Journal of The Gujarat Research Society

ISSN: 0374-8588
Volume 21 Issue17,December 2019

An Efficient Interference Management using Dynamic Resource Allocation with Adaptive Power Control in Femtocell Networks

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Abstract- *In a Heterogeneous Network (HetNet) inter-cell interference which leads to severe degradation and link failure for neighboring macrocell users. As a result, Adaptive Network Sensing Power Control (ANSPC) technique is proposed for downlink power control for obviating the interference but this technique is not suitable for highly dense small cell structure filled with large number of femtocell Base Stations (BSs) since these networks increase the data demand of end users in current and upcoming generation of wireless networks.To overcome this issue, Dynamic Resource Allocation (DRA) is proposed with ANSPC technique that consists of a dynamic distributed clustering and a fog-driven RA to optimize the total throughput of the network while mitigating the interference. This is fully distributed clustering method which is designed so that femtocell BSs adaptively form clusters with dynamic size based on the current status of the network and end users.*

Key words: *Interference, Cluster Formation, intra and inter-cluster, ANSPC , ANSPCDRA*

1.INTRODUCTION

Over the previous decades, there is a remarkable growth in the traffic demands. It enforces the network service providers to experience Quality-of-Service (QoS).Recent studies on wireless majority of mobile users experience from inadequate indoor signal penetration. Femtocells are better solution to provide higher capacity and coverage for in-building network atmospheres. It has several problems to deploy femtocells in real network atmospheres which need to be considered such as interference avoidance, handover, synchronization, cell selection and self optimizing networks. There are three technical factors that can decide the successful performance of the femtocell technology: i) the definite coverage region of the cell, ii) the auto-configuration and the self-optimization capabilities of the cell and iii) the core network signalling caused by the user mobility.From the technical and industry point of view, femtocells provide the following benefits:Coverage and capacity improvement, High data rates and call quality, Improved macrocell reliability, Cost reduction for mobile operators, Compelling new femtozone services, Simple deployment, intra and inter-cluster interference are addressed, increased performance.

To address and mitigate the intra and inter-cluster interferences in femtocell BSs,a dynamic distributed clustering scheme is proposed to optimize the overall network throughput by clustering the femtocell BSs based on dynamic
size.Dynamic Resource Allocation (DRA) scheme is proposed with Adaptive Network Sensing Power Control (ANSPC) technique for allocating the resources for end users in each cluster and mitigating the intra and inter-cluster interference in the large and dense HetNet without degrading the performance.

2. LITERATURE SURVEY

2.3.1 Power Control-based Interference Avoidance Techniques

The basic mechanism of power control is focusing on avoiding small cells to transmit more power than the users required. Wang et al. [1] investigated the co-channel deployment of femtocells with macrocells. A novel macro user assisted HetNet power control approach is proposed for maintaining the increased interference caused by femtocell low. This approach regulates the transmit power of the HetNet while receiving interference message from a macro user. Two timers are used for controlling the decrease and increase of the transmit power of the HetNet, timer 1 is used for reducing the transmit power, whereas timer 2 is used for controlling the time while the HetNet must initiate to increase the power transmission. The system level simulation outcomes illustrate that this proposed approach cannot only lower the interference to the victim macro user; but also avoid the redundant performance loss of the femtocell. However, the interference between the femtocell BSs is not considered in this approach. Moreover, the macro user requires transmitting interference messages to HetNet and macro user, which implies the probable delay and low reliability in transmitting the control information.

Yeh et al. [2] focused on solving the downlink interference problem. The power control-based interference mitigation algorithms have been designed and evaluated. Initially, the fixed power level operation is considered. Then, two additional adaptive power control algorithms are designed: i) Femto-QoS power control which performs femtocell BS power back-off under the constraint of minimum QoS at femto-users being maintained and ii) Macro-QoS power control which constraints femtocell BS interference to the macro network specific requirements of macro user performance. Outcomes show that the femtocell BS power control can decrease the number of macro users driven into outage by the femtocell BS; but in the cost of decreasing the femto user data rates.

Akbudak and Czylwik [3] formulated the power control problem by considering the worst-case scenario, considering no dominating interferer. A heuristic distributed algorithm is executed for determining the optimum power level, if no feasible solution for a sub-channel, the algorithm determines the admissible subset of users on the given sub-channel by removing the interferers causing unnecessary interference level.

Choi et al. [4] suggested a new Time-Division-Duplex (TDD) frame structure named Listening-TDD Frame (LTDDF) for femtocells. In LTDDF femtocell has both downlink and uplink intervals during downlink interval of macrocell. The uplink interval in macrocell is used as a listening time in femtocell that is used to overhear the signals from surrounding macrocell users to obtain their Channel Quality Information (CQI). Based on the CQI of macro users, the femtocell BS adaptively regulates its transmission power. Outcomes show that using LTDDF supports to effectively mitigate the interference so macro user has better capacity than using a traditional TDD frame. However, the capacity of femtocell reduces due to shorter downlink time than macrocell.

Wang & Kao [5] proposed both functions of frequency channel allocation and transmission power adjustment. Each interfered HetNet decreases it's transmit power, thus the handover process will be triggered for the victim femto users to re-associate with another HetNet for better QoS. This algorithm is suitable only for open access femtocells. Moreover, a dedicated channel scenario is considered to reduce the cross-tier interference; but, the efficiency and flexibility of using the valuable spectrum will be scarified.

Mhiri et al. [6] considered that users can access the femtocell based on three priority levels. An adaptive coverage coordination scheme dynamically optimizes the Femto-enterprise coverage according to the number of users per femtocell and their access level, when satisfying the decision criteria imposed by the threshold SINR condition. Enterprise femtocell needs various deployment solutions as multiple units are required to mutually provide the capacity and coverage. Furthermore, in public locations, the wireless atmosphere is more complex and the interference is relatively solemn whereas the distances between the femtocells are short.

Iturralde et al. [7] proposed power control of femtocell using 2-person game bargaining between throughput and SINR at the femtocell in order to find an optimum trade-off between them to avoid interferences with its neighbours when the femtocell power level transmission is lower. The results show the proposed technique improved in throughput, Packet Loss Ratio (PLR) and SINR. The drawback of this technique is the interference value at macrocell is not taken into account in this literature. Moreover, Alexiou et al. [8] also proposed the power control technique. However, this techique uses priority grouping in which each user of femtocell was assigned to one of the available groups with different priorities in terms of power requirements and traffic load. But the advantages lies on it focuses on distance (between the Access Points (APs) and users parameter) and load as the parameters. However, the drawback of this method is it is more time consuming.

Chaves et al. [9] proposed interference aware operating point in LTE-Wi-Fi network. The performance of this simulation network was measured by mean user throughput and results in improvement of Wi-Fi coexistence and slightly reduces in LTE network. The disadvantage of the proposed network is it focuses only at indoor network. However, Khawam et al. [10] proposed power control technique focuses on outdoor areas. He used non-cooperative game where the interactions between players competing for a common resource. The advantages of the proposed technique are it can be controlled based on only local information and has low convergence time. The drawback its usage is only for macro network.

3.METHODOLOGIES

3.1 EXISTING METHODOLOGY ANS POWER CONTROL TECHNIQUE LIMITATIONS

- It can suitable for large and random deployment of femtocell BSs which incur severe interference that leads to significant performance degradation.The overall throughput of the network is not optimized while mitigating the interference.Also, intra and inter-cluster interference are not addressed which are two potential types of interference.

3.2 PROPOSED INTERFERENCE MANAGEMENT TECHNIQUE

ANSPC with DRA technique is proposed to mitigate the intra and inter-cluster interference in dense femtocell networks with optimizing the overall throughput of the network. Define a set of femtocell BSs as $\mathcal{F} = \{f_1, f_2, \ldots, f_M\}$, so that each femtocell BS is a member of disjoint cluster set $\mathcal{C} = \{c_1, c_2, \ldots, c_L\}$. Therefore, each femtocell BS $f_i \in c_l$ can be represented by $f_{i,l}$. Moreover, the in-range neighbors of femtocell BS f_i is defined as a set of femtocell BS shown by $\mathcal{N}_{f_i}$ and the set of end users of f_i are defined as $\mathcal{V}_{f_i}$.

The set of Resource Blocks (RBs) is denoted as Δ and thus, the received amount of SINR of each $u \in \mathcal{V}_{f_i}$ on the RB $k \in \Delta$ is defined as follows:

$$\gamma_{u,k}^{f_{i,l}} = \frac{P_k^{f_{i,l}} H_{u,k}^{f_{i,l}}}{\sigma^2 + \sum_{f_{j,l'} \in \mathcal{F}, j \neq i, l \neq l'} P_k^{f_{j,l'}} H_{u,k}^{f_{j,l'}}} \qquad (3.1)$$

Each CH is responsible to allocate the RBs so that no intra-cluster interference occurs in its cluster. Since each CH is unaware of adjacent cluster's RAs, there is high probability of inter-cluster interference on edge FBSs.

The fog servers provide a set of policies for each cluster c_l in which each element contains the specific femtocell BS on which that policy should be applied and specific subset of RBs called range representing the RBs which can be assigned to that femtocell BS as shown in the following:

$$Policy_{c_l} = \left\{ \left(f_{i,l}, range(f_{i,l}) \right) \middle| f_{i,l} is\ Edge, range(f_{i,l}) \subseteq \Delta \right\} \qquad (3.2)$$

The policies to mitigate the inter-cluster interference are provided in three phases including graph formation, graph coloring and graph relaxation.

Graph Formation:

The main aim of this phase is to form an interference graph of edge femtocell BSs. To achieve this, CHs send their neighbor lists of edge femtocell BSs and their respective demands to the fog servers.

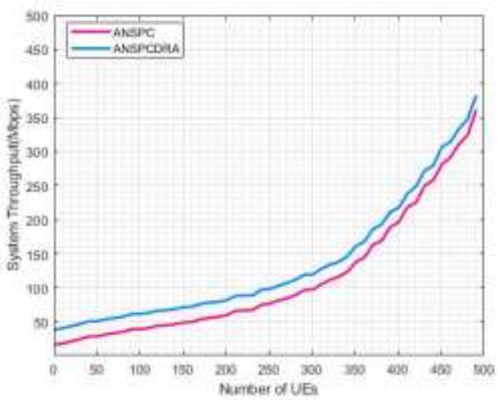
Graph Coloring:

In this phase, the inter-cluster interference is addressed by a graph coloring method for each connected graph g_z in the G created in the graph formation phase. The main objective of graph coloring method is to find a set of different colors for edge femtocell BSs and assign a set of respective policies to CHs for the RA, so that the inter-cluster interference reduces.

Graph Relaxation:

This phase is the backup phase for the graph coloring and is invoked if graph coloring cannot find any solution to color g_z up to K_{max} colors. The graph relaxation phase attempts to decrease the maximum vertex degree of sub-graph g_z by ignoring the weak interferences leading to creation of new g_z with less constraint.

4.RESULTS



In the graph, x-axis denotes the number of UEs i.e., end users and y-axis denotes the system throughput i.e., total throughput in Mbps. From this analysis, it is observed that the proposed ANSPCDRA technique achieves higher throughput than the ANSPC technique for mitigating the interference in femtocell networks.

Spectrum efficiency is defined as the ratio of transmission number and spectrum bandwidth.

$$Spectrum\ Efficiency = \frac{Transmission\ number}{Spectrum\ bandwidth}$$

the proposed ANSPCDRA technique achieves higher spectrum efficiency than the ANSPC technique while avoiding the interference in HetNet networks, less transmission delay than the ANSPC technique for mitigating the interference in femtocell networks. Path loss is defined as the ratio of the transmit power to the receive power. The highest path loss is computed from the largest transmit power and the smallest receive power.

Transmission delay is defined as the number of time units taken during transmission of one packet.

The comparison values of path loss for proposed ANSPCDRA and existing ANSPC techniques are given in Table 4.1.

Table.4.1 Comparison of Path Loss

Techniques	Path Loss
ANSPC	89.7988
ANSPCDRA	79.2270

the performance efficiency of proposed ANSPCDRA based interference management technique is evaluated and compared with the existing ANSPC technique in terms of total throughput, spectrum efficiency, transmission time delay and path loss. From the analysis, it is concluded that the proposed ANSPCDRA technique achieves better performance than the existing technique to optimize the total throughput of the network while mitigating the interference in the HetNet.

5. CONCLUSION

In this work, an enhanced version of ANSPC technique for interference management is proposed, namely ANSPCDRA technique in dense femtocell networks. In this technique, DRA scheme is proposed to allocate the RB for each femtocell BS in the network with optimizing the network throughput and improving the performance. A dynamic distributed clustering scheme is applied in which femtocell BSs choose the CHs which are responsible to allocate the cluster RBs and notify its corresponding fog server of the cluster's parameters. Moreover, a policy aware fog-driven RA method is used for reducing inter-cluster interference based on three phases including graph formation, simplification and relaxation which are performed on the fog servers located at the proximity of clusters. The outcome of these phases is a set of policies for edge FBSs of each cluster, by which the CH can assign the RBs more efficiently and prevent the severe inter-cluster interference. Finally, the simulation results show that the proposed ANSPCDRA technique outperforms the ANSPC technique in terms of total throughput, spectrum efficiency, transmission delay and path loss.

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