 7  | 25 | 25 | 15  | 15  | 3   | 3   | 29  | 29  | 15  | 15  | 25  | 25  |  |
| 21                    | 19 | 19 | 20 | 26 | 26 | 11 | 11 | 8  | 8  | 26 | 26 | 16  | 16  | 4   | 4   | 0   | 0   | 16  | 16  | 26  | 26  |  |
| 22                    | 20 | 20 | 21 | 27 | 27 | 12 | 12 | 9  | 9  | 27 | 27 | 17  | 17  | 5   | 5   | 1   | 1   | 17  | 17  | 27  | 27  |  |
| 23                    | 21 | 21 | 22 | 28 | 28 | 13 | 13 | 10 | 10 | 28 | 28 | 18  | 18  | 6   | 6   | 2   | 2   | 18  | 18  | 28  | 28  |  |
| 24                    | 22 | 22 | 23 | 29 | 29 | 14 | 14 | 11 | 11 | 29 | 29 | 19  | 19  | 7   | 7   | 3   | 3   | 19  | 19  | 29  | 29  |  |
| 25                    | 23 | 23 | 24 | 0  | 0  | 15 | 15 | 12 | 12 | 0  | 0  | 20  | 20  | 8   | 8   | 4   | 4   | 20  | 20  | 0   | 0   |  |
| 26                    | 24 | 24 | 25 | 1  | 1  | 16 | 16 | 13 | 13 | 1  | 1  | 21  | 21  | 9   | 9   | 5   | 5   | 21  | 21  | 1   | 1   |  |
| 27                    | 25 | 25 | 26 | 2  | 2  | 17 | 17 | 14 | 14 | 2  | 2  | 22  | 22  | 10  | 10  | 6   | 6   | 22  | 22  | 2   | 2   |  |
| 28                    | 26 | 26 | 27 | 3  | 3  | 18 | 18 | 15 | 15 | 3  | 3  | 23  | 23  | 11  | 11  | 7   | 7   | 23  | 23  | 3   | 3   |  |
| 29                    | 27 | 27 |    |    |    |    |    |    |    |    |    |     |     |     |     |     |     |     |     |     |     |  |
| 30                    | 13 | 13 | 16 | 16 | 16 | 29 | 29 | 11 | 11 | 1  | 1  | 24  | 24  | 24  | 24  | 22  | 22  | 16  | 16  | 19  | 19  |  |
| 31                    | 14 | 14 | 17 | 17 | 17 | 0  | 0  | 12 | 12 | 2  | 2  | 25  | 25  | 25  | 25  | 23  | 23  | 17  | 17  | 20  | 20  |  |

Fig. 8B

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2010/054417

A. CLASSIFICATION OF SUBJECT MATTER  
INV. H04J13/16

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)  
H04J

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 practical, search terms used)

EPO-Internal, INSPEC, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                              | Relevant to claim No. |
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| X         | <p>HUAWEI: "Impacts of OCC on UL DM RS for LTE-A"<br/>3GPP RAN WG1 DRAFT R1-101075,<br/>16 February 2010 (2010-02-16), page 7PP,<br/>XP050418640<br/>San Francisco, USA<br/>page 1, section 2<br/>page 5, section 4.2</p> <p>-----<br/>-/--</p> | 1-33                  |



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Date of the actual completion of the international search

15 February 2011

Date of mailing of the international search report

18/03/2011

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Authorized officer

Ó Donnabháin, Emma

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| X         | <p>MOTOROLA: "Views on Remaining Issues on Uplink DM-RS for LTE-A"<br/> 3GPP RAN WG 60 R1-101133, [Online]<br/> 22 February 2010 (2010-02-22), - 26<br/> February 2010 (2010-02-26) pages 1-7,<br/> XP002622678<br/> San Francisco, USA<br/> Retrieved from the Internet:<br/> URL: <a href="http://ftp.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_60/Docs/R1-101133.zip">http://ftp.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_60/Docs/R1-101133.zip</a><br/> [retrieved on 2011-02-14]<br/> pages 4,7</p> <p style="text-align: center;">-----</p> | 1-33                  |
| A         | <p>"3rd Generation Partnership Project;<br/> Technical Specification Group Radio Access<br/> Network; Evolved Universal Terrestrial<br/> Radio Access (E-UTRA); Physical Channels<br/> and Modulation (Release 8)"<br/> 3GPP STANDARD; 3GPP TS 36.211, V8.9.0,<br/> 9 December 2009 (2009-12-09), pages 1-83,<br/> XP050400542<br/> pages 9-10, section 4</p> <p style="text-align: center;">-----</p>                                                                                                                               | 1-33                  |