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Inter-Cell Interference

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ABSTRACT
The continuously increasing demand for higher data rates results in increasing network density, so that inter-cell interference is becoming the most serious obstacle towards spectral efficiency. Considering that radio resources are limited and expensive, new techniques are required for the next generation of cellular networks, to enable a more efficient way to allocate and use radio resources. In this framework, we target the design of a frequency reuse 1 scheme, which exploits the coordination between base stations as a tool to mitigate inter-cell interference.

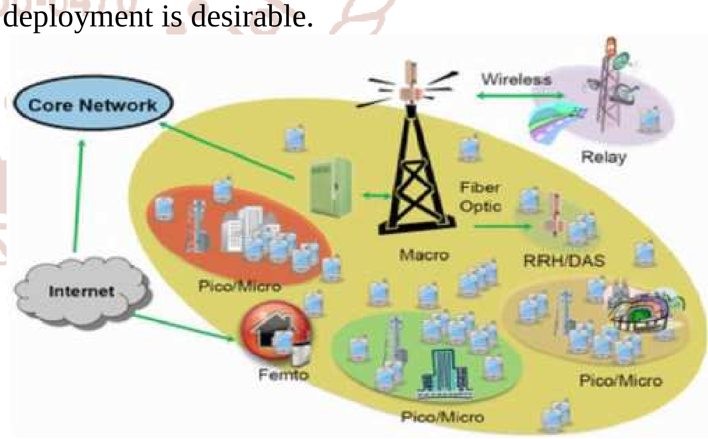
Keyword: *LTE, FRF, ICI*

I. INTRODUCTION

Long Term Evolution (LTE) is all about 4G, which tends to complement LTE (3G) networks with higher data rates, low latency and a flat, IP-based architecture. It also allows operators to use a new and a much wider spectrum when compared to the previous standards. A part from the enhancements in the radio link, the next performance leap in wireless networks will come from an evolved network topology. The concept is to improve spectral efficiency per unit area. With various combinations of femto cells, relays and Pico cells, heterogeneous networks can provide the optimal experience to the user. In any cellular mobile communication system, two major classes of interference must be considered, namely: intra-cell interference, and inter-cell interference. When a travelling user, connected to a large, umbrella-type of cell, stops then the call may be transferred to a smaller macro cell or even to a micro cell in order to free capacity on the umbrella cell for other travelling users and to reduce the potential interference to other cells or users :this works in reverse too, when a user is detected to be moving faster than a certain threshold, the call can be transferred to a larger umbrella-type of cell in order to minimize the frequency of the handovers due to this movement. Bandwidth Spectrum flexibility is a key feature of the LTE system to operate in different geographical areas with the different frequency bands and different bandwidth. It can be implemented on either paired or unpaired frequency bands. In paired frequency bands, a separate frequency band is allocated for uplink and downlink transmissions, respectively, while uplink and downlink share the same frequency band in the unpaired frequency bands.

II. INTER-CELL INTERFERENCE MITIGATION

It is known that effective reuse of resources in a cellular system can highly enhance the system capacity. With a smaller frequency reuse factor (FRF), more available bandwidth can be obtained by each cell. So, in this sense the classical FRF deployment is desirable.



Inter-Cell Interference Mitigation

Microcells are composed of conventional operator-installed eNBs which provide open access mode and covers wide area with few kilometers. In general, the open access mode means that each user in the network can automatically be connected to the eNBs.

Microcells are designed to guarantee the minimum data rate under maximum tolerable delay and outage restrictions. Macro eNBs emit transmission power up to 46 dBm and can serve thousands of customers.

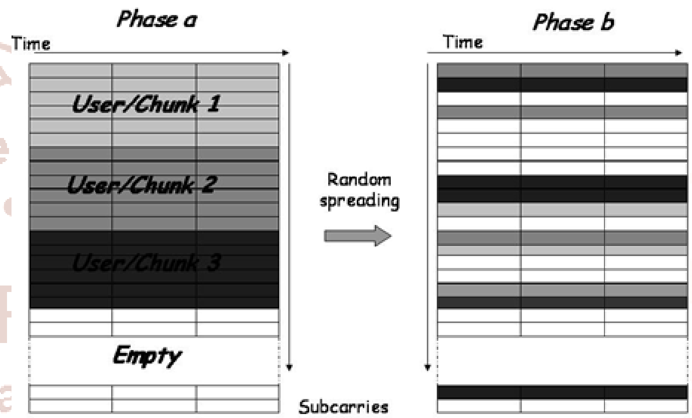
Pico cells are low power nodes which are deployed by the operator. Pico eNBs have lower transmission powers compared to macro eNB within a range from 23 to 30 dBm. Pico cells can improve capacity as well as the coverage of outdoor or indoor regions for environments with inadequate macro penetration (e.g., office buildings). Since microcells work in open access mode, all users can access them.

III. INTERFERENCE AVOIDANCE SCHEMES

In cellular network, different power and frequency allocation schemes are deployed to avoid the impact of ICI so as the system's spectral efficiency can be improved. In many ICI mitigation schemes, frequency reuse technique is taken as the main idea. These frequency reuse planning algorithms aim to improve the SINR, and must fulfill the power constraint of each cell by making sure that the transmit power of an eNB is not exceeding the maximum allowable limit. Based on time scale, ICI avoidance schemes can be categorized as static, semi-static and dynamic schemes. Static allocation schemes can operate on a relatively large time scale. In static scheme, the resource allocation for each cell is determined during radio planning and only long-term readjustments are made during network operation. Therefore, the power levels and the set of sub-carriers assigned for each cell and cell regions are static (fixed). In semi-static approach, a part of the RB allocation is predefined and the other RBs allocations reserved for cell edge users are dynamically changed. Timescale of reallocation is in seconds or several hundred milliseconds. In dynamic scheme, resource allocation is dynamically updated based on the variations of network conditions. Dynamic allocations are done after a very short time period.

IV. INTERFERENCE RANDOMIZATION

One of three ICI mitigation techniques is named as interference randomization. In interference randomization policy, the users' data are spread up over a distributed set of subcarriers so that interference scenario can be randomized and frequency diversity gain can be achieved. In interference randomization, in each cell the users' data are sequentially allocated over a time-frequency chunks. When all the requested transmission is allocated, subcarriers permutation is made in random manner so that each UE's transmission is arbitrarily spread up over the total time-frequency grid. The following figure shows the allocation of subcarriers in a given cell before and after the pseudorandom permutation. In each interfering cell, the pseudorandom permutation is performed independently. The cell specific scrambling causes the interference spread up along with the transmission of a given user. As the coding is performed at the transmitter during transmission, the whole bit stream can be easily recovered at the receiving end.



Subcarrier allocation before (a) and after (b) random permutation

V. FEMTOCELLS

Femtocells are low-power base stations that can be installed inside buildings as a single stand-alone device or in clusters, and provide improved indoor coverage at low-cost. The femtocells are linked to the main core network using the mobile backhaul scheme that uses the user's Digital Subscriber Line (DSL) or other internet connections. In addition to high performance and better coverage, femtocells can also help to reduce load from MBS by channelling a fraction of its traffic through the internet service provider of the user. This freed-up capacity can be used to accommodate more users entering the network.

- The femtocell encrypted all voice calls and data sent or received by the mobile phone. This makes it impossible for an external user to break into a user's home network. For a standard 3G cellular phone, the femtocell appears as another cell site or microcell, hence communicating with it as it would with a macrocell, when the mobile phone is used outdoors. Since femtocells operate at very low radio power levels, battery life is high. Also call quality is excellent, when the distance between the femtocell and the mobile handset is short. The connection between the femtocell gateway and the femtocell is encrypted using IPsec, which prevents interception.

- There is also authentication when the femtocell is installed for the first time to ensure that the access point is a valid one. Inside the femtocell there are the complete workings of a mobile phone base station. Some additional functions are also included, such as the RNC (Radio Network Controller) processing, which would normally reside at the mobile switching centre.
- Large cells can be subdivided into smaller cells for high volume areas. Cell phone companies also use this directional signal to improve reception along highways and inside buildings and arenas.

VI. CONCLUSION

In a multi-cell environment, inter-cell interference is the most important problem addressed. In order to avoid resource collisions during transmission from adjacent cells, several techniques have been suggested. The research paper describes number of parameters related to inter-cell interference like Interference Avoidance Schemes and Interference Randomization. The need is to have a scheme to coordinate neighbouring base stations that minimize inter-cell interference while achieving high spectral efficiency.

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