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Interference Management, Backhaul Routing & Switching off in 5G Hetnets with Mmwave Backhaul Links: A Relative Perspective

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Abstract*: Today most of the next generation wireless communication systems(5G) faces the challenge of supporting the demands for higher data rates growing exponentially and ensuring to provide a stable quality of service (QoS) throughout the network. Over the next 2 years meeting up these requirements need to maximize the capacity of the network by a factor which will multiply it by thousands. Moreover, the most important societal as well as economical concerns include the power usage of data and communication technology industry and pollution mostly energy-related. On 5G two contrary requirements of providing capacity to support higher cellular networks along with consuming less energy needs to be focused upon. Due to the scarcity of spectral sources, a wide consensus can only be achieved by increasing significantly the number of antennas operating per unit area. Here a heterogeneous network named HetNet is analysed, comprising a macro base station (BS) along with several antennas and an overlaid dense tier possessing SCAs(small cell access points)through a wireless backhaul to get data traffic. The SCAs mostly associate with static as well as low mobility user equipment whereas macro BS serve the medium-to-high mobility. This work analyses the methods of the ultra-dense wireless 5G heterogeneous networks considering the interference management along the mm-Wave backhaul links to utilize the spectrum and network densification to operate mm-Wave 5G HetNet. The study reviews several literature works, their drawbacks and developing a joint model by combining base station switch-off technique with interface mitigation. This study further throws light on the scope of managing the backhaul-aware interference which in turn enhances potential capacity of the system and depending on the suitable backhaul the capacity is improved. Millimetre wave(mm-Wave) has proved to be a remarkable candidate to overcome the issue of ensuring a broad bandwidth having secure link transmission. The ultra-dense heterogeneous networks are discussed along with discussing the role interference management algorithms to minimize energy consumption. The importance of interference management is discussed along with discussing issues related. The research problem is formulated following a comparative analysis.

Keywords: UMH, backhauling, mm-Wave, interference management, RAT

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I. INTRODUCTION

The exceptional increment of cell phones amid the most recent years has prompted the purported ultra-thick heterogeneous systems (Hetnets) for improving the coverage, capability, and efficiency of the energy, which is a positive Fifth Era response (5 G). The ultra-dense multi-level Hetnets (UMH) is viewed as a key innovation to tackle the issue of high information stream in versatile systems when defied with high capability and high power (Li et al., 2018). Nevertheless, deploying the ultra-thick considerably builds interference among the base stations, and the energy consumed, operational costs are also increased. Because of the irregularity and thickness of deploying small base stations, studies on effectively managing the interference present in between the base stations has stayed the basic of the architecture for energy-awareness. The algorithms of managing interference can likewise decrease the energy which is being consumed in the UMH; hence, it has turned into an essential point of study in ultra-thick systems.

Dissimilar to the initial cell network, the interference in case of ultra-thick multi-level Hetnets is limited and sporadic (Wu et al., 2016). The interference is present in both contexts of inter and intra cell as well as inter and intra tiers. In UMH, the base stations that are small accept a similar range and Radio Access Technology(RAT) in the form of a full-scale base station for Challenging Impedance Management and conservation of energy in UMH. Numerous researchers consider that centralized control like data centers, virtualization, cloud computing, or clustering attempts to relieve these issues. But the process of optimizing the energy saving and managing the interference in the centralized infrastructure which controls ought to be energy aware. Interference in the environments of UHM is particularly complex.

The deployments of the base stations are conducted in an unplanned manner and the full-scale base station supports the expansion capacity of including the first user, bringing about more prominent interference (Zhang et al., 2015). In the event that the system model's intricacy can be diminished by means of graph theory and dynamic auxiliary change as indicated by conditions of interference, the system will benefit by the previously mentioned techniques while managing interference all the more sensibly, therefore improving energy productivity.

Hence this work aims at conducting an exhaustive review of underlying methods in an ultra-dense wireless 5G heterogeneous networks interference management.

II. LITERATURE SURVEY & INFERENCES

An ordinary mobile network has two separate channels, one from devices at the user end to the base station for transmission termed as uplink and another reverse path from base station to end-user devices called downlink. If they use a similar frequency, then it leads to co-channel interference, which has been studied in many works (Panwar et al., 2016). Samarakoon et al., (2013) have considered a Hetnets for uplink interference management, in which the small cells depend on capacity constrained backhaul systems for macro base station offloading problems.

In the suggested mechanism, the macrocell user equipment can utilize the nearby base stations to improve their uplink performance. A distributed learning algorithm was employed to solve the noncooperative game-based problem expression for the macrocell user to pick a suitable uplink transmission. A traffic model has been designed by Tran et al., (2016) dependent on the estimation data in Tokyo city using the model the on-request cell activation or deactivation happens with customer affiliation components which boost the system's energy proficiency.

The C-RAN based cloud operated Hetnets architecture with resource optimization among the small cells is considered. The empirical results show that, when compared with the homogeneous structures, the feasibility of the proposed measure against diverse hourly traffic variety with increasing customer fulfilment.

Orhan et al., (2017) proposed an interference mitigation strategy within a 5 G ultra-thick remote system. It considers a collection of transmission focuses which serve the various client equipment using a similar remote asset.The user end scheduling which is proposed will help in scheduling a single user end or multiple users end and can be represented by a dozens of different non-orthogonal access.

For single user networks where the NOMA is known the interference is regarded as noise. The results show that the interference management scheme proposed can improve sum throughput and coverage.

Yang et al. (2017) introduced a possible network for architecture for ultra-thick heterogeneous systems and proposed a symmetric or non-symmetric arbitrary access plan to improve system performance by decreasing overhead signaling..

The DUdE (downlink and uplink decoupling) and C-RAN (Cloud radio access network) are introduced for 5G. The Generalized orthogonal/non-orthogonal random access scheme for massive Machine type communication devices and helps in analyzing the challenges of ultra-dense heterogeneous networks. The proposed UDHN is seen as a development of the existing heterogeneous LTE networks, which shows that the present architecture is strong.

Zola et al., (2018) built up an ideal strategy dependent on the blended number direct programming (MILP) which thinks about various client dissemination and traffic requests in various timeframes. The two-phase solution is developed which combines the users and helps in calculating the backhaul routes for optimizing energy efficiency.The basic goal is to mitigate the expense of life for the operator of the network and fulfill the customer requests. This tests the 5 G systems ' successful conceptual ideal energy setup. Static use of power arranges the dynamic base stations and the backhaul procedures.

The empirical evaluation demonstrates the benefit of the streamlining approaches in terms of the efficiency of energy with demands for company traffic. Li et al., (2018) proposed an impedance that the executives conspire on ultra-thick multi-level HetNets depending on the energy-aware design. Issues of energy effectiveness are discussed using map hypothesis and HetNets classification. The connection between the executives ' energy and obstruction is broken down by using the led overview.

The suggested approach based on the strife map includes telephone grouping and asset classification that disrupts the structure of the network. The algorithm of Q learning is used to enhance the control of power in cell clustering. The proposed scheme thereby allocates the frequency spectrum fairly by reducing the system interference signals to improve the throughput.

III. THE SCOPE OF BACKHAUL-AWARE INTERFERENCE MANAGEMENT

Among the research community, the establishment of small cell networks otherwise termed as heterogeneous networks or HetNets has gained huge popularity. In ultra-dense networks, small cells having high data rates are mostly distributed in hotspots like malls, offices and residential buildings to offer traffic offload from macrocells, because of large traffic demands arise from these hotspots. So, a wide bandwidth with trustworthy link transmission should be provided by the associated backhaul. As a result, finding solutions for the backhaul of small cell networks becomes very significant so as to improve the system potential capacity and the capacity improvements depend on choosing an appropriate backhaul. Millimeter wave (mm-Wave) backhaul appears to be an excellent candidate to overcome the above constraints and it has benefits such as:

1. Unlike traditional mobile networks, mm-Wave backhaul could influence a huge quantity of underused band in mm-Wave to offer the appropriate gigahertz transmission bandwidth.
2. The signal directivity, link reliability could be enhanced, and co-channel interference too could be reduced by easily employing numerous antennas for mm-Wave communications because of its small wavelength.

Research Objectives

1. To study related existing work and evaluate the future scope of Backhaul aware interference management in mm-Wave 5G HetNet.
2. To develop an interference management scheme by employing SC-BS ON/OFF status and mm-Wave backhaul links.

IV. ULTRA-DENSE HETEROGENEOUS NETWORKS AND MM-WAVE BACKHAUL

The ultra-thick heterogeneous networks (UDHN) are considered probably the best thought of the flexible communication architectures of the fifth-generation (5 G) (Ma et al., 2018). Such compact 5 G communication mechanisms improve flexibility and range efficiency when compared, and the flexible communication structures of the fourth era (4 G) long haul technology (LTE) (Park et al., 2017). The ultra-thick heterogeneous systems utilizing minimal effort of small cells satisfy the different types of 5 G administrations (Galinina et al., 2015). Despite the fact that UDHN is a significant 5 G improvement, they face few specialist challenges and problems (Gupta et al., 2015). Impedance in cell and wi-fi transmitters are the fundamental problems in UDHN systems. The ultra-thick heterogeneous systems utilizing minimal effort of small cells satisfy the different types of 5 G administrations (Galinina et al., 2015). Despite the fact that UDHN is a significant 5 G improvement, they face few specialist challenges and problems (Gupta et al., 2015). Impedance in cell and wi-fi transmitters are the fundamental problems in UDHN systems. The ultra-dense deployment gradually increases interference between the base stations, energy consumption, and always has high operational costs. The interference management algorithms help in reducing the energy consumption in UDHN (Li et al., 2018). If the cell density in the network increases the topology of the complete network becomes more difficult, and the problems of interference become more critical in the ultra-dense cell deployment scheme. The system presentation is to express the management's positive impedance and to boost cell edge client counter sticking view. To mitigate the issues of interference management, the researchers follow different techniques like cloud computing, clustering or virtualization, etc., (Wang et al., 2016). The UDHN exhibition does not increase with BS thickness, and the limit between cell obstruction and the fronthaul and backhaul arrangement is restricted (Zhang et al., 2016). The UDHN's main difficulties are operating and transmitting cell systems to combat the production of traffic with less radio properties.

The mm-Wave backhaul networks along with base stations could be built on urban regions and lamp poles, etc. For transmission of large data demanded by cellular devices, the customer hardware portable base station and the mm-Wave base station need to help each other successfully transmit. Either Multihop mm-Wave wireless or optical fiber backhaul links would be used by the mm-Wave base station for routing to transfer/receive large data from users to the mobile networks. The traditional networks handle the data exchange via the mm-Wave access link (Dehos et al., 2014)

V. ISSUES AND NEED FOR INTERFERENCE MANAGEMENT

The introduction of the Inter-cell interference coordination in LTE networks is co-channel interference where the neighboring base stations allocate different radio resources to the users. The obstruction of the co-channel caused by the restricted separation between the adjacent little cells would dramatically disintegrate the system execution of cell-edge clients ' QoS. Impedance is therefore expected of the board for the customer experience. The partial frequent reuse technique is used for doling out the various assets to cell edge clients where the various frequent reuse factors are implemented in the cell population to reduce the impedance between cells. In 5G UDHN propelled impedance the board methodologies are considered to beat the more genuine obstruction status where impedance molding and obstruction abuse is of numerous sorts. These are system-side methodologies and to further improve the obstacle of executives, customer-side methodology can also be applied in 5 G UDHN to defeat impedance problems. This methodology has the collector that considers the structure of the impedance signal, and the signs are determined by subtracting the replicated interference symptoms from the received signs.So, both the approaches help in the interference mitigation issues. Different interference management schemes are considered for increasing the spectrum efficiency and the between cell impedance is increasingly genuine and requires the propelled plan to acquire a higher throughput (Lee et al., 2016).

VI. RESEARCH PROBLEM

The 5G networks will have a tough time in managing interference as the interference grows in proportion to the huge advancement and multitude of the user equipment and heterogeneous networks. The sources of interference in 5G networks include macrocell and small cell base stations and different user equipment. Therefore, it is essential to construct an effective and reliable interference management scheme for objectives like detecting, interpreting and mitigating overloads, balance load, and energy management. During the management's impedance, a BS configuration and use of more transmitting receiving devices will lead to a decrease in vitality efficiency and result in a critical increase in operational and energy costs for the network operator due to the complex customer transportation and traffic variety. Nonetheless, it does not consider RAN (Radio Access Arrangement) and backhaul shared power utilization enhancement and does not find heading selectivity as agreed inside the mm-Wave backhaul joins the case. There is such a large number of connection heading blend up-and-comers, so it's difficult to locate the best mix of mm Wave backhaul connections and the ON / OFF status of SC-BSs for the best contact bearing mixIn a mm-wave backhaul arrangement, just a few Small Cell BSs are connected through the fibre to the portal and backhauling relies heavily on mm-wave joins.

In an mm-wave backhaul arrangement, just a few Small Cell BSs are connected through the fibre to the portal and backhauling relies heavily on mm-wave joins. These mm-wave connections will be slowly set up which adds incredible adaptability to the transmission of information backhaul.

VII. COMPARATIVE STUDY:

Omidvar et al, 2018 assessed the dynamic resource problem in HetNets with both wired and wireless backhaul.

But the work has not taken into account the growing multitude of antennas and users in load balancing problems. Also, only a few works have evaluated the user association problem like Ye et al.,2013; Bethanabhotla et al., 2016 but without considering the backhaul elements. From the literature, it can be observed that there is no work that considers the backhaul link constraints with energy effective interference management. Feng et al., 2017 evaluated the challenges and scope of BS ON-OFF switching in 5G. They have done a comparative study to assess the challenges of BS ON-OFF switching in 5G wireless networks and offer a solution to those problems. Also, an overview of recent works that have implemented BS ON-OFF switching in 5G was provided for future development and outlook. Some of the study and interference techniques used are given below.

The table below represents the different types of interference management techniques, the summary of the proposed approach and the possible outcome of the conducted research. The different interference management techniques like cognitive radio interference management, co-channel interference management, self-interference cancellation, NOMA, energy-aware architecture, co-channel interference suppression techniques have been considered.

Table I: Interference Management Techniques

Reference Number	Type of interference management	Proposed approach summary	Outcome
13	Cognitive radio interference management	This work is based on cognitive radio based mechanism to improve the interference coordination in femtocell (small cell) networks	It indicates that for femtocell networks cognitive radio based mechanism is an appropriate and effective scheme to manage cross-tier interference coordination. The work suggests future scope may include game-theory-based spectrum sharing and cooperative spectrum sensing in femtocell systems along with detecting the rangecould be investigated for wireless backhaul to improve spectrum bandwidth.
23	Co-channel interference management	This work analyzed the important factors in interference management of 5G networks in detail, specifically interference management with regards to end user equipment. The practical issues in implementing interference management in 5G networks were investigated. Furthermore, the benefits of advanced interference management were provided.	It was suggested that the advantages of advanced receivers could be reaped if 5G mobile networks implement wide joint scheduling mechanisms. The joint scheduling mechanism might gain about 50 percent improvement in cell edge throughput without compromising the cell average throughput. This work finally revealed that if 5G networks employ advanced interference management, it would enhance the user experience efficiently.
20	Self-interference cancellation in Full duplex communication network	This investigation assessed Full duplex communication self-interference cancellation mechanism such as passive suppression etc, and its focal points and inconvenience. What's more, the Complete duplex system discussed the start to finish postponement and the congestion in the network. The problems in MAC-layer conventions dependent on the FD have been dissected.	It deals with explaining the difficulties in self-interference cancellation and it indicates that if the interference is reduced below 3 db then, it might not affect the system throughput. Also, the passive and active Self-interference cancellation methods were evaluated and their benefits along with difficulties were explained. It reveals that, to efficiently model the SI cancellation, the analog/digital functions should be managed first.
10	Non-Orthogonal Multiple Access (NOMA)	This study proposed for managing the interference utilizing NOMA where a class of transmit points (TPs) which aims to serve the multiple UE utilizing the same resource.	It suggested the scheduling technique of UE which can adeptly line up the UE for each TP for serving in NOMA or single user mode. generalized ITL in Q conditions determined the TP. This technique outperformed the existing techniques with respect to coverage as well as sum-throughput.

1	Energy aware architecture	The main goal is to study the issues related to the efficiency of energy with the help of clustering and graph theory. Further, the interference management that is in the process is optimized using the optimization algorithm of reinforcement-learning.	In the clustering interference management obstruction and productively coordinate the use of energy, avoiding superfluous energy utilization, and limiting impedance signals. The proposed plan could also apportion the frequency range reasonably, lessen framework interference, and improve throughput execution.
5	Co-channel interference suppression technique	This study aims to minimize the receiver's co-channel interference by means of a suppression technique.	The results of the developed low-complex method proved that this technique performed better than the authentic IRC method by 5dB at a 0dB interference ratio.

VIII. RESEARCH DIRECTIONS & CONCLUSION

This work has analysed a heterogenous network named HetNet comprising of macro base station (BS) along with several antennas and an overlaid dense tier possessing SCAs(small cell access points)through a wireless backhaul to get data traffic. The SCAs role in associating static as well as low mobility user equipment whereas macro BS serve the medium-to-high mobility. This work analyses the hidden methods of the ultra-dense wireless 5G heterogeneous networks with respect to the interference management along the mm-Wave backhaul links to ensure effective usage of the spectrum and network densification for operating the mm-Wave 5G HetNet. Several literature works, are reviewed along with their drawbacks and developing a joint model by combining base station switch-off technique with interface mitigation. The scope of managing the backhaul-aware interference are discussed which in turn enhances potential capacity of the system and depending on the suitable backhaul the capacity is improved. Millimetre wave(mm-Wave) has shown excellence as a candidate to solve the issue of ensuring a broad bandwidth having secure link transmission. The ultra-dense heterogeneous networks are discussed along with discussing the role interference management algorithms to minimize energy consumption. The importance of interference management is discussed along with discussing issues related. The research problem is formulated following a comparative analysis.

An interesting direction of the future works include display of the accomplishment of the energy-based additions which is empowered by turning off the base stations in case of managing energy-based interference and more research will be carried out on the display gap between the ideal model and the related work.

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