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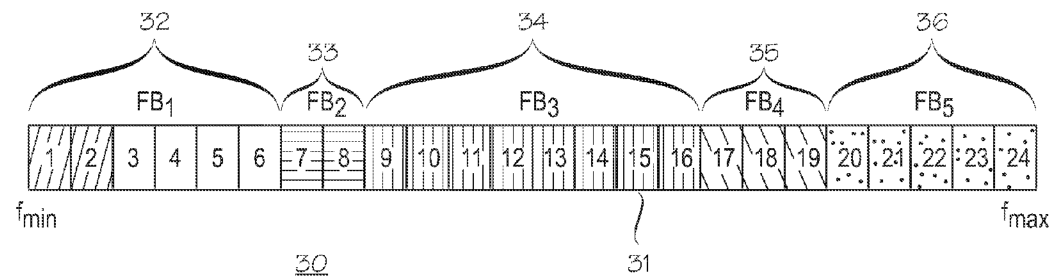

(57) Abstract: A cellular communication system comprising a plurality of user equipment and a network infrastructure. Radio resource of the plurality of cells is divided into more than one-radio resource blocks. A network infrastructure element detects a requirement of radio resource allocation for a user equipment and determines effective interference to be generated by the required radio resource to a defined group of neighboring cells. User equipment is allocated a radio resource from one of the radio resource blocks on the basis of the determined effective interference to be generated to the defined group of neighboring cells. Inter-cell interference decreases and the throughput of the cellular system increases, but the exchange of physical layer information is not increased.

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IMPROVED RADIO RESOURCE ALLOCATION MECHANISM

FIELD OF THE INVENTION

The present invention relates to telecommunications and more particularly to radio resource allocation in cellular communication systems.

BACKGROUND OF THE INVENTION

A cellular network is a radio network made up of a number of radio cells each served by a transceiver, known as a cell site or base station. Cellular networks are inherently asymmetric such that a set of fixed transceivers serve a cell and a set of distributed mobile transceivers provide services to the users.

A cellular network is able to provide more transmission capacity than a single transmitter network because a radio frequency of a cell can be reused in another cell for different transmission. Frequency reuse, however, causes interference between cells that use the same and nearby frequencies.

This inter-cell interference has conventionally been solved by co-ordination/planning based methods. An example of such methods is frequency reuse where different groups of radio channels may be assigned to adjacent cells, and the same groups are assigned to cells separated by a certain distance (reuse distance) to reduce co-channel interference. The method is relatively effective and straightforward, but wastes channel resource.

Another alternative is provided by co-ordination/planning based methods that comprise use of dynamic channels temporarily assigned for use in cells for the duration of the call, returned and kept in a central pool after the call is over. In some other dynamic solutions the total number of channels is divided into two groups, one of which is used for fixed allocation to the cells, while the other is kept as a central poor to be shared by all users. The reuse factor of these methods still remains low, actually in heavy traffic load they may perform worse than the above disclosed fixed channel assignment method.

In the new emerging systems, for example in the upcoming evolution of 3rd Generation Partnership Project (3GPP) systems (also called as Long Term Evolution (LTE) systems), the requirements, according to the working assumptions, are challenging. The planned frequency reuse factor is 1, and at the same time significantly improved system performance, in terms or average throughput and cell throughput is targeted. In order to meet these challenges, mitigation of inter-cell interference is now extensively studied.

The approaches considered in inter-cell interference mitigation comprise Inter-cell-interference co-ordination/avoidance. The common theme of inter-cell-interference co-ordination/avoidance is to apply restrictions to the resource management (configuration for the common channels and scheduling for the non common channels) in a coordinated way between cells. Such restrictions in a cell will provide the possibility for improvement in (Signal-to-Interference Ratio) SIR, and cell-edge data-rates/coverage, on the corresponding time/frequency resources in a neighbor cell.

The available inter-cell interference co-ordination methods require certain inter-communication between different network nodes in order to set and reconfigure the above mentioned restrictions. However, links between cells are expensive and typically cause delays. Thus, for the time being it seems that reconfiguration of the restrictions will be done on a time scale corresponding to days, and the inter-node communication is going to be very limited, basically with a rate of in the order of days. In such scenarios mechanisms that do not rely on inter-cell co-ordination are critically needed.

SUMMARY OF THE INVENTION

An object of the present invention to provide a solution that enables mitigation of inter-cell interference in a cellular communication system where capacity and system performance requirements are high, and inter-communication of physical layer information between different network nodes is limited. The objects of the invention are achieved by a radio resource allocation method, a cellular communication system, user equipment, a control unit, a network infrastructure element, a computer program product and a ccomputer program distribution medium, which are characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the idea that radio resource of cells in the communication system are divided into more than one radio resource blocks. User equipment are then allocated a radio resource from one of the radio resource blocks on the basis of the determined interference to be generated to the defined group of neighbouring cells.

An advantage of the invention is that the inter-cell interference decreases and the throughput of the cellular system increases, but the exchange of physical layer information is not increased.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which:

Figure 1 illustrates a simplified example of a mobile communications system;

Figure 2 illustrates the central elements of the embodiment of Figure 1;

Figure 3 illustrates the radio resource of a cell in the embodiment of Figure 2;

Figure 4 illustrates the steps of the improved radio resource allocation method;

Figure 5 illustrates the step of determining the interference from the point of view of the user equipment; and

Figure 6 illustrates the step of determining the interference in the embodied radio resource allocation method from the point of view of the network infrastructure element.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 illustrates a simplified example of a cellular communications system to which the present solution may be applied. The system of Figure 1 is a mobile communication system that comprises a number of wireless access points through which users may connect to the network and thus utilize the communication services of the system. In the following, the invention is described with base station cells of a mobile communications system, where the access point may change when users are moving within the service area of the systems. It should be noted, however, that the solution may be applied in interference control of any access point, notwithstanding whether part of the same or different system as the potentially interfering access points.

A mobile network infrastructure may be logically divided into core network (CN) 10 and radio access network (RAN) 11 infrastructures. The core network 10 is a combination of exchanges and basic transmission equipment, which together provide the basis for network services. The radio access network 11 provides mobile access to a number of core networks of both mobile and fixed origin.

Based on the cellular concept, in RAN a large area is divided into a number of sub-areas called cells. Each cell has its own base station 12, which is able to provide a radio link for a number of simultaneous users by emitting a controlled low-level transmitted signal. In present mobile communications systems RAN typically comprises a separate controlling network element 13, which manages the use and integrity of the radio resources of a group of one or more base stations. However, the scope covers also systems without such separate physical element, for example systems where at least part of the radio network control functions are implemented in the individual base stations.

A user accesses the services of the mobile communication system with user equipment 14 that provides required functionality to communicate over a radio interface defined for the radio access network 11.

Figure 2 illustrates in more detail the central elements used in implementing the embodiment of Figure 1. As described above, a base station is in control of defined (static or dynamic) radio resources, and users communicate with the network infrastructure using a particular radio resource of at least one base station, typically the base station in the coverage area of which the users presently resides.

A mobile communication system utilizes a predefined channel structure, according to the offered communication services. A typical example of a channel structure is a three-tier channel organization where topmost logical channels relate to the type of information to be transmitted, transport channels relate to the way the logical channels are to be transmitted, and the physical channels provide the transmission media through which the information is actually transferred. In this context the role of a base station is to implement radio access physical channels and transfer information from transport channels to the physical channels according to predefined radio network control functions.

Part of the physical channel resource of a cell is typically reserved for some particular use, for example for transport channels that are common for all user equipment in the cell, and those used for initial access. Part of the physical channel resource of a cell may, on the other hand, be allocated dynamically for traffic. Figure 2 shows elementary configurations for the system elements involved in allocating physical channels for user equipment.

User equipment 14 of the mobile communications system can be a simplified terminal for speech only or a terminal for diverse services. In the latter case the terminal acts as a service platform and supports loading and execution of various functions related to the services. User equipment typically comprises mobile equipment and a subscriber identity module. The subscriber identity module is typically a smart card, often a detachably connected identification card, that holds the subscriber identity, performs authentication algorithms, and stores authentication and encryption keys and other subscription information that is needed at the mobile station. The mobile equipment may be any equipment capable of communicating in a mobile communication system or a combination of several pieces of equipment, for instance a multimedia computer to which a card phone has been connected to provide a mobile connection. In this context, the user equipment thus refers to an entity formed by the subscriber identity module and the actual mobile equipment.

A network infrastructure element 216 of Figure 2 is any entity comprising the functions that control use of radio resources of at least one cell in the mobile communication system. In the context of the embodiment of Figure 1, the network infrastructure element 212 may be a base station, or a separate base station control element.

The network infrastructure element 216 comprises processing unit 218, an element that comprises an arithmetic logic unit, a number of special registers and control circuits. Connected to the processing unit is a memory block 220, a data medium where computer-readable data or programs or user data can be stored. The memory block typically comprises memory units that allow both reading and writing (RAM), and memory units whose contents can only be read (ROM). The network infrastructure element also comprises an interface block 222 with input unit 224 for inputting data from other network infrastructure elements, for internal processing in the network infrastructure element, and output unit 226 for outputting data from the internal processes of the network infrastructure element to the other network infrastructure elements. Examples of elements of said input unit comprise network interfaces, generally known to a person skilled in the art.

The network infrastructure unit also comprises a transceiver block 228 configured with receiving unit 230 for receiving information from the air interface and for inputting the received information to the processing means 218, as well as with transmitting unit 232 for receiving information from the processing means 218, and processing it for sending via the air interface. The implementation of such a transceiver block is generally known to a person skilled in the art. The processing unit 218, memory block 220, the interface block 222, and the transceiver block 228 of the network infrastructure element are electrically interconnected for performing systematic execution of operations on the received and/or stored data according to predefined, essentially programmed processes of the unit. In systematic execution of the operations the processing unit 218 acts a control unit that may be implemented as a single integrated circuit, or a combination or two or more functionally combined integrated circuits. In a solution according to the invention, the operations comprise the functionality of the network infrastructure element as described with Figures 4 and 6.

User equipment of Figure 2 comprises a processing unit 200, and a memory unit 202. The user equipment also comprises a user interface block 204 with input unit 206 for inputting data by the user for internal processing in the unit, and output unit 208 for outputting user data from the internal processes of the unit. Examples of said input unit comprise a keypad, or a touch screen, a microphone, or the like. Examples of said output unit comprise a screen, a touch screen, a loudspeaker, or the like.

The user equipment also comprises a radio communication unit 210 configured with a receiver 212 for receiving information from the radio access network 11 over the air interface and processing it for inputting to the processing unit 200, as well as a transmitter 214 for receiving information from the processing unit 200, for further processing and transmitting the information via the air interface to the radio access network 11. The processing unit 200, the memory unit 202, the user interface block 204, and the radio communication unit 210 are electrically interconnected for performing systematic execution of operations on the received and/or stored data according to predefined, essentially programmed processes of the user equipment. In a solution according to the invention, the operations comprise the functionality of the user equipment as described with Figures 4 and 5.

In the embodiment of Figure 2, the radio resource of each cell exists in the form of frequency band, and is divided into radio resource units in form of physical channels. A physical channel 234 is typically defined by its carrier frequency, and one or more parameters according to the selected multiple access scheme. For example, a physical channel of wideband code division multiple access (WCDMA) scheme is defined by its carrier frequency, channelisation code (CDMA) and relative phase for the uplink connection. In time division multiple access (TDMA) a radio frequency is divided into time slots and a physical channel corresponds to one or more time slots. In frequency division multiple access (FDMA) technique in which each user receives a radio channel of its own on a common frequency band. In the emerging systems, these basic forms of multiple access schemes are combined into more and more sophisticated schemes to meet the key performance and capability targets for rational long-term evolution. For example, in the upcoming evolution of 3rd Generation Partnership Project (3GPP) LTE systems, a potential candidate for uplink is single carrier FDMA (SC-FDMA). During channel allocation a dedicated channel in form of unique combination of transmission parameters defining a radio resource is agreed between the network infrastructure element and the user equipment so that information streams to and from the user equipment can be differentiated in the air interface.

For mobility management purposes, when the user moves within the coverage area of the system, user equipment 14 continuously receives and transmits signals using the undedicated physical channels arranged into the system. When there is user data to be transmitted to or from the user equipment, a dedicated radio resource, as described above, needs to be allocated to the task. Allocation is typically performed through a predefined signaling procedure, which takes place between the user equipment 14, and the network infrastructure element 216 that controls the radio resource from which the allocation is to be made. Basic channel allocation procedures are widely documented, and well known to a person skilled in the art, and therefore not described in more detail herein. As a result of the channel allocation, a unique radio resource is allocated to the user equipment, and the network infrastructure and the user equipment begin to transmit and receive using the transmission parameters that define the allocated radio resource.

Figure 3 illustrates the radio resource of a cell in the embodiment of Figure 2. The radio resource corresponds to a continuous set of frequencies F lying between two specified limiting frequencies f_{min} and f_{max}. The set of frequencies F forms a frequency band 30. The carrier frequency of the frequency unit increases towards the limiting frequency f_{max}. According to the invention, the frequency band 30 is divided into more than one frequency blocks 32, 33, 34, 35, 36, wherein each frequency block comprises one or more radio resource units 31. As described above, a radio resource unit 31 may correspond to a carrier frequency, timeslot, spread spectrum code, or any other combination of transmission parameters that may be separately allocated to users, depending on the selected multiple access scheme. For simple graphical illustration, the exemplary frequency blocks 32, 33, 34, 35, 36 of Figure 3 are shown as comprised of one or more adjacent radio frequency carriers. It is clear that the radio resource blocks according to the invention may comprise any logical combination of a number of related radio resource units that for a purpose can be dealt with as an entity. For example, a radio resource block can consist of a number of (for example 2-4) physical radio resource units that may, or may not reside next to each other in the frequency domain.

As will be described in the following, user equipment requiring dedicated transmission capacity will be allocated a radio resource from the radio resource block in the serving cell, and the radio resource block will be selected on the basis of interference to be generated by the user equipment to the surrounding cells.

Figure 4 illustrates the steps of the embodied radio resource allocation method according to the invention, applied to the embodied system described in Figures 1, 2, and 3. As discussed above, the radio resource of a plurality of cells is first divided (step 41) into more than one radio resource blocks.

Radio resource allocation begins when the network infrastructure element 216 detects (step 42) a need for dedicated or shared radio resource of the cell 12 for the user equipment 14. Such may happen, for example, when the user of user equipment 14 initiates a call or a session, at handover procedures, where the user equipment moves from one cell to another, and at setup of user equipment terminated call or session. In the following, the case of radio resource request by the user equipment is described as an example.

The radio resource request inherently or explicitly specifies transmission characteristics of the required radio resource. Advanced cellular communications systems may employ several data modulation schemes (e.g. quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM)) to transfer data with variable data rates. Additionally, several coding schemes may also be implemented with different effective code rates (ECR). In the radio resource request, the user equipment specifies the required data modulation schemes and code rates it uses. These transmission characteristics of the requested radio resource are typically specific to the user equipment and vary, for example, according to the supported data modulation and coding scheme supported by the user equipment. However, if the user equipment can support more than one data modulation and coding schemes, the transmission characteristics of the requested radio resource may even vary according to the communication instance, and the data modulation and coding scheme combination chosen for the instance.

When a radio resource request reaches the network infrastructure element, the network infrastructure element analyses from the request the relevant transmission characteristics, and if possible allocates a radio resource that corresponds to the transmission characteristics, rejects the request, or initiates a signalling procedure to re-negotiate with the user equipment new, achievable characteristics.

According to the invention, channel allocation is adjusted to take into consideration the interference to be generated by the requested radio resource to a defined group of neighbouring cells. The interference is determined (step 43) in the network infrastructure element on the basis of information on the transmission paths to the defined group of neighbouring cells, provided by the user equipment.

Figure 5 illustrates the step 43 of determining the interference in the embodied radio resource allocation method from the point of view of the user equipment 14. In general terms, the user equipment acquires the required information on the transmission paths to the defined group of neighbouring cells, and provides this information to the network infrastructure to be used in channel allocation decisions. More specifically, for handover purposes the user equipment continuously collects measurement data m_k, k=1,...,K, that provides basis for computing the properties of the transmission paths to a selected group of neighbouring cells (step 51). Here m denotes measurement data element, k denotes the identity of a cell, and K the number of cells in the selected group of cells.

Within the scope of protection, the selection of the group can be implemented in various ways. For example, the handover procedures utilize groups to which cells are classified according to the pilot signal of the radio link. As an example, an active set comprises cells that form a soft handover connection to the mobile station, a candidate set comprises cells that are not presently used in the soft handover connection, but whose pilot signals are strong enough to be added to the active set, and a neighbour set or monitored set is the list of cells that the user equipment continuously measures, but whose pilot signals are not strong enough to be added to the active set. The selection of the group can thus be a dynamic decision based on signal levels, for example, as in any of the above groups, or a static definition based on some other criteria, for example, geometric locations of the user equipment, etc.

The conventional measurement types comprise, for example, intra-frequency measurements, inter-frequency measurements, inter-system-measurements, traffic volume measurements, quality measurements and internal measurements of the user equipment transmission power and user equipment received signal level. In the emerging systems, some new measurement types may also be applied. The measurement events may be triggered based on several criteria, for example at change of best cell, change in defined pilot channel signal level, changes in the signal-to-noise (SIR) level, periodically, etc. Through these measurement procedures, the user equipment has a substantial basis for estimating the characteristics of the transmission paths to the selected group of surrounding cells.

According to the invention, the user equipment generates (step 52) from the measurement data m_k a plurality of measurement indications M_k that represent properties of the transmission paths to the k=1,...,K cells of the selected group, and thus serve as a basis for estimating interference to be generated to the selected group of cells by a particular radio resource of a user equipment. Depending on the complexity of the computations, and the processing capacity of the user equipment, the measurement indications M_k may be simple measurement data to be forwarded to the network side for further processing, or more or less computed values directly applicable for further analysis. In the embodied solution, the measurement indication M_k by the user equipment comprises advantageously values of measured path loss to the cells in the active group.

The user equipment sends (step 53) the measurement indications M_k of all the cells in the selected group of K cells to the controlling network infrastructure element such that they are available in the network infrastructure element at least at the time of the radio resource allocation. Transfer of measurement indication events can be triggered in line with some other measurement events, or be based on a separate scheme, for example take place periodically or at the time of connection setup.

Correspondingly, Figure 6 illustrates the step 43 of determining the interference in the embodied radio resource allocation method from the point of view of the network infrastructure element 216. In general terms, the network infrastructure element receives the information on the transmission paths to the defined group of neighbouring cells from the user equipment, and uses this information to select an appropriate radio resource block for the user equipment. More specifically, the network infrastructure element NIE_j receives (61) measurement indication values M_k from the user equipment. On the basis of the measurement indication values M_k, the network infrastructure element computes (step 62) one or more interference values $I_{j,k}$ that represent the effective interference to be incurred by the requested radio resource to the selected group of neighbouring cells. Effective interference relates herein to the interference that is considered relevant for the radio resource allocation and is associated with a particular computing method. Several different measurement indications are applicable. In the presently embodied example, the network infrastructure element NIE_j receives from the user equipment the computed path loss values p_k for the transmission path between the user equipment and the cells in its active group, and computes effective interference $I_{j,K}$ as total interference to the active group by the equation

$$I_j = \sum_{\substack{k=1 \\ k \neq j}}^{K} p_k$$

where j is the index of the own cell, p_k is the measured path loss to the kth cell, and K is the number of cells in the active set. Other computing methods, for example, weighted averages or the like are possible within the scope of protection.

In another embodiment of the invention, the network infrastructure element NIEj computes the effective interference $I_{j,K}$ on the basis of the Channel Quality Indicator (CQI) values, received from the user equipment. The CQI reporting concept is basically a concept for the downlink, and the user equipment is configured to measure CQI to be able to provide to the base station a metric, which indicates the current experienced channel quality. User equipment may, for example, suggest a radio resource transmission configuration that it needs to support while observing a certain block error probability. Different receiver implementations typically offer a different mapping between SINR and sustained throughput. A good downlink channel indicated by the CQI measurements of the user equipment means lower path loss and transmission power, and accordingly corresponds with lower interference to the selected group of neighboring cells. The user equipment generates measurement indications M_k in form of CQI measurements, which in this embodiment serve as a basis for estimating interference to be generated to the selected group of cells by a particular radio resource of a user equipment. The effective interference $I_{j,K}$ to be incurred by the radio resource associated with the user equipment to the selected group of neighbouring cells can be determined on the basis of the CQI values of the user equipment directly or through simple correlation.

According to the invention, the users are arranged into different radio resource blocks by allocating their radio resources according to a computed value that represent interference to be generated to defined neighbouring cells. Users whose requested radio resource is estimated to generate a similar interference to the surrounding cells, will be allocated to the same radio resource blocks. Accordingly, based on the computed total interference $I_{j,K}$ the embodied network infrastructure element selects (step 44) a radio resource block f_K from which the radio resource is to be allocated. In the embodied case, each of the frequency blocks 32, 33, 34, 35, 36 of the frequency band 30 correspond to a defined range of total interference values. The computation of the total interference provides a value $I_{j,K}$, for the interference. A corresponding frequency block may determined by comparing the value $I_{j,K}$, to the ranges, and choosing the frequency block in the range of which the value exits. The channel allocation may then be made from the determined frequency block. Channel allocation within a frequency block may be made using a selected multiple access scheme, for example, FDMA, CDMA, TDMA, etc., and the channel may utilize one or more radio resource units of the frequency block.

Through the invented mechanism, a plurality of user equipment that cause similar interference to relevant neighbouring cells becomes automatically arranged to the same frequency block. The power control of the user equipment classified to frequency blocks as described above can then managed separately, which gives rise to several advantages.

Cellular systems typically comprise a mechanism by which a network infrastructure element, like a base station, can command user equipment to increase or decrease the uplink transmission power. The comparison involving the received power is based on a predefined measurement parameter, for example, signal-to- interference ratio (SIR), signal-to-noise ratio, signal strength, Frame Error Ratio (FER) and Bit Error Ratio (BER). The base station receives the user equipment signal, estimates a pre-defined parameter, for example, signal-to-noise-power ratio and/or signal-to-interference-power ratio, compares the estimated value with a pre-defined threshold value and, when necessary, sends a transmission power command to the user equipment to increase or decrease its signal power.

When physical layer information of several cells is available to a controlling network element, the network infrastructure element is able to coordinate the allowed power levels of the cells and target SIRs to be used by the base stations. When exchange of physical layer information between base stations is limited, only methods that apply pre-defined control procedures and levels are practically possible. In addition, the size of cells in mobile communications systems varies considerably, which means that also the dynamic range for transmission path measurements, for example path loss measurements varies accordingly. With large and moderate cell sizes the dynamic range is adequate, and measurements of the transmission path within the own cell, and arranging users in frequency blocks accordingly would already be enough to provide the increased performance. However, with smaller size cells the dynamic range for, for example, path loss measurements becomes correspondingly smaller, and the granularity of the path loss measurements within the own cell may in some cases be deficient. The full effect of the information received from the user equipment is achieved by utilizing information on the plurality of transmission paths to the neighbouring cells.

In a typical environment, signals transmitted from user terminals located close to a base station are expected to induce a smaller interference to the neighbouring cells and signals transmitted from user terminals distant to a base station (i.e. located at the edge of a cell) a more significant interference. User terminals located at the edge of the cell are likely to be allocated to the same sub-block and the user terminals located close to the base station to the same sub-block, which means that the negative effect of "near-far" problem is reduced.

In addition, the classification is based, not only on the path loss in the own cell, but on information or estimates on a comprehensive amount of radio links to the surrounding cells and is therefore more accurate and thus effective, even with smaller cell sizes. The reduced interference results in increased overall performance and system capacity.

In the embodied example, the base station receives the user equipment signal, estimates a pre-defined parameter, for example, signal-to-noise-power ratio and/or signal-to-interference-power ratio, compares the estimated value with a pre-defined threshold value and, when necessary, sends a transmission power command to the user equipment to increase or decrease its signal power. According to the invention, the system may set (step 45) a different target value for each radio resource block such that high signal-to-noise-power ratio and/or signal-to-interference-power ratio can be used in radio resource blocks where user equipment generate only moderate interference to the other cells. Correspondingly, in the radio resource blocks where interference to the other cells is considerable, lower signal-to-noise-power ratio and/or signal-to-interference-power ratio needs to be used. When the power is adjusted (step 46) according to the improved method, the user equipment that generates moderate interference may be commanded to use higher transmission power and thus achieve higher throughput, while the transmission power of the more interfering user equipment can be effectively controlled at the same time. Use of similar classification criteria in all the cells results in increased throughput rates and higher overall performance of the system.

An embodiment of the invention may be implemented as a computer program comprising instructions for executing a computer process for radio resource allocation of a cellular telecommunication system. The computer program may be executed in the processing unit 218 of the network infrastructure element 216. The network infrastructure element 216 represents herein a logical element the processes of which can be performed in the processing unit of one network entity, or as a combination of processes performed in the processing units of a base station, radio network controller, or even some other elements (for example, servers, router units, switches, etc) of the telecommunication unit.

The computer program may be stored on a computer program distribution medium readable by a computer or a processor. The computer program medium may be, for example but not limited to, an electric, magnetic, optical, infrared or semiconductor system, device or transmission medium. The medium may be a computer readable medium, a program storage medium, a record medium, a computer readable memory, a random access memory, an erasable programmable read-only memory, a computer readable software distribution package, a computer readable signal, a computer readable telecommunications signal, and a computer readable compressed software package.

Even though the invention has been described above with reference to examples in conjunction with the accompanying drawings, it is clear that the invention is not restricted thereto but it can be modified in several ways within the scope of the appended claims.

CLAIMS

1. A radio resource allocation method, comprising:

dividing radio resource of a plurality of cells into more than one radio resource blocks,

detecting in a cell a requirement of radio resource allocation for a user equipment;

determining effective interference to be generated by the required radio resource to a defined group of neighbouring cells; and

allocating to a user equipment a radio resource from one of the radio resource blocks on the basis of the determined effective interference to be generated to the defined group of neighbouring cells.

2. A method as claimed in claim 1, where in the radio resource is a frequency band and the step of dividing comprises dividing the frequency band into more than one frequency sub-bands, each frequency sub-band comprising one or more frequency units.

3. A method as claimed in claim 1 or 2, where

the step of determining comprises:

receiving in the user equipment information indicating properties of one or more transmission paths to one or more neighbouring cells;

generating in the user equipment from the received information corresponding one or more measurement indication;

sending from the user equipment the measurement indication to a network infrastructure element responsible for allocating the radio resource; and

computing in the network infrastructure element responsible for allocating the radio resource the effective interference on the basis of the measurement indications received from the user equipment.

4. A method as claimed in claim 3, where the step of generating comprises generating measurement indications indicating path loss to a defined group of cells; and the step of computing comprises computing the effective interference as total path loss to the defined group of cells.

5. A method as claimed in claim 4, wherein the defined group of cells is the active group of the user equipment.

6. A method as claimed in claim 3, where the step of generating comprises generating measurement indications providing channel quality indi-

cations (CQI); and the step of computing comprises computing the effective interference from the received channel quality indications.

7. A method as claimed in any of the preceding claims, further comprising controlling transmission power of the user equipment on the basis of the radio resource block of the allocated radio resource.

8. A method as claimed in claim 7, further comprising controlling transmission power by using same SIR target with the radio resources of the same radio resource block.

9. A cellular communication system comprising a plurality of user equipment and a network infrastructure, wherein radio resource of the plurality of cells is divided into more than one radio resource blocks, and a network infrastructure element is configured to

detect a requirement of radio resource allocation for a user equipment;

determine effective interference to be generated by the required radio resource to a defined group of neighbouring cells; and

allocate to the user equipment a radio resource from one of the radio resource blocks on the basis of the determined effective interference to be generated to the defined group of neighbouring cells.

10. A system as claimed in claim 9, where in the radio resource is a frequency band and the frequency band is divided into more than one frequency sub-bands, each frequency sub-band comprising one or more frequency units.

11. A system as claimed in claim 9 or 10, where

the user equipment is configured to

receive information indicating properties of one or more transmission paths to one or more neighbouring cells;

generate from the received information corresponding one or more measurement indication;

send the measurement indication to a network infrastructure element responsible for allocating the radio resource; and

the network infrastructure element responsible for allocating the radio resource is configured to compute the effective interference on the basis of the measurement indications received from the user equipment.

12. User equipment for a cellular communication system, configured to

receive information indicating properties of one or more transmission paths to one or more neighbouring cells;

generate from the received information corresponding one or more measurement indication;

send the measurement indication to a network infrastructure element responsible for allocating the radio resource.

13. User equipment as claimed in claim 12, wherein the defined group of cells is the active group of the user equipment.

14. A control unit for network infrastructure element with a defined radio resource, the control unit being configured to

divide the radio resource of the network infrastructure element into more than one radio resource blocks;

detect a requirement of radio resource allocation for a user equipment;

determine effective interference to be generated by the required radio resource to a defined group of neighbouring cells; and

allocate to the user equipment a radio resource from one of the radio resource blocks on the basis of the determined effective interference to be generated to the defined group of neighbouring cells.

15. A control unit as claimed in claim 14, where the radio resource is a frequency band and the frequency band is divided into more than one frequency sub-bands, each frequency sub-band comprising one or more frequency units.

16. A control unit as claimed in claim 14 or 15, where the network infrastructure element is configured to

receive from the user equipment one or more measurement indications corresponding to properties of one or more transmission paths to one or more neighbouring cells; and

compute the effective interference on the basis of the one or more measurement indications received from the user equipment.

17. A control unit as claimed in claim 16, where the one or more measurement indications indicate path loss to a defined group of cells; and the network infrastructure element is configured to compute the effective interference as total path loss to the defined group of cells.

18. A control unit as claimed in claim 17, wherein the defined group of cells is the active group of the user equipment.

19. A control unit as claimed in claim 16, wherein the one or more measurement indications provide channel quality indications (CQI); and the network infrastructure element is configured to compute the effective interference from the received channel quality indications.

20. A control unit as claimed in any of the preceding claims, configured to control transmission power of the user equipment on the basis of the radio resource block of the allocated radio resource.

21. A control unit as claimed in claim 20, configured to control transmission power by using same SIR target with the radio resources of the same radio resource block.

22. A control unit as claimed in any of the preceding claims, wherein the control unit is implemented as an integrated circuit.

23. A network infrastructure unit comprising a control unit of any of claims 14 to 22.

24. A computer program product encoding a computer process of instructions for executing a computer process for a radio resource allocation method, the process including:

dividing radio resource of a plurality of cells into more than one radio resource blocks,

detecting in a cell a requirement of radio resource allocation for a user equipment;

determining effective interference to be generated by the required radio resource to a defined group of neighbouring cells; and

allocating to a user equipment a radio resource from one of the radio resource blocks on the basis of the determined effective interference to be generated to the defined group of neighbouring cells.

25. A computer program distribution medium readable by a computer and encoding a computer program of instructions for a radio resource allocation method of managing configuration of user equipment, the process including:

dividing radio resource of a plurality of cells into more than one radio resource blocks,

detecting in a cell a requirement of radio resource allocation for a user equipment;

determining effective interference to be generated by the required radio resource to a defined group of neighbouring cells; and allocating to a user equipment a radio resource from one of the radio resource blocks on the basis of the determined effective interference to be generated to the defined group of neighbouring cells.

26. The computer program distribution medium of claim 25, the distribution medium comprising a computer readable medium, a program storage medium, a record medium, a computer readable memory, a computer readable software distribution package, a computer readable signal, a computer readable telecommunications signal, and a computer readable compressed software package.

Fig. 1

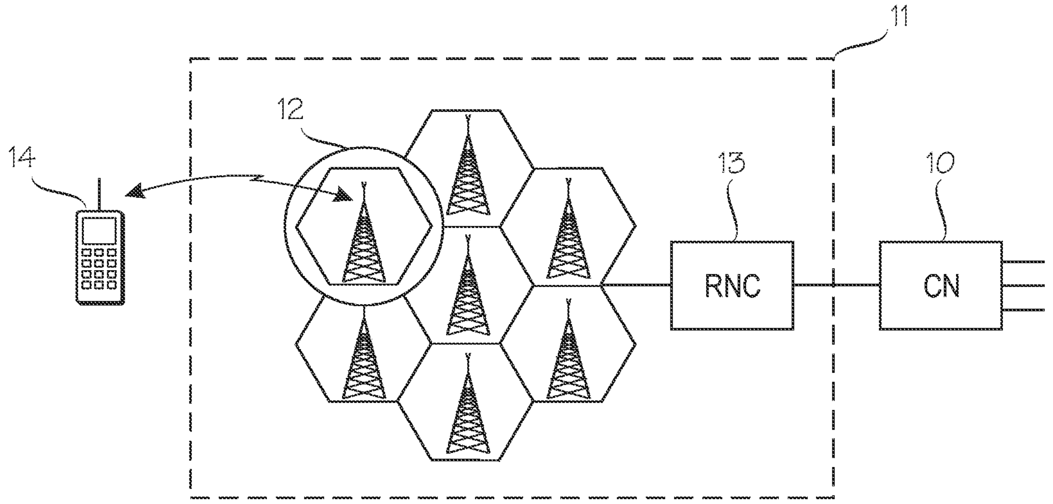


Fig. 2

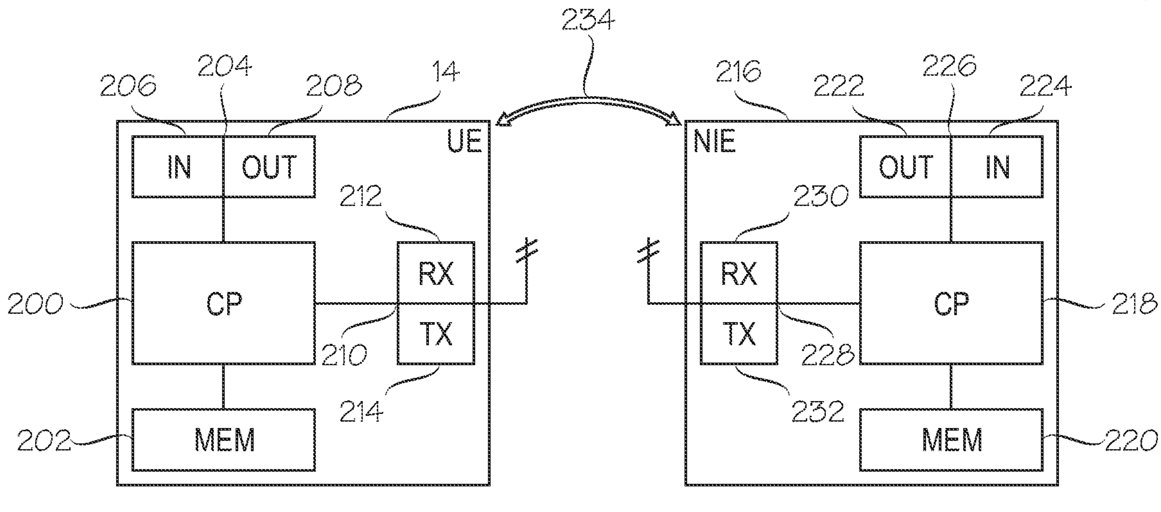


Fig. 3

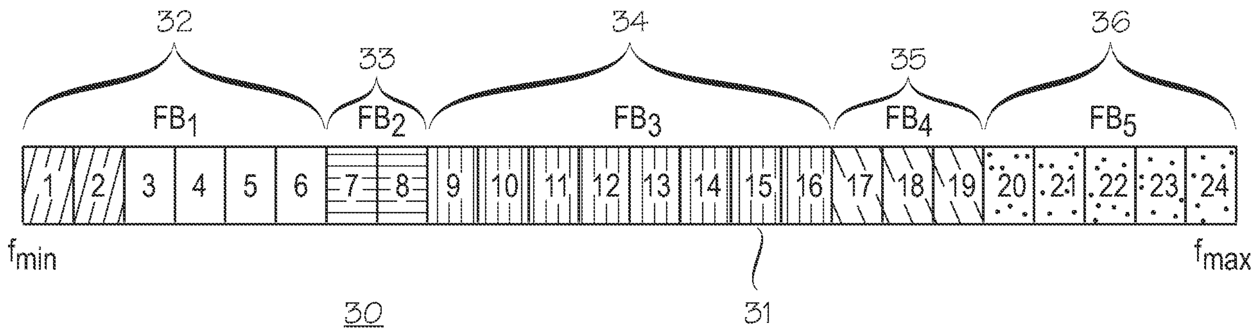


Fig.4

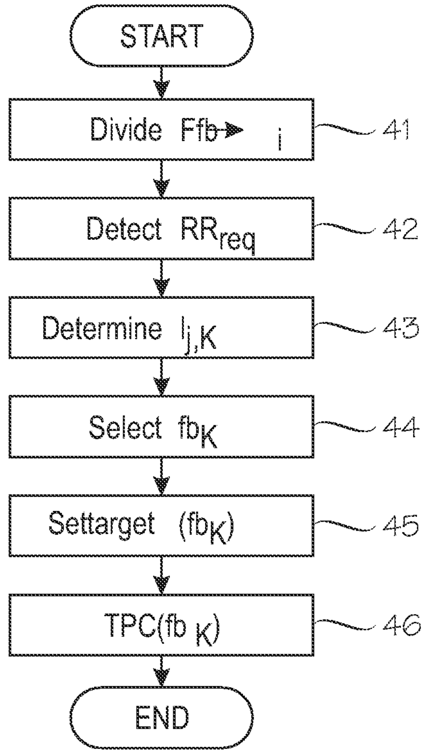


Fig.5

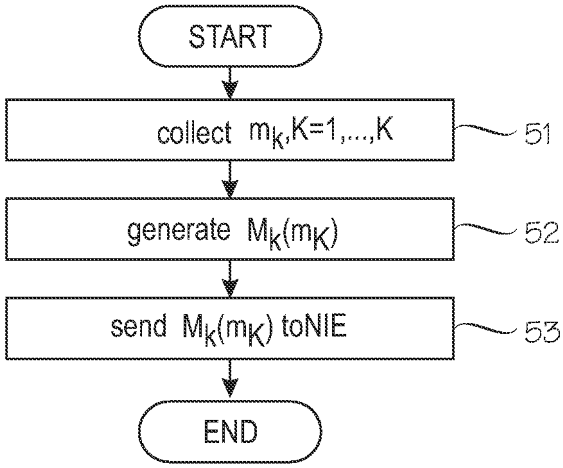
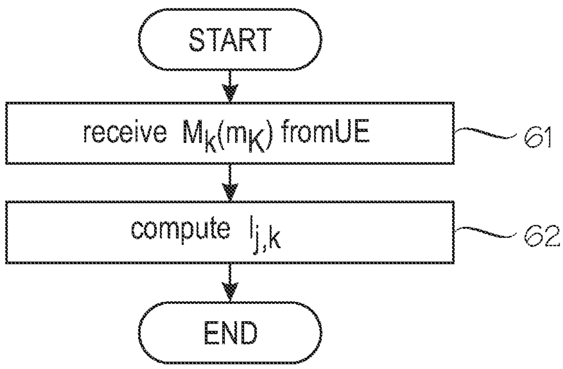


Fig.6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2006/050324

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC8: H04Q

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

DK, FI, NO, SE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1603356 A2 (SAMSUNG ELECTRONICS CO LTD et al.) 07 December 2005 (07.12.2005)	1 - 26
A	EP 1589776 A1 (ERICSSON TELEFON AB L M) 26 October 2005 (26.10.2005)	1 - 26
A	US 2005/0009532 A1 (CUFFARO ANGELO et al.) 13 January 2005 (13.01.2005)	1 - 26

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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

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

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

"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
29 January 2007 (29.01.2007)	23 March 2007 (23.03.2007)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2006/050324

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		WO 2005008933 A2	27/01/2005

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
H04Q 7/36 (2006.01)
H04Q 7/38 (2006.01)