

WIRELESS TELECOMMUNICATIONS SYSTEMS

The present invention relates to wireless telecommunications systems, and in particular to resource allocation in wireless telecommunications systems.

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BACKGROUND OF THE INVENTION

Wireless telecommunications systems typically use a cellular structure in which a plurality of basestations define respective communications cells, and mobile terminals within those cells communicate with the corresponding basestation. A basestation allocates communication resources (typically time-frequency blocks) to each mobile terminal within its cell, for enabling communications between the mobile terminal and the basestation.

As a mobile terminal moves around a cell, the radio conditions that it experiences change. In some locations, such as those at an edge region of the cell, high transmission power may be required in order for data to be successfully transmitted between the mobile terminal and the basestation.

However, as a mobile terminal approaches a cell border, the high transmission powers can cause the mobile terminal to disturb communications in a neighbouring cell. In addition, or alternatively, communications from the mobile terminal may be disturbed by communications within the neighbouring cell.

In addition, the handover from one basestation to another will cause the mobile terminal to make an unsynchronised random access in the destination cell. The random access will add to the handover interruption time.

Furthermore, the frequency planning of cell-border mobile terminals is difficult: either a static distribution (for example, 1/3) reuse scheme is used, or a fractional load scheme. However, neither of these schemes gives optimum performance.

Accordingly, it is desirable to provide a technique that can mitigate the effects of mobile terminals disturbing neighbouring cells.

SUMMARY OF THE PRESENT INVENTION

According to one aspect of the present invention, there is provided a wireless
5 telecommunications system comprising a first basestation which defines a first
communications cell, and which is operable to communicate with mobile terminals
located within the first communications cell, a second basestation which defines a
second communications cell, and which is operable to communicate with mobile
10 terminals located within the second communication cell, a resource allocation unit
operable to allocate communication resources within the second communications cell,
a detector operable to detect a mobile terminal within the first cell, which mobile
terminal has a communications quality below a threshold level, the detector being
operable to communicate information relating to such a mobile terminal to the resource
15 allocation unit, wherein the resource allocation unit is operable to receive information
relating to such a mobile terminal from the detector, and to allocate resources within
the second communications cell using such received information.

The detector may be provided by the first basestation, and the resource allocation unit
may be provided by the second basestation. The first basestation may be operable to
20 transmit information relating to a detected mobile terminal to the second basestation.

The resource allocation unit may be operable to allocate communications resources
within the second cell so as to avoid resources allocated to the detected mobile
terminal from the first cell.

25 A second resource allocation unit may be provided in the first basestation, and such a
unit may be operable to allocate communications resources within the first
communications cell so as to avoid allocated resources in the second communications
cell.

30 The resource allocation unit may be operable to allocate communications resources
within the second cell without reference to the information relating to such a detected
mobile terminal.

According to one aspect of the present invention, there is provided, a method for allocating communication resources in a wireless telecommunications system including a first basestation which defines a first communications cell, and which is operable to communicate with mobile terminals located within the first communication cell, and a
5 second basestation which defines a second communications cell, and which is operable to communicate with mobile terminals located within the second communication cell, the method comprising detecting a mobile terminal which is communicating within the first communications cell with a communication quality below a threshold level, allocating communications resources for the second cell using
10 information relating to such a detected mobile terminal.

Detecting such a mobile terminal may be performed by the first basestation. Allocating resources for the second cell may be performed by the second basestation. Such a method may further comprise transferring information relating to such a detected
15 mobile terminal from the first basestation to the second basestation.

Allocating communications resources may comprise allocating resources for mobile terminals within the second cell so as to avoid resources allocated to the detected mobile terminal from the first cell.
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Allocating resources for the first communications cell may use the first basestation, and preferably avoids allocated resources in the second communications cell.

Allocating communications resources may comprise allocating resources for mobile terminals within the second cell without reference to the information relating to such a
25 detected mobile terminal.

The information relating to such a detected mobile terminal may relate to scheduling of communications for that mobile terminal within the first cell.
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The information relating to such a detected mobile terminal may be transmitted from the first basestation to the second basestation using an X2 communications interface.

The information relating to such a detected mobile terminal may includes information relating to possible disturbance of the second cell of the mobile terminal.

5 According to another aspect of the present invention, there is provided a basestation for use in a wireless telecommunications system, the basestation defining a communications cell, and being operable to communicate with mobile stations located within the communications cell, and comprising a resource allocation unit operable to receive information relating to a mobile terminal operating in another communications cell, and to allocate communication resources within the communications cell, in
10 dependence upon such received information.

Such a basestation may include a detector operable to detect a mobile terminal operating within the communications cell, which mobile terminal has a communications quality below a threshold level, the detector being operable to transmit information
15 relating to a detected mobile terminal to another basestation.

The resource allocation unit may be operable to allocate communications resources within the communications cell so as to avoid resources allocated to the detected mobile terminal from the other communications cell.

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According to another aspect of the present invention, there is provided a basestation for use in a wireless telecommunications system, the basestation defining a communications cell, and being operable to communicate with mobile stations located within the communications cell, and comprising a detector operable to detect a mobile
25 terminal operating within the communications cell, which mobile terminal has a communications quality below a threshold level, the detector being operable to transmit information relating to a detected mobile terminal to another basestation.

30 Mobile terminals having low quality radio conditions and/or high transmission power are treated somewhat differently from mobile terminals which are closer to the basestation.

Embodiments of the present invention may give the following benefits:

- No reserved cell-edge frequency pools are required for 1/3 or similar reuse. The cell-edge blocks are reserved, and released, as the load changes.
- The second basestation can chose to accept the reservation and avoid using the corresponding resource blocks, or, if the load is too high, reject it.
- 5 • The signalling can include quality of service (QoS), etc. and therefore better control of the second target basestation usage is possible compared to a mere opportunistic approach.
- The mobile terminal is also a very high candidate for a future handover to the second basestation. The second basestation may get an opportunity to measure
- 10 the mobile terminal to allow for a synchronous handover.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram illustrating a wireless telecommunications system;
 15 Figure 2 is a block diagram illustrating a basestation embodying one aspect of the present invention;
 Figures 3, 4 and 5 are flow charts illustrating steps in methods embodying various aspects of the present invention;
 Figures 6 to 10 illustrate resource allocation in a wireless telecommunications system.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a schematic diagram of a wireless telecommunications system 1 which is operable in accordance with an aspect of the invention. The system 1 of Figure 1
 25 includes core network (CN) resources 2, a first basestation 6, and a second basestation 8. The first basestation 6 defines a first communications cell in which communications with mobile terminals are handled by the first basestation 6. Similarly, the second basestation 8 defines a second communications cell in which communication with mobile terminals are handled by the second basestation 8. An
 30 exemplary mobile terminal (or user equipment UE) 4 is illustrated in Figure 1. Each of the basestations is able to communicate with the core network resources 2 for call routing and other tasks, as is well known and understood, using signalling links S1₁ and S1₂. In addition, the first and second basestations 6 and 8 are able to communicate with one another using a communications route (or interface) X2.

It will be readily appreciated that the system of Figure 1 is simplified, and that, in practice, a system will have many basestations defining respective communications cells. Such a system is able to provide communications for many mobile terminals.

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As mentioned above, the mobile terminal 4 communicates with a single basestation at any one time, and, as the mobile terminal moves around the area covered by the system, the mobile terminal will cross cell boundaries, and so communication will need to be transferred to the next basestation. This process is known as "handover".

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In the following description, the mobile terminal 4 is assumed to be at an outer limit of the communications cell defined by the first basestation 6, and that, therefore, the quality of the communications with the mobile terminal 4 is relatively low. The mobile terminal 4 can be considered to be in a "bad" radio environment, which is one that requires high output power to enable successful transmission. This high output power, however, means that the mobile terminal 4 is likely to interfere with, or disturb, communications in a neighbouring cell, in the example shown, the second cell defined by the second basestation 8. Alternatively, or additionally, the mobile terminal 4 may have its communications with the first basestation disturbed by the communications in the second cell.

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The embodiments of the present invention are intended to mitigate these disturbances.

The structure of a basestation embodying one aspect of the present invention will now be described with reference to Figure 2. Typically, in a wireless telecommunications system, each basestation will be substantially the same as the next. Thus, the description of the basestation shown in Figure 2 applies to both the first and second basestations shown in Figure 1. The basestation of Figure 2 includes a controller 10 for controlling the overall operation of the basestation. The controller 10 is able to communicate with the core network resources. The basestation also includes a radio frequency (RF) transmitter (TX)/receiver (RX) unit 12 for communicating with mobile terminals via an antenna 18 in known manner.

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In an embodiment of the present invention, the basestation includes a detector 14 and a resource allocation unit 16. It will be readily appreciated that the detector 14 and resource allocation unit may be provided by the controller 10 or other appropriate means. The controller 10 is able to communicate with other basestations using an interface connection X2 20.

Operation of the basestation of Figure 2 will now be described with reference to Figures 1 and 2, and to the flow charts of Figures 3, 4 and 5.

Figure 3 is a flow chart illustrating a process performed in the first radio basestation 6. At steps 101 and 103, the detector 14 detects the communications of a mobile terminal within the first cell, and determines a quality measure of those communications by determining downlink communication (that is mobile terminal to basestation communication) quality. This is achieved by interpreting downlink (DL) measurements that have been reported from mobile terminals with bad radio conditions in the first cell. The DL radio conditions are known from the number of retransmissions that are required for successful transmission of data to be achieved, together with the output power used for those retransmissions. This information is known by the first radio basestation. The DL radio conditions can also be derived from the mobile terminal quality measurements reported to the basestation. Determining the uplink (UL) radio conditions can be achieved in a number of ways. For example, the DL radio conditions can be assumed to provide a fair picture of the UL conditions to the first radio basestation. Alternatively, the first radio basestation 6 can detect the number of transmission required by the mobile terminal 4 in order that data is received by the basestation successfully. This information can be combined with the power levels instructed to the mobile terminal, and with the first radio basestation's quality measurements. The expected interference contribution in the cell, for the chosen mobile terminal, can therefore be derived. As a result, it is possible to determine whether or not the mobile terminal 4 disturbs a neighbouring cell.

At step 105, it is determined whether the quality measure is below a threshold value, that is, it is determined whether the communications with the mobile terminal are of high enough quality. If they are, then the detector reverts to step 101, and detects another mobile terminal.

If the communications do not reach the required quality, for example when the mobile terminal is at an edge of the first cell and requires high output power, the details of the mobile terminal are stored as part of a candidate list. This candidate list represents
 5 mobile terminals that may be disturbing, or being disturbed by, one or more neighbouring cells. In the present example, it is assumed that the mobile terminal 4 is at the edge of the first cell bordering the second cell, and that, therefore, disturbance is likely between the mobile terminal 4 and the second cell.

10 In a practical embodiment of the invention, many mobile terminals will be communicating in each cell, and so the candidate list is likely to include many mobile terminals.

For each of the mobile terminals on the candidate list, at step 107, the controller 10
 15 obtains measurements from the mobile terminal of the neighbouring cells. Such measurements are obtained from determining pilot channel signals from the neighbouring cells. The measurements are returned to the basestation by the mobile terminal, preferably in the form of a RRC message. From this information, the cell disturbance levels (both by and to the mobile terminal) are determined (step 109).

20 The cells that then appear to be disturbed or disturbing (the so-called "target cells") are then added to a cell list (step 111). A cell list is created for each identified mobile terminal.

25 The controller 10 then transmits information concerning the disturbing or disturbed mobile terminals to the appropriate basestations for the target cells on the cell list of the mobile terminal concerned. In the example being described, details of the mobile terminal 4 are sent by the first basestation 6 to the second basestation 8, via the interface X2.

30 Figure 5 is a flow chart illustrating a process performed in the basestations of the target cells. For the sake of simplicity, a single operation at the second basestation 8 will be described for the single mobile terminal 4 will be described. It will be readily

appreciated that such a process can be carried out for as many mobile terminals and cells as appropriate.

At step 115, the information relating to the mobile terminal 4 is received at the second
5 basestation 8 from the first basestation 6. The information preferably contains at least
scheduling and resource allocation information for the mobile terminal 4. At step 117,
the resource allocation unit 16 of the second basestation evaluates the scheduling
information for the mobile terminal 4 in order to confirm whether or not it will disturb the
10 second communications cell. This evaluation is described in more detail below. The
resource allocation unit 16 then proceeds to allocate resources for the second cell
(step 119) using the received information.

If it is determined that the mobile terminal 4 will not, in fact, disturb the cell, or be
disturbed by the cell, then the received information is discarded and resource allocation
15 for the second cell is performed without reference thereto.

If, however, it is determined that the mobile terminal 4 is disturbed by, or is disturbing,
the second cell, then there exist several options for allocation of resources for the
20 second cell.

For example, the resource allocation unit 16 may terminate the scheduling of any of its
existing mobile terminals using the time/frequency period in which the disturbance
occurs. This may be possible, for example, through rescheduling its existing mobile
25 terminals to a time/frequency period different to that of the disturbing/disturbed mobile
terminal 4.

An alternative is for the second basestation to schedule only mobile terminals with
good radio conditions in the disturbed time/frequency period. This will serve to reduce
the interference, since good radio conditions suggest that low transmission powers are
30 used, and so the likelihood of disturbance is reduced.

The second basestation 8 may also take steps to avoid scheduling new users in the
disturbed time/frequency period, thus reducing any further possible disturbance.

The approach requires that the scheduling is deterministic for at least a few 10 ms ahead. Deterministic allocation requires significant latency (10-100 ms) to ensure that all affected basestations are made aware of the intended scheduling, before it occurs.

5 The effects of latency may be handled differently for different transmission situations:

- Best efforts. Best effort data is not latency sensitive. The resource allocation decision can be made many milliseconds in advance.
- 10 • Voice/video telephone. Voice/video codecs are very predictive and so resource allocation can be made for a long duration of time, i.e. a mobile terminal will be allocated X basic resource blocks every 20 ms, and according to a specific frequency hopping scheme. The first scheduled message/messages may not be known by the other basestations, but once the scheme is received the other basestations can counteract.
- 15 • Quality of Service (QoS) non-predictive services. These are services which are unknown but have requested high QoS. The amount of data to be transmitted cannot be assumed to be small. Such communications can be handled by each basestation reserving a part of the bandwidth (or time domain) for high-interfering mobile terminals. In some techniques, this is a static part of the bandwidth and denoted "1 reuse on cell centre and >1 reuse on cell border". In accordance with
20 the principles of the present invention, this reserved area can grow and decrease based on the actual need in the cell. When a QoS non-predictive service is initiated the corresponding expected bandwidth is "reserved" and signalled to the neighbouring cells. This can either be done by reserving a portion of the
25 bandwidth or by reserving a frequency-hopping scheme of certain bandwidth.

Figures 6 to 10 will now be described in order to explain resource allocation according to an aspect of the present invention. In these Figures, the grid represents exemplary basic resource blocks, where the horizontal axis indicates the time duration of a block,
30 and the vertical axis indicates the frequency bandwidth of a block. Each mobile terminal has one or more contiguous blocks allocated for communications.

Figure 6 illustrates an example of allocation of resources block to the mobile terminal 4 by the first basestation 6. Blocks A in Figure 6 indicate the resource blocks allocated to the mobile terminal 4.

- 5 As mentioned above, when the first basestation determines that the second cell may be disturbed by, or disturbing, the mobile terminal 4, the first basestation transmits information concerning the intended resource allocation for the mobile terminal 4.

- 10 Figure 7 illustrates an example of intended resource allocation in the second cell by the second basestation 8. As can be seen in Figure 7, mobile terminals B, C, D, E, F, and G are allocated resources in the second cell.

- 15 Figure 8 illustrates how the intended allocation for the mobile terminal 4 (shown by blocks A) conflicts with the intended allocation for the existing mobile terminals in the second cell. Accordingly, assuming that the second basestation 8 determines that the mobile terminal 4 will disturb communications for at least some of the existing mobile terminals in the second cell, the second basestation must reallocate resources in order to avoid disturbance.

- 20 Figure 9 illustrates a possible reallocation scheme for the second cell, in which the allocated resources for the existing mobile terminals and the mobile terminal 4 are arranged so as not to overlap or disturb one another.

- 25 The second basestation 8 reallocates its resources in order to ensure a proper communications with the existing mobile terminals in the second cell. In addition, the second basestation 8 can detect, at least, the envelope of the signal from the mobile terminal 4, so as to determine the amount of possible disturbance caused by the mobile terminal 4. Typically, the second basestation 8 will not be able to decrypt the signal from the mobile terminal 4, and so only the signal envelope is available to be measured. However, in one alternative example, the second basestation 8 is able to
30 decrypt communications from the mobile terminal 4, and so is able to measure timing (offset from ideal), signal quality (e.g. signal to noise ratio), and/or signal strength.

In addition to the second basestation 8 reallocating resources in the second communications cell, the first basestation can reallocate resources for the first cell using the information gathered for the mobile terminal 4. The reallocation of resources in the first and second communications cells can serve to optimise the capacity of those cells.

When allocating resources for the first and/or second communications cells, frequency hopping techniques can be used in order to obtain frequency diversity frequency hopping schemes are particularly relevant to longer term resource allocation.

Since a disturbing, or disturbed, mobile terminal will be unsynchronised in the time domain with respect to the second cell, it is preferable schedule the mobile terminal over resource blocks that are continuous in the time domain, rather than in the frequency domain. Such allocation is illustrated in Figure 10. The allocation B is contiguous in the frequency domain; and it can be seen that this allocation disturbs a large number of blocks in the time domain. In contrast, the allocation C disturbs only two blocks in the time domain.

Each basestation can maintain a "buffer" of resource block hopping sequences. This is similar to a static configuration, but the size of the allocated bandwidth (BW) is set to a small value – to allow for moving mobile terminals to a "protected" BW fast and with low requirements on the communications interface X2, but without allocating a significant part. The "buffer" is updated on second-to-second basis to minimise wasted BW but to maintain a small margin for new mobile terminals with bad signal quality. The update of buffer can include the current usage of the sequences to allow for timing advance measurements by the probable target cells.

In one example, the second basestation 8 is able to report to the first basestation 6, via the communications interface X2, on the measurements taken regarding the mobile terminal 4. For example, if the second communication cell is heavily disturbed by the mobile terminal 4, then the second basestation 8 can propose handover of the mobile terminal from the first basestation 6 to the second basestation 8. Alternatively, the first basestation 6 could lower the data rate allocated to the mobile terminal 4, thereby

reducing the transmission power required, and reducing possible disruption to the second communications cell.

Another possibility is for the second basestation 8 to transmit data to the mobile terminal 4, such data being supplied to the second basestation 8 from the first basestation 6, via the communications interface X2. Such data transmission results in downlink macro diversity. The first basestation 6 provides both the payload data to transmit and the channel coding, modulation and possible scrambling to use. The second base station 8 outputs the data according the channel coding, modulation and possible scrambling. The mobile terminal 4 will receive the same signal from both the first and second basestation. However, scheduling control and retransmission control will only be sent from the first basestation 6. Uplink macro diversity can be achieved by the second basestation 8 forwarding the received data from mobile terminal 4 to the first basestation 6. If the data received by the receiver of the first basestation 6 is insufficient for successful decoding of the mobile terminal 4 uplink information, the first basestation 6 can use the forwarded data from second basestation 8. The acknowledgement or retransmission request sent back to the mobile terminal 4 by the first basestation 6 is based on one or both of the received pieces of data. A drawback with uplink macro diversity as described here is an extra delay imposed due to the communication path between the first and second basestation. The delay will add up to hundreds of microseconds extra delay before the data received from the second basestation 8 is received and ready to be used by the first basestation 6, and thus extra delay before a acknowledgement or retransmission request can be sent to the mobile terminal 4. The extra delay will not have significant system degradation.

Both UL and DL macro diversity will work best where the basestation to basestation distance is small as the difference in path delay between each basestation and the mobile will be within the range the receiver, in the mobile and the basestation respectively, is required to be able to compensate for. Typically, basestation-basestation distance of 2 km can easily be handled. For distances larger than that, the communication for the second basestation 8 to the mobile terminal 4 will have another timing (advanced or delayed) compared to the mobile terminals in the cell controlled by the second basestation.

CLAIMS

1. A method to be performed by a second base station (8) serving mobile terminals with communications in a second cell, and wherein a first cell served by a first base station (6) is neighboring the second cell, the method comprising the steps of;

- scheduling communication resources among the mobile terminals (4) in the second cell, characterized by the further steps of:
- receiving (115) information from the first base station, on resources scheduled in the first cell to a first mobile terminal that is determined to be disturbing or disturbed by communications in the second cell;
- avoid (117, 119) scheduling, at least to one or more mobile terminal on the cell edge, resources in the second cell that have been scheduled to the first mobile station in the first cell.

2. The method of claim 1 comprising the further step of, determining (117) whether the first mobile terminal is disturbing the second cell or not, wherein the avoiding step is entered on condition the second base station evaluates the first mobile terminal is disturbing.

3. The method of claim 1 wherein the second and the first cells are assigned at least partly overlapping frequency spectrum for scheduling to the mobile terminals served by the respective cell.

4. The method of claim 1 or 3 wherein the second base station (8) is operable to communicate data with the first mobile terminal (4) without the first mobile terminal registering with the second base station (8).

5. The method of claim 1 or 4 wherein the second base station (8) is operable to receive data for transmission to the first mobile terminal (4) from the first base station (6) .

6. The method of claim 1, 4, or 5 wherein the second base station (8) is operable to receive data for transmission to the first base station (6) from the first mobile terminal (4).

7. The method of claim 1, wherein determination of whether any of said second cell mobile terminal is/are on the cell edge or not is based on transmission power used for the communication with respective of said second cell mobile terminals.

8. A base station (8) for use in a wireless telecommunications system and arranged for supporting communications with mobile terminals in at least a second cell, and comprising:

- an interface for communicating with at least a first base station serving communication in a first cell that neighbors the second cell;
- a resource allocation unit (16) operable to schedule resources among mobile terminals in the second cell, characterized by:
- said resource allocation unit operable to avoid scheduling some blocks of resources in the second cell at least to mobile terminals that are determined to be on the cell edge, in response to information received from the first base station that said blocks of resources has been scheduled in a first cell to a mobile terminal that is expected to be disturbing or disturbed by the second cell.

9. The base station of claim 8 and that is arranged to operate on a frequency band that is commonly used by the first and the second cells.

10. The base station of claim 8 or 9 wherein said blocks of resources are blocks in time and frequency domain.

11. The base station of claim 8 or 9 and that is arranged to communicate data with the first mobile terminal (4) without the first mobile terminal having registered with the second base station (8).

12. The base station of claim 8, 9, or 11 and that is arranged to receive data for transmission to the first mobile terminal (4) from the first base station (6).

13. The base station of claim 8, 9, 11, or 12 and that is arranged to receive data for transmission to the first base station (6) from the first mobile terminal (4).

14. The base station of claim 8, and that is further arranged to determine whether any of said mobile terminals in the second cell is/are on the cell edge based on the transmission power used for the communication with the respective second cell mobile terminal.