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Region splitting-based resource partitioning to enhance throughput in long term evolution - Advanced networks

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ABSTRACT

In Long Term Evolution-Advanced networks, efficient resource partitioning is needed for improving throughput for User Equipment (UE). In this research, a region splitting-based resource partitioning scheme is proposed for enhancing the throughput of indoorMacro UE (MUE). The macrocell is divided into three regions, namely, the inner, centre and outer regions. The femtocells present in each region share the resources of the corresponding macrocell. The spectrum is partitioned into four non-overlapping sub-bands. These sub-bands are assigned to a cluster of three cells for mitigating cross-tier interference. The throughput of indoorMUE which is located at the boundary of inner region is analysed with respect to various numbers of femtocells and, MUE devices, angles made by MUE devices and femtocell transmission power. The proposed scheme has been compared with a fractional frequency reuse scheme in terms of inner-region radius. The inference drawn is that a maximum throughput enhancement of 29.7% has been achieved.

1. Introduction

A conventional cellular network includes macrocells which provide coverage to a limited area. In a homogeneous network, each macrocell has a Base Station (BS), which offers service to mobile users. In such a network, degradation in Quality Of Service (QoS) is experienced by mobile users as a result of channel multipath propagation, interference from other users, improper resource allocation, etc. Therefore, the Third Generation Partnership Project (3GPP) developed the Long Term Evolution (LTE) [1] standard in Release 8 for enhancing the throughput of cell-edge users and increasing system capacity. The objective of LTE is to fulfil the requirement to increase network traffic. However, in Release 10, 3GPP incorporated advanced features into LTE for further enhancement of the QoS for mobile users. This is called LTE-Advanced (LTE-A) [2]. The advanced features introduced were cooperative multipoint communication, Multiple-Input Multiple-Output (MIMO), Heterogeneous Networks (HetNets), enhanced Inter-Cell Interference Coordination (eICIC) and carrier aggregation. These features pose several challenges, namely, handover management, security, self-organization, interference management, scheduling and load balancing. In this research, the challenges related to interference management schemes are investigated.

In LTE-A, the HetNet consists of small cells, namely microcells, picocells and femtocells. The functionalities of microcells are similar to those in the cell splitting technique adopted in conventional cellular networks. The small cells of HetNets differ in terms of transmission power, plan of deployment, coverage, etc. Femtocells have gained more attention to date because they are deployed by users, whereas picocells and microcells are deployed by a network operator. Hence, the challenges imposed by femtocell deployment are greater than those for microcells and picocells. Femtocells [3] operating with low transmission power offer a coverage of

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Nomenclature

eICIC	enhanced inter-cell interference coordination
FBS	Femto base station
FUE	Femto user equipment
FFR	Fractional frequency reuse
5G	Fifth generation
HetNet	Heterogeneous network
ICI	Inter-cell interference
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MBS	Macro base station
MUE	Macro user equipment
OFDMA	Orthogonal frequency division multiple access
QoS	Quality of service
RRP	Region splitting-based resource partitioning
SINR	Signal-to-interference-plus-noise ratio
3GPP	Third Generation Partnership Project

10–30 m. The femtocell partially shares the spectrum resources of a macrocell. This may lead to interference of two kinds: cross-tier interference and co-tier interference.

In a two-tier network, the User Equipment (UE) may experience three kinds of interference: co-tier, cross-tier and Inter-Cell Interference (ICI). In co-tier interference, the interference occurs in the same tier of the network, while in cross-tier interference, interference occurs between different tiers [4]. The interference that occurs between adjacent cells is termed ICI. This interference can result in QoS degradation in UE. It can be minimized by devising proper mechanisms to be involved in resource allocation between adjacent Macro Base Stations (MBS) and co-channel deployment of Femto Base Stations (FBS). Adaptive transmission power control in HetNets can also improve the QoS for UE [5]. The existing techniques in the literature for mitigating cross-tier interference include conventional frequency reuse (FR), resource scheduling, femtocell clustering, cognitive radio and power control approaches, etc. [6]. From the literature, it is found that ICI has recently been considered the most prominent problem in cellular communication. Hence, in this research, issues related to ICI in LTE HetNets are investigated.

The main objective of this research is to propose an ICI mitigation scheme to enhance the throughput experienced by Macro UE (MUE) in indoor environments. A region splitting-based resource partitioning (RRP) scheme is proposed for achieving the objective. In the proposed scheme, the macrocell is partitioned into inner, centre and outer regions. In each region, the femtocells partially share the resources of the corresponding macrocell. The entire frequency band is partitioned into four non-overlapping sub-bands. These sub-bands are assigned to each region in a cluster of three cells for mitigating the ICI in the LTE HetNet. The throughput of indoor MUE which is placed inside the boundary of the inner region is analysed with respect to the angle made by the MUE and the FBS transmission power. Further, the impacts of the inner-region radius, the number of MUE devices and the number of femtocells are analysed, to understand the performance of the proposed RRP method in a practical scenario.

In recent years, Fifth Generation (5G) wireless access technology through the Internet of Things has aimed at providing automation in various applications, namely, health-care, logistics, industry, etc. These 5G systems are designed to achieve the above objective and to support a multi-tier architecture. They consist of macrocells, small cells, relays and device-to-device networks with different sets of QoS requirements. Due to diversified deployments, interference in the HetNet may be the major factor that influences QoS. Hence, management of radio resources and interference is one of the major areas of research in 5G systems. In Release 15, 3GPP introduced new radio access technology [7] for meeting the above requirements. This is a new air interface supporting operation beyond 6 GHz with unique radio functionalities such as massive MIMO, beam forming, non-orthogonal multiple access and full duplex. However, the basic frame structure, modulation and coding schemes are the same as for fourth-generation systems. Hence,

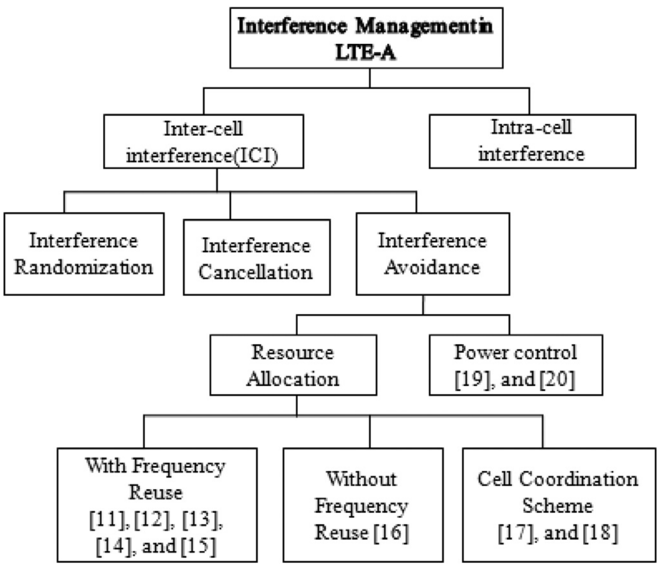

Fig. 1. Taxonomy of Interference Management Techniques in LTE-A.