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Abstract			
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Operational rules for self-organized radio deployment

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Introduction

We present in this contribution an approach for self-organization of radio networks which has two main targets:

- Protection of the cell size and the associated traffic for certain cells, to be named “protected cells”. Example of such cells are the macro-cells, which might suffer, for example, from the interference created by a femto-BS (Base Station) to a MS (mobile or fix subscriber) operating in the femto-BS vicinity;
- Operation with reduced interference of the other cells.

It is assumed that an operator can provision the different Base Stations to belong to one of the following categories:

- Cat.1 – Protected cells, for example macro-cells;
- Cat.2 – Regular cells, for example micro-cells;
- Cat.3 – Cells including BSs or MSs having the ability of creating harmful interference to the MSs of the other cells, as femto cells. The requirements for the Femtocell operation are detailed in [1].

Overlapping deployment scenarios are possible between these types of cells. With the exception of the femto-cells, which may not belong to the mobile operator, the BS-MS interference can be simply resolved by the hand-over of the MS to the BS which is creating interference to it. In case of the femtocells, the hand-over is limited to those situations where user’s access is allowed by the target cell. Due to this, the most important scenario to be resolved is the overlapping between femto-cells and the other cells.

It is assumed that the operator will provision each possible operating radio channel in accordance with the basic sharing scenario, indicating which categories of cells may share the radio channel.

As an example, the protected cells or regular cells may share the channel with femto cells.

For self-organization at radio level, the operator or a rule in the standard will establish the minimum OFDMA and time resources to be reserved for Control and Data channels of different cell types.

Each system will chose the operational frequency-time resources based on this simple provisioning and a set of interference assessment and avoidance rules, to be further explained. No frequency planning or inter-cell communication will be necessary for the basic operation.

Resource allocation within the superframe

The resource allocation will take into account the BS-SS or SS-SS interference (some cases may appear in Relay operation). In general the allocation of dedicated resources for the control and data channels in OFDMA (frequency) domain is sufficient to resolve the interference, but there are cases, when due to the low distance between a femto-BS and a MS belonging to a macro-cell, the interference can be separated only in the time domain.

The most important resources to be allocated are those for the Control Channels. The Control Channels include transmission of information related to synchronization, control, sounding, resource allocation, etc.

See my other contribution regarding the allocation of the Control Channel resources for the three categories of cells deployed in overlapping heterogeneous deployments.

Operational rules for the self-organized radio deployment

Rules for the BS installation phase

At the installation a BS shall determine the most suitable frequency-time resources for the operation of its Control and Data Channels, according to its Category of operation.

For doing this, the Base Station shall know:

- Which are the possible operating resources, as established by the operator or by standard within the frame structure;
- Category of operation of the Base Station;
- Interference potential, based on measurements.

The operating resources are:

- Available frequency channels;
- Time-frequency resources for the control channel. These resources may be used by BSs actively communicating with the associated MSs or by BSs which signal their presence to the MSs looking for association or for hand-over. It is possible to further separate the resources for regular operation from resources used only for signaling the BS presence and allowing the association of a first MS. In case that the resources are separated, in the installation phase a BS will use only the dedicated Control Channel resources used for installation .
- Minimum resources for data channels, if allocated
- Extended operational resources for the data channels.

Assessment of interference

The new Base Stations will assess the interference, based on the following procedures:

- Measurement of the interference created by other Base Stations during their transmissions on the resources assigned to control channels:
 - o downlink (DL) sub-frames for TDD operation;
 - o on transmit frequency channels for FDD operation.
- Measurements of the interference created by the MSs associated with other Base Stations during the MS transmission intervals (TDD) or frequencies (FDD); if up-link reference carriers or control channels are assigned and have sufficient short repetition intervals, these reference carriers or control channels may give the best indication. If the above conditions are not fulfilled, it is possible to define time intervals within which all the MSs will transmit.

High interference levels during downlink activity indicate the presence of another BS (or BS Sector) operating in the vicinity; the new BS will create interference to the MSs associated to that BS. The new BS shall avoid using the same resources.

High interference levels during the up-link activity indicate high levels of MS interference; the new BS shall avoid using those resources for its up-link operation.

It is recommended to create pairs of DL and UL resources, such that a new BS will avoid using resources which are interfered either in UL or DL.

It should be noted that BS can also sense interference caused by the MS operation in the adjacent OFDMA sub-channels or adjacent frequency channels. For example, Category 3 systems can create such accumulated interference cases. In such cases, the Category 3 operation shall be restricted in the time domain.

Choosing the suitable resource for operation

A new Base Station should choose the least interfered resource as allocation for its Control Channels and the least interfered and occupied resource for the operation of its data channels.

Additional rules

These rules extend the operational time-frequency resource for cases when on the field is not detected the presence of other systems. The assessment of presence shall be repeated at defined time intervals.

If the Cat. X system will not detect interference above a specific power threshold P_{xy} , to be established by the standard or by the operator, within the dedicated resources for the Cat.Y systems, the Cat.X system can temporarily use the specific frequency and/or time resources allocated for the Cat.Y system, which the exception of minimum resources to be allocated for the control channels of the Cat. Y systems.

This will always allow to a Cat. Y system to start its operation and find a resource for its Control Channels.

Rules for BS operation phase

BS maximum power

The Cat. 3 BS shall have a lower maximum power level as compared with Cat. 2 BS.
Cat. 2 BS should have a lower maximum power level as compared with Cat. 1 BS.

Traffic scheduling

The BS transmissions and receptions should be scheduled according to the following rules:

- The BS should schedule the downlink transmissions to the interfered MSs during the dedicated assignments.
- The BS should schedule the up-link transmissions which experience interference during the dedicated assignments.

Reports

The standard shall include appropriate MS reports regarding their interference (SINR) state, on both operational assignments and assignments on adjacent sub-carriers or adjacent sub-channels In addition, the number of downlink packets received by an MSs with errors also constitutes an indication of the interference state.

Change of operational resources for Control Channels

If the BS cell (BS or its associated MSs) is interfered during the operational phase, it will be allowed to re-assess the interference in the same way as new installed BSs, implying that some of the transmissions of its Control Channels will be skipped, for the benefit of listening to the medium. It is recommended that such intervals will be announced to the associated MSs.

The changes of the operational channels are allowed only at relatively random, long time intervals, for avoiding network instability cases.

Identification of Cat. 2 cells creating harmful interference

A Base Station can start operating according to Category 2 rules as long as it is not creating harmful interference to Category 1 cells.

The interference created to a Cat. 1 cell can be caused by accumulated transmissions of other systems operating as Cat.2. or by the approach of an Cat. 1 MS to a Cat. 2 Base Station. Such interference cases can be assessed by

a Cat. 2 cell (BS and MSs) by listening to the media. If the interference levels sensed from time to time are higher than a level either prescribed by the standard or by the operator, such a BS will have to change its operating mode according to Cat. 3 rules. Note that this level will be established as a function of the transmitted powers of the Cat. 1 and Cat. 2 Base Stations. It can be assumed that the MS transmitted powers are similar.

Relay operation

The Relays access cell can be assimilated with any of the above cell categories. The Relay acts as a BS for its access cell.

SDD Text

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The self-organized radio deployment needs well defined allocations of the control channels within the superframe, function of the deployment category of each base station.

A set of rules shall be established for the installation and the operational phase. These rules shall take into account the deployment category of the base station. The base stations will select the channel and the allocation for operation based on the assessment on minimum interference created and experienced within these partitions.

End text insertion

References

[1] IEEE L802.16-08/053 Liaison statement from WiMAX Forum to IEEE 802.16 on Femtocell requirements