INTERFERENCE MANAGEMENT OVER GREEN SMALL CELL NETWORKS

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***Abstract*—**
Cellular Communication has experienced an explosive growth in the past two decades. Today millions of people around the world use mobile phones. This increases the network densification. Energy efficiency in cellular networks is also a growing concern for cellular operators to maintain profitability and to reduce the overall environment effects. The promising solution to overcome both the problems of network densification and energy consumption is the concept of Green Small Cell Networks. The small cell networks brings the mobile users and base stations closer together which increases the capacity of cellular networks, reduces the energy consumption and reduces the carbon emissions due to electromagnetic pollution. But the major challenge faced by the small cell networks is to overcome Interference which occurs between small cells and between small cells and macro cells. This paper proposes the novel algorithm known as Multi channel distributed admission path control algorithm which enables the small cell networks to drastically reduce the interference experienced by both macro- and small cell users. Simulation results show that the proposed approach yields significant packet delivery ratio, delay and the overall throughput performance.

Keywords- Small cell Networks, Interference Management, Multi channel distributed admission path control algorithm, Packet delivery ratio, End-to-End delay, Throughput.

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I. Introduction

Mobile communication sectors is experiencing a tremendous amount of growth driven by the following key market influences such as Smart phones and tablets with cellular/Wi-Fi connectivity, Extensive application for smart mobile devices, The surge of video enabled internet applications, HD video moving into the mainstream, The emerging "always on" broadband wireless user culture.

Mobile service providers are willing to offer increasingly innovative and cost competitive wireless data services to capture the demanding smart phone and tablet markets [1]. The increasing popularity of video enabled applications like Netflix, Apple Face Time, videoconferencing, plus streaming and downloading of music/video content will continue to drive user's desire for lower cost wireless data consumption. Current macro cell networks cannot cost effectively scale to meet this capacity demands in dense user population environments. Operators are thus making use of lower-cost small cell networks to augment existing services by bringing capacity closer to consumption and thus improving customer's experience in dense urban areas.

The small cell networks are used to offload the macro cell traffic in the urban environment. Thus the small cell deployments are intended to relieve capacity-stressed sites in zones across dense urban areas, at lower costs than by rolling out an equivalent macro cell expansion[2]. It helps to meet the future traffic demands. But the challenge of integrating a small cell layer into the macro layer brings with it a major concern for mobile operators which is the interference management[3]. The proposed approach of multi channel distributed admission path control (MDAPC) algorithm reduces the interference significantly and improves the overall performance of small cell Networks.

II. Related work

Christian Androne and Tudor Palade investigated the impact of small cells networks deployment in a typical residential environment. They Proposed two algorithms in order to reduce the interference level at the macro cell user site, considering that the operator owns at least two carrier frequencies which will be used for both the macro cellular and small cellular layers. The performances of these algorithms are presented in comparison with the case when no interference mitigation methods are implemented. These algorithms offer important enhancements, but still have the disadvantage that they can be applied only for operators that have at least two carriers available for usage. This could be an important option for operators, considering the future benefits of the cellular communication[4].

Francesco Pantisano, Mehdi Bennis, Walid Saad, Merouane Debbah and Matti Latva-aho[5] investigated the coexistence of SBSs underlaid to an existing macro-cellular network faces important challenges, notably in terms of spectrum sharing and interference management. They proposed a game-theoretic model that enables the SBSs to optimize their transmission rates by making decisions on the resource occupation jointly in the frequency and spatial domains. this cooperative strategy among interfering small cells brings significant gains, in terms of average rate per small cell, reaching up to 37%, relative to the non-cooperative framework.

III. SMALL CELL NETWORKS

The general term "small cell networks" covers a range of radio network design concepts which are all based on the idea of deploying BSs smaller than typical macro cell devices to offer public or open access to mobile terminals. In essence, a small cell BS can be seen as a cellular BS designed to serve a limited coverage area, around a factor 100 smaller than a traditional macro cell [3].

A small cell BS is a small, portable, low-cost and low-power device. It can be deployed in plug-and-play fashion, self-configures all necessary parameters and does not require any regular maintenance. Small cells (SCs) target a coverage radius of 50−150m and radiate at low power (0.1-10W).Small cells can be of micro cell, pico cell , femto cell and the features of small cells are discussed in Table.1

TABLE I
FEATURES OF VARIOUS SMALL CELL BASE stations

Features	Microcells	Pico cells	Femtocells
Size	Bigger	Medium	Smallest
Coverage	< 35 kms	<200meters	<10 meters
Number of users	< 256	<128	< 64
Deployment	Outdoor	Outdoor/ indoor	Indoor
Transmitting power	~ 10 W	50MW~ 1W	~15 MW
Example scenarios	Urban, residential.	Airport, stadium, aircraft.	Hotspots, office, apartments.

A. *Deployment of Small Cell Networks*

The exponential growth in demand for higher data rates and other services in wireless networks require a more dense deployment of base stations within network cells. Whereas conventional macro-cellular network deployments are less efficient, it may not be economically feasible to modify the current network architectures [6].

Macro cells are generally designed to provide large coverage and are not efficient in providing high data rates. One obvious way to make the cellular networks more power efficient in order to sustain high speed data-traffic is by decreasing the propagation distance between nodes, hence reducing the transmission power. Therefore, network deployment solutions based on smaller cells such as micro, Pico and femtocells are very promising in the cellular network.

The heterogeneous deployment of small cell network along with macro cell network in various public places is shown in Fig.1.The mobile users inside the university, office and government building can access to the particular small cell base station deployed above the corresponding buildings and the macro cell base station can be used as umbrella coverage[8].This deployment of small BS offers high capacity, less energy consumption and high data rates to the mobile users.

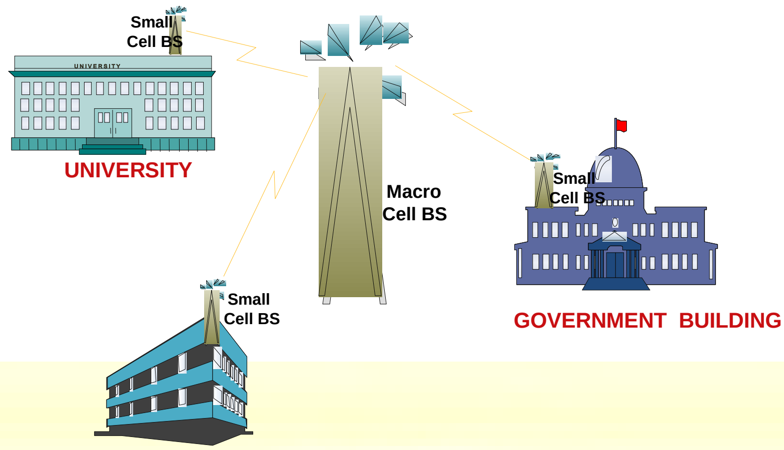

Fig.1 Heterogeneous Deployment of small cell Networks

B. *Interference scenarios in Small Cell Networks.*

Interference is a particularly difficult issue to be solved and it is mainly occurs due to the heterogeneous deployment of small cell Base stations along with the macro cell Base stations. This includes interference between both the macro cell layer and the small cell layer, as well as interference between the small cells themselves, between neighboring small cells [9]. The different interference scenarios in small cell networks are as follows.

1) *Scenario 1*: A small cell Base station covers smaller area such that it can accommodate only the minimum number of users within a building or the users in a particular location. The interference occurs when two or more users in the particular location access the small cell base station at a time. This scenario is illustrated in Fig.2

Fig.2 Interference between users within a small cell Network

2) *Scenario 2:* The small cell Base station uses macro cell base station for the coverage issue. The interference occurs when the user is in the intermediate region between the small cell coverage area and the macro cell coverage area. This scenario is illustrated in Fig.3

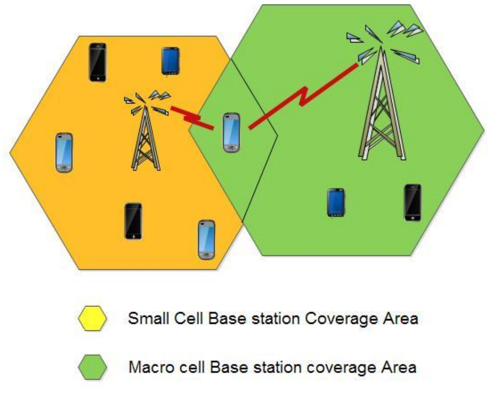

Fig.3 Interference occurs a single user is served by both small cell and macro cell Base stations.

3) *Scenario 3:* Interference may occur when two small cell networks access the macro cell Base station and it also occurs when a user from one small cell communicate with the user in the other small cell network. This scenario is illustrated in Fig.4.

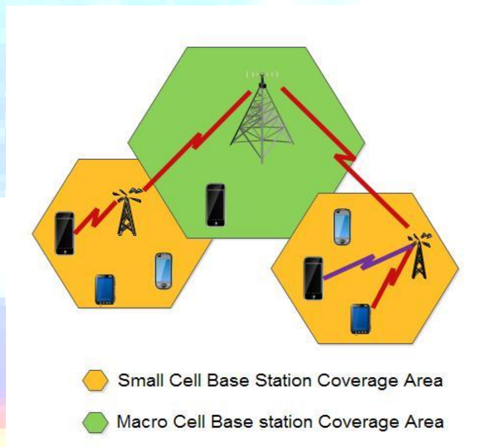

Fig.4 Interference due to Multiple Transmissions.

IV. INTERFERENCE MANAGEMENT IN SMALL CELL NETWORKS

Interference Management in small cell networks is a big issue. All the above interference scenarios can be overcome by a novel algorithm known as **Multichannel distributed admission path control(MDAPC) algorithm**.

A. Multichannel Distributed Admission Path Control Algorithm (MDAPC)

This proposed algorithm limits the bandwidth allocation among the user and it also enhances the dynamic spectrum access [8].It also provides the temporary shutdown of lightly loaded sectors/cells leading to reduced power density can help to minimize interference.

This algorithm checks the priority of the users according to their load and it automatically provides the sequence of the users as per the priority[11].This helps to avoid the interference which occurs due to the multiple transmissions. Frequency reuse and dynamic frequency allocation are key factors in this proposed algorithm. The frequency band is subdivided into several sub-bands, each sub-band is allocated to the small cells in different ways and this helps to overcome interference. The ultimate aim of this algorithm is to improve the overall throughput of the small cell network.

B. Algorithm Description

The formal Description of the Multichannel distributed admission path control algorithm is shown in algorithm 1.

Algorithm 1: MDAPC

M_S-Source
M_D-Destination
M_N-cellular Network
M_U- Users
Collect Network _Discovery
If (M_s->M_D) then
Find BS to destination Selection
Send Data Transmission
Else if(Update_neighbor_channel->true) then
Update_neigbor channel_list
Route_update ()
Route discovery ()
End if
If (Multichannel->True) then
Schedule. Update ()
End If
If (M_U is more)
Rate allocation_ users _ need higher rates
Estimate _ available BS capacity.
Prioritize_ users _ demand higher rates.
Get_ first user_ prioritized user list.
If (available BS capacity >0)
Transmit the data
End if
If (available BS Capacity <0)
Drop the transmission
End if
End if

C. Performance Evaluation

To The performance of small cell network using proposed MDAPC algorithm can be evaluated with the following key performance metrics :

1) Packet Delivery Ratio : It is the ratio of the number of Packets successfully received by the mobile users to the number of packets transmitted by the base stations. It is calculated for both constant bit rate and variable bit rate files at particular time interval and it is shown in the Fig.5

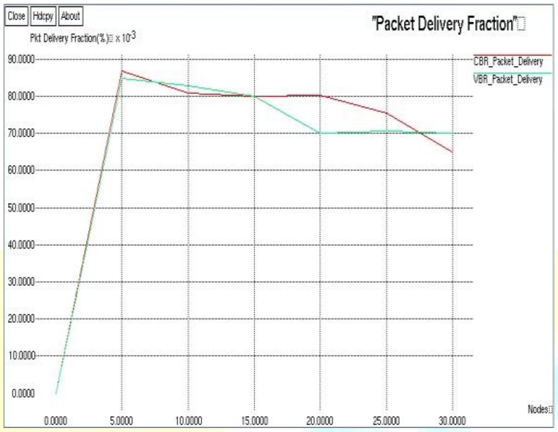

Fig.5 Packet Delivery Ratio

2)End to end delay: It is the total delay of successfully delivered packets from Small cell access point to destination node. It includes all possible delays occurred during the transmission. Fig.6 shows the end to end delay of the network.

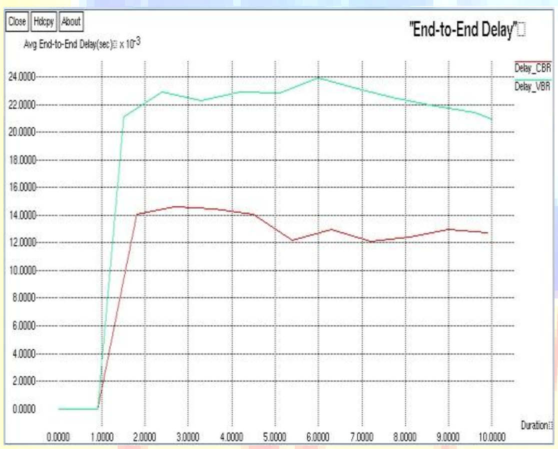

Fig.6 End to End Delay

3) Throughput: It is average rate of the Successful message delivery over a communication channel. The throughput performance by using this multichannel distributed admission path control algorithm is shown in Fig.7

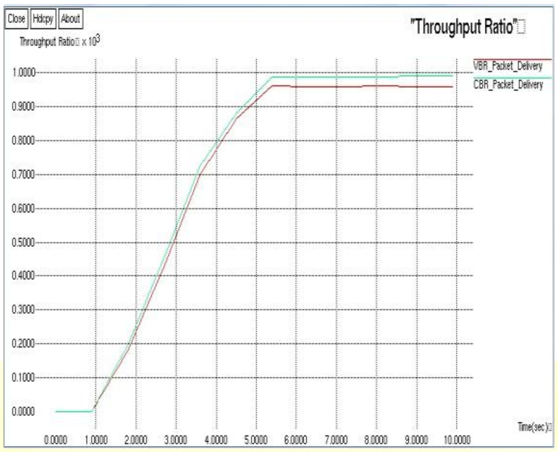

Fig.7 Throughput Performance

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Small Cell Network Performance Report
*****************************************
Throughput ratio = 0.93
send = 915
recv = 791
Packet Delivary Fraction= 86.45
Average e-e delay(ms)= 11.83
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Fig.8 Performance Report

Fig.8 shows the performance report of the green small cell networks. Through the small cell network , 915 packets are transmitted and the received packets at the other end of communication was 791 packets. Thus the small cell network yields significant throughput ratio using the proposed algorithm of about 0.93, Packet delivery ratio as 86.45% and average end to end delay is about 11.83 ms.

V. CONCLUSION

In this paper, the various interference scenarios in the heterogeneous deployment of small cell networks along with the macro cell Base station were studied and cooperative framework for interference mitigation in both the small cell and the macro cell was introduced. The interference management with the aim of throughput maximization was formulated and proven by the use of the proposed Multi channel Distributed Admission Path Control Algorithm. The results show the effectiveness of the proposed algorithm and because of the dynamic frequency allocation and scheduling mechanism used in this algorithm, the interferences can be easily mitigated. The results also show that the proposed algorithm has good performance as it increases the packet delivery ratio, decreases the end to end delay and as it achieves the maximum throughput over the small cell network The average throughput ratio achieved is 0.93 and this shows the effective transmission through the small cell networks. It is obvious that in the small cell environment the mobile users and base stations are closer together and this leads to less energy consumption during the communication. Hence, small cell networks are energy efficient too.

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