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Dynamic Resource Allocation Scheme Based on Interference Coordination and Load Balancing for Multihop Cellular Networks

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Abstract

Multihop Cellular Networks (MCN) have a fixed infrastructure of base station with a combination of ad-hoc network. The MCN provides a high throughput and extensive coverage. But there are certain issues such as resource allocation, cochannel interference and unbalanced user distribution. In order to overcome these issues this work proposes a resource allocation scheme by collectively considering Interference Coordination (IC) and Load Balancing (LB) in MCN. This is done by analyzing the characteristics of resource allocation in IEEE 802.16.Thus achieves a reduction in interference and to support high spectral efficiency and to provide a LB-based handover mechanism to equally distribute the traffic among the Base Stations (BSs) and guarantees users' QOS. It improves throughput by affording more users in MCNs.

Keywords- Multihop Cellular Networks (MCN), Interference Coordination (IC), Load Balancing (LB), Base Station (BS)

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX) is a wireless access technology based on IEEE 802.16 standard. It is a broadband wireless access technology, aims to provide mobility enhancement for Mobile Stations at the vehicular speed for long distances, in a mobile environment [1].Fixed WiMAX, supports only restricted coverage and roaming. The IEEE 802.16 systems will choose orthogonal frequency division multiple access (OFDMA) technology for Multihop cellular networks (MCNs). OFDMA is regarded as the most assuring physical layer technology for the fourth generation (4G) wireless networks. New strategies are proposed to provide services with extended coverage and higher data rate. Fixed relay stations (RSs) with less functionality than base stations (BSs) can be installed to overcome poor channel conditions [2]. OFDMA systems should employ frequency planning for better cell edge performance and the ease of interference management [3].Single-hop cellular networks (SCNs) employ the frequency reuse pattern with factor of 3 or 7 which results in low spectral efficiency. The high data rate is one of the desired features of the future cellular networks. It requires a highly efficient utilization of the available spectrum. Frequency reuse with factor of 1 is likely to be used in LTE-Advanced and IEEE 802.16 systems, aiming at improving the spectral efficiency[4]-[7].This paper proposes a practical Load Balancing scheme to how to distribute the traffic load from loaded stations to unloaded stations and to increase the available frequency resource for loaded stations to achieve LB. The performances of single hop cellular networks (SCN) and Multihop cellular networks (MCN) are simulated using NS2.

II. RELATED WORKS

In [8], a relay-based orthogonal frequency planning is proposed to improve cell edge performance. In [9], Fractional Frequency Reuse (FFR) is extended to MCNs as a solution to reduce Cochannel Interference (CCI) while maintaining the sector frequency reuse factor as 1. The idea of FFR is to choose frequency reuse 1x3x1 at the cell center to increase the network spectral efficiency [10]. In [11], the reduction of the CCI has been obtained by adjusting the transmission (Tx) power at BSs and RSs under orthogonal frequency resource allocation. In practical, users are not equally distributed among cells. Too many users accessing one station (BS or RS) yields load imbalance in MCNs. Such an imbalance could severely affect the performance of hotspot areas, which may not meet the users' quality of service (QoS) requirements. This is another major reason for system performance degradation. To guarantee users' QoS, therefore, load balancing (LB) should be chosen along with IC for MCNs. LB has been widely used in SCNs and heterogeneous networks (HetNets). For SCNs, resource allocation schemes have to work in conjunction with the Connection Entry Control (CEC) mechanisms, which determines, based on available resource and users' QoS, whether to provide an entry to an incoming connection to a particular cell or to reject it in the current cell, but to switch the user to an adjacent unloaded cell through a handover mechanism. Here, the corresponding handover mechanism is not executed due to position change of users, but due to the lack of resource in the original cell. As important methods in LB, the cell breathing and load-ware handover are proposed in [12] and [13]. The idea is that if a cell is heavily loaded, the adjacent unloaded cell may expand the coverage and accommodate more users by raising transmission power. For HetNets, an integrated cellular and ad hoc relay (iCAR) system has been proposed in [14] and [15], in which some users can be moved to adjacent cells through ad hoc RSs and the spare resource are then acquired by incoming users.

III. RESOURCE SCHEDULING

The scheme of load balancing of the system by using resource allocation is based on carrying the unused resources to the area where most of users are placed. In this approach, a centralized component assigns additional or free resources to overloaded cells. Resource allocation can be categorized into two main classes, fixed channel allocation (FCA) and dynamic channel allocation (DCA). In an FCA class, a fixed number of channels are allocated to each base station. Though, this scheme does not use the channel sufficiently because of the variability of the traffic. DCA as an enhancement to the FCA can adapt itself with changes in traffic and adjusts frequency assignments relevant to the traffic load.

The IC and efficient resource scheduling can improve system performance, and then extend the proportional fair (PF) algorithm for MCNs. In (Round Robin) RR algorithm, a slots are allocated to the users in the cell coverage in order and thus seems to be absolutely fair. Since the difference of slot efficiency of users is not taken into consideration. PF algorithm provides an efficient throughput-fairness tradeoff. In MCNs, the BS is responsible for gathering link information and allocating the available resource to the corresponding links according to the PF algorithm. Since PF is applied to MCNs, increasing throughput implies that more users' QoS requirements are met. Therefore, system throughput is improved and more reliable

Service is attained.

The PF metric $M_l^n(s)$ for user n on link l is given by,

$$M_l^n(s) = \eta(\chi_l^n)/R_l^n(s-1) \quad (1)$$

Where

$R_l^n(s)$ denotes the average data rate of user n from the start of the frame to the allocation of slot s in the frame.

$\eta(\chi_l^n)$ represents the slot efficiency of user n on link l.

IV. LOAD BALANCING MECHANISM

A. LOAD BALANCING AT RELAY STATIONS (RSs)

When an RS is loaded heavily, it does not have enough frequency resource for the users nearby. There by shifting some users from the loaded RS to some unloaded BSs in the same sector through the handover mechanism to keep traffic load in balance and reduce the blocking probability. The handover mechanism is as follows:

- **Measurement and report:** The BS often measures and computes for any user related with RSs so that the BS has the knowledge of the RS's load status. When a new user arrives at the RS, the BS will determine whether the RS is overloaded and declare the information about its own load status together.
- **Decision and execution:** If the RS is determined to be loaded heavily, and the BS has available resource to accept more users, some users originally related with the RS will change their serving station from the RS to the BS. However, the BS cannot always over the place where a new arrival arises, and the optimal value of the throughput cannot be obtained by the handover of the new arrival either. Therefore, the BS needs to calculate the expected data rate if a user is moved to the BS.
- **Notification:** To prevent possible bouncing back effects the users moved to the BS are not switched back to the RS even if the traffic load is reduced at the RS. Because the handover mechanism between a BS and an RS is implemented in one sector, it brings less delay and system overheads than LB among cells in the traditional sense. Thus, the handover should be performed on a short time scale.

B. LOAD BALANCING AT BASE STATIONS (BSs)

When a BS is loaded heavily, it is not useful to move the users related with the BS to an RS in the same sector. Because these kinds of users are close to the BS and far from RSs, once handover occurs, the data rates of these users will decrease. Moreover, the users only need the good one-hop links to directly access the BS, whereas they need the poor two-hop links to re-access the BS via RSs. Therefore, when the overall concerns are taken into consideration, it will occupy additional resource in the system. The handover mechanism is as follows:

- **Measurement and report: The** BS is in charge of often measuring and computing of the users related with the BS. When any new user accesses the BS, the BS will compare and determine whether the BS itself is loaded heavily or not.
- **Decision and execution:** If the BS is found loaded heavily when new users arrive, the handover mechanism will be executed to prevent heavy traffic load.
- **Notification:** If the handover condition is not satisfied, new users will be refused because entering of new users will worsen the network performance. Otherwise, the BS will carry out the handover mechanism and accept new users. This type of handovers is a procedure to switch the frequency band currently being used rather than an actual handover.

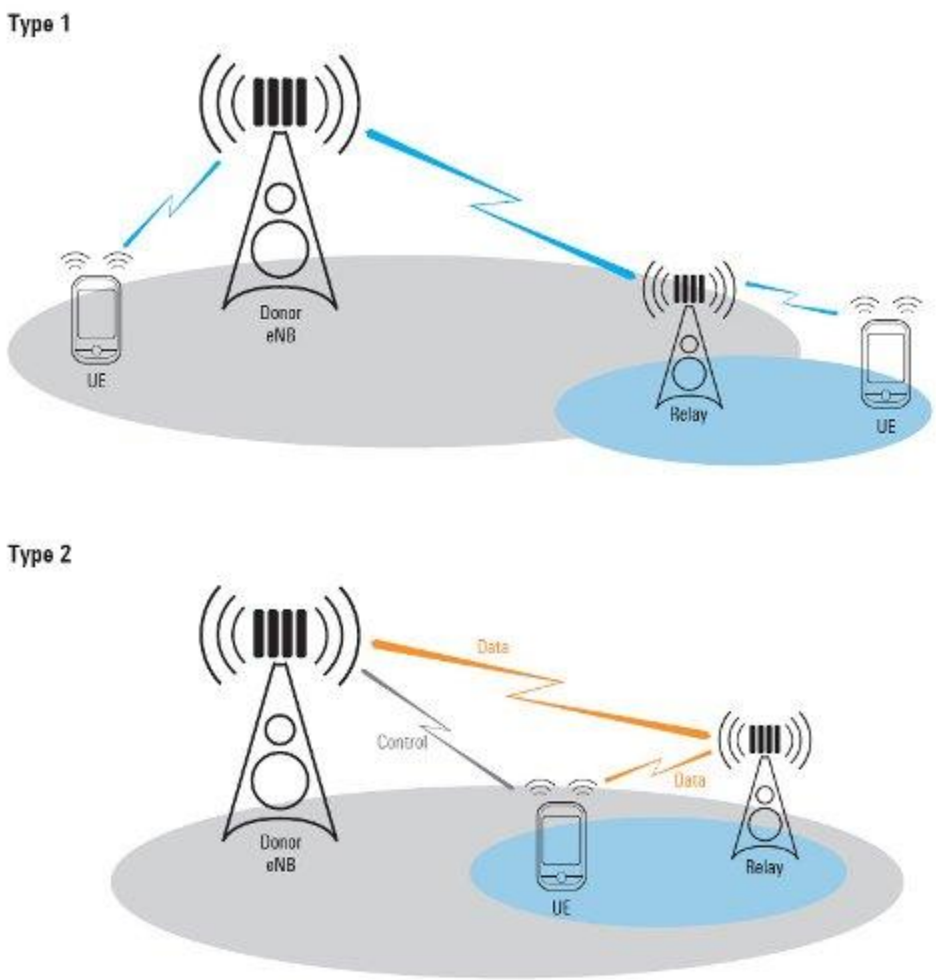

Fig 1: Load Balancing

The figure 1 shows the Load Balancing within a coverage area in which the Type 1 shows that User Equipment (UE) that is away from the base station so that it access from the relay station.

In Type 2 UE is can access from the BS too but it is very near and within the coverage of the relay station so it access from that station.

V. SIMULATION RESULTS

The User Equipment (UE) moves from one station to another station during the Load Balancing (LB) mechanism. The following figures show the simulated results generated by NAM (Network Animator).

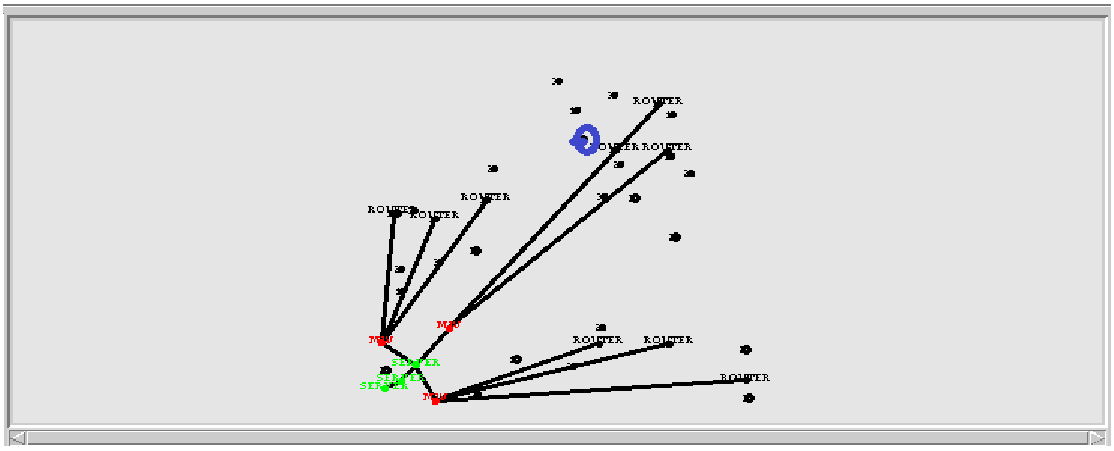

Fig 2: Position of the UE (blue)

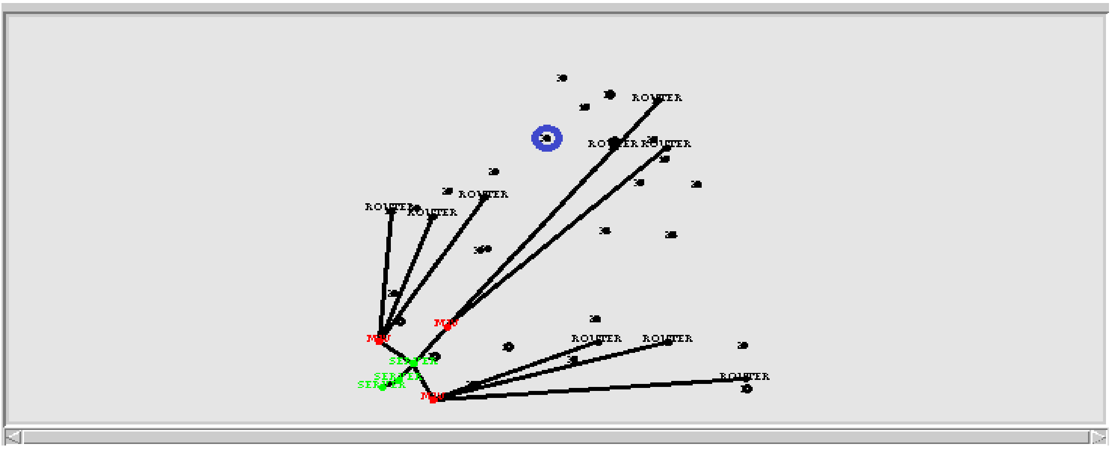

Fig 3: The UE moves from one station to another

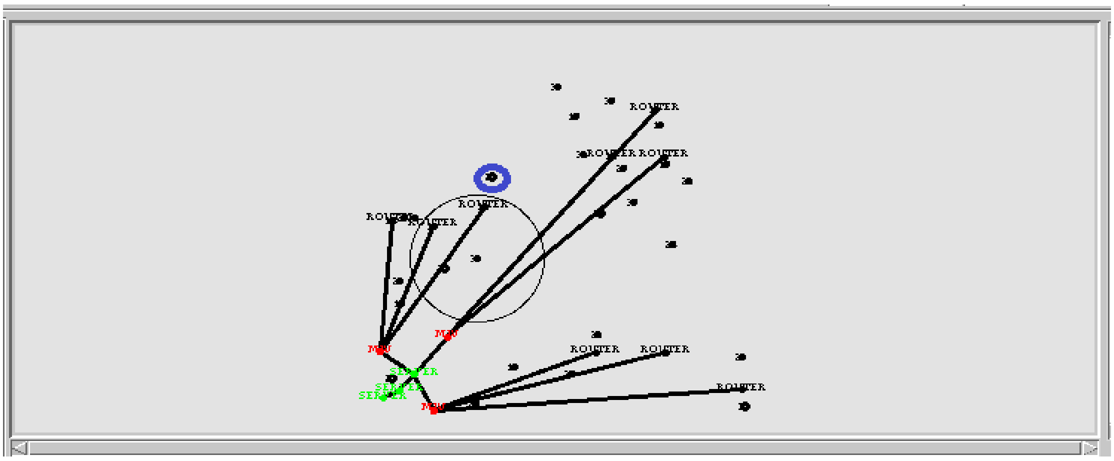

Fig 4: The UE comes under the coverage of another RS due to LB mechanism

The graph shows the comparison between the SCN and MCN. The Sector Throughput and the QOS Violation Probability are calculated for SCN and MCN.

1. SECTOR THROUGHPUT

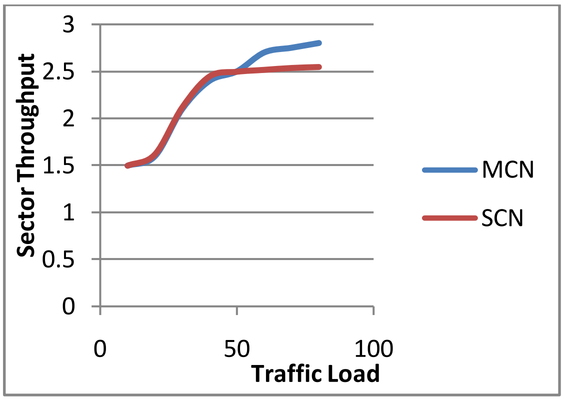

Fig 5: Sector Throughput

From the above figure the sector throughput of MCN is high than SCN. Because the MCN provides extensive coverage than SCN.Throughput is high due to LB and IC.

2. QOS VIOLATION PROBABILITY

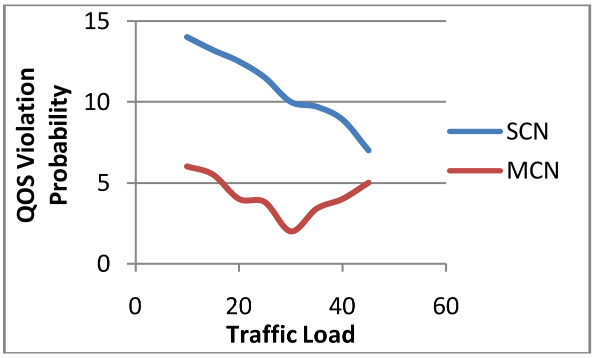

Fig 6: QOS Violation Probability

QoS violation probability represents the percentage of users whose R(Tw) is lower than Rmin.

Where
Rmin denote the user's minimum traffic rate under QoS requirements.
R(Tw) the average data rate for user n over fixed-length time window Tw.

In the SCN the QoS is not satisfied because it can't provide extensive coverage like MCN.

3. SPECTRAL EFFICIENCY

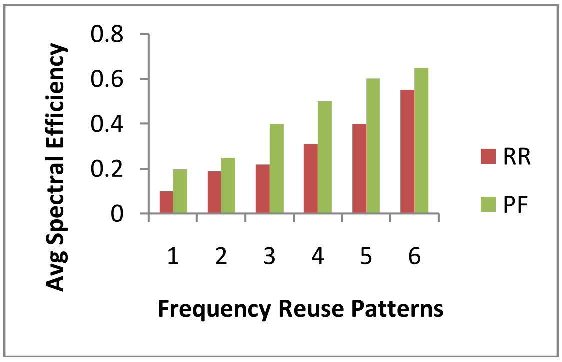

Fig 7: Spectral Efficiency

The RR (Round Robin) algorithm without considering the slot efficiency of users leads to the worst performance. We can observe that the PF (Proportional Fair) algorithm offers significantly improved performance compared with the RR algorithm and takes fairness into account.

VI. CONCLUSION AND FUTURE WORK

This work proposes a frequency reuse scheme to reduce interference and to keep up high spectral efficiency, and present practical LB-based handover mechanism which can equally distribute the traffic load and guarantee users' quality of service. The simulation result shows that this scheme not only meets the coverage probability, but also improves the sector throughput and accommodates more users.

In future this method will play an important role in planning the network and allocating the resources to the MCN thereby increasing the coverage and affording more users in MCNs.

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