The Impact of Heterogenous Ultra-dense Network Technologies on the Performance of 4G and 5GNetworks

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Abstract-The flood of applications that demand massive data has imposed a challenge for 5G cellular network in order to deliver high data rates, a better quality of service, and low energy consumption. Heterogenous ultra- dense networks are one of the major technologies to address such challenges. HUDNs play a big role in a cellular system. They deliver cost-effective coverage with low transmit power and high capacty to face the risen data and the high expectations of the user's performance. In this paper, we introduce the impact of small cells on the cellular system and the technologies the small cells utilize to make the cellular system faces the subscriber's demands. First, we discuss the fundamentals of used technologies in small cells. Next, we studied the small cell management. Then, self-organizing networks are studied. After that, we have reviewed the small cell's power consumption, mobility, and handover. Finally, the real-world experience of mm-waves and MIMO in 5G small cells.

Keywords—4G,5G, small cells, mm-wave, SON,MIMO

I. INTRODUCTION

The fifth generation of cellular wireless communication provides smooth continuous communication for machines and users. High-resolution video streaming, telemedicine, telesurgery, smart transportations, and real-time control are new applications that precept an updating for reliability, throughput, end-to-end latency, and network robustness. However, small cell densification is imperative to achieve the success of the 5G network and make it meet the highly anticipated increase of capacity to a thousand times. Network densification will increase the capacity of the network and cell sites including, macro sites, small cell deployments, and radio access. The most favorable location for network densification will be close to urban areas and large places where there are huge numbers of digital users who demand high connectivity and fast speeds ten times faster than 4G. Increasing the number of antennas and small cell sites besides using sector splitting and massive multiple input multiple output (mMIMO) technologies achieve network densification. Cell splitting increases the number of antennas and that leading to an increasing number of hand-off which produces larger interference between the small cell sites. “Fig. 1”shows the interference between the small cells and macrocells [1].

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5G aims to be autonomously intelligent and the resources must match all patterns of traffic, which can be achieved by presenting new wireless technologies and by increasing node density. To be more accurate, deploying small cell densification on both licensed and non-licensed bands, a live example of unlicensed bands is WiFi access points (APs), and device-to-device (D2D) communication that exists to mitigate the tension between resources and traffic in the conventional networks. However, due to user mobility and diversity, and spectrum limitation, new challenges have arisen. Small cell traffic offloading classified as an effective and important mechanism to alleviate those challenges [2]. İn small cell traffic offloading, the heavily loaded cells offload a portion of their traffic to the low utilized cells which have an available resource that can be shared with the heavily loaded cells. Small cell traffic offloading improving the utilization of resources, alleviating the congestion of the network, enhancing user service quality and network availability, and extending the sustainability of the network. Many technologies have been introduced to enhance the performance of 4G and 5G networks which will be discussed. In this paper, we studied the developed technologies of small cell management, self-organizing networks, and the revolutionary impact on cellular systems. After that, we have introduced how small cells affect the power consumption of the system. Subsequently, mobility and handover through heterogeneous ultra-dense networks (HUDNs) were reviewed. Finally, the real-world experience of (HUDNs) using mm-waves and mMIMO in 5G small cells.

II. SMALL CELLS MANAGEMENT

In LTE, the small cells play a big role in term of the macro station, it has helped to cover the locations which macros could not manage very well such as the edge of the cells. Many kinds of research have been done to manage the interference of adjacent macro base stations or adjacent small base stations or interference between adjacent small and macro base stations

A. Inter-tier interference

When a connection is done between two network elements of two different tiers, this could be called Inter-tier interference or cross-tier interference. It's interference between small cell equipment user and Macro base station due to the difference of several situations, i.e., Case (1) for upload inter-tier interference between the macro station and the small cell user, Case (2) represents downlink inter-tier interference between the small cell user and (MBS), case (3) and (4) are upload and download cross-tier interferences between (MBS) user and (SCBS) respectively [3], [4].

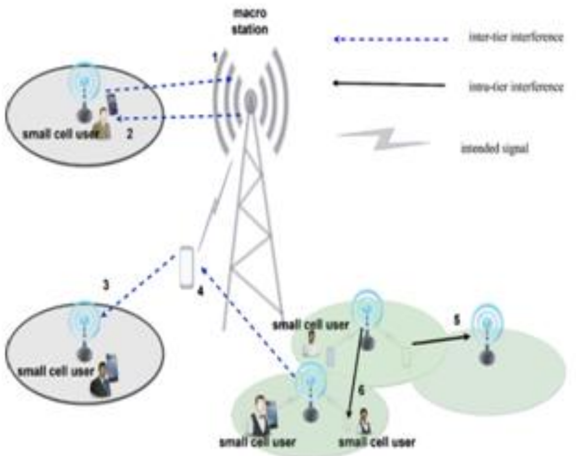

Fig. 1. Inter-tier & intra-tier interference scenario

B. Intra-tier interference

Intra-tier or co-tier interference designates the same tier base stations in the network, it could be between the same macro base station (MBSs) or the same small cell base stations (SCBSs) which are positioned randomly and separated at small distance densely. Furthermore, (SCBSs) will interfere with each other due to the process of sharing the same band as a result of not using an allocated orthogonal sub-channel. Figure (1) demonstrates the intra-tier interference as two cases, (5) and (6) wherein case(5) an upload intra-tier interference between small cell user of a cell and small cell base station (SCBS) of another cell. Case (6) shows the download intra-tier interference between small cell users and SCBS of another cell which is not meant to be connected to that SCBS [4]. In [5], interference management in ultra-dense networks has been investigated for several domains by an algorithm that deals with SBSs co-tire interference. That algorithm schedules OFDM, TDMA, and interference alignment (AI), besides power optimization. Firstly, Neighbouring SBS interference is reduced using OFDMA scheduling and that's by allocating Sub-channel and establishing stable transmission links. Secondly, depends on overlapping coalition formation game (OCFG), SBSs forming a coalition structure which is stable overlapping where the IA aligns the intra-coalition interference and TDMA scheduling reduces the co-tier interference among coalitions. Finally, mitigating the remaining of the interference by the optimization of the power further.

C. Fractional Frequency Reuse (FFR)

In cellular networks, managing the radio resources to address the cross-interference is called fractional frequency reuse. It is different in the WiFi networks, to manage the transmission over the cells it`s required intelligent scheduling for download and upload synchronous operations. For microcell networks, “Fig. 2”shows the popular 1-3 FFR scheme which divides the spectrum into four fixed size bands, one of the bands in each cell is used by the clients of the cell interior, those do not experience the interference due to the closeness to the base station, where the other three bands usually used by clients of the cell exterior in an orthogonal way between the three cell sectors just to mitigate the adjacent cells interference. Therefore, the band used by the clients of the cell interior is used in each cell, the reuse of the three bands are submitting to the possible spatial reuse [7]. Dynamic FFR methods for small cells have been proposed by [8] which calculate the size and number of bands

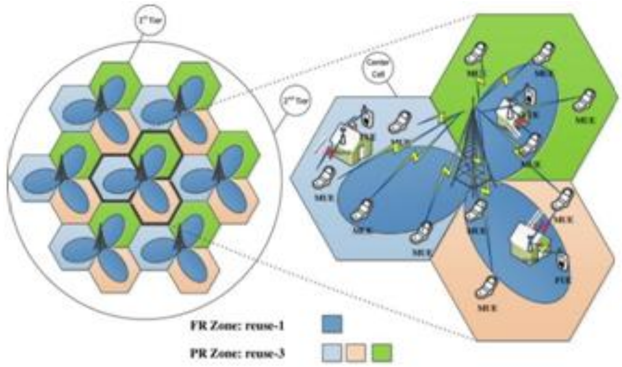

Fig. 2. Popular 1-3 FFR scheme (Network deployment) [6]

used by each small cell based on the cumulative traffic demand from the clients of the interior and exterior of the cell; they permit only for better spectral utilization and do not rely on planned sectorization (unlike microcells). Note that the FFR schemes only determine the set of spectral resources assigned to cells - scheduling of clients within those resources is done by each cell locally (based on per client feedback) to leverage multi-user diversity. For FFR was adopted in FluidNet, although other FFR schemes can also be easily used. While point-to-point MIMO is automatically incorporated in FFR, other cooperative techniques such as multi-user MIMO and co-ordinated multipoint transmissions (CoMP) can also be applied under FFR [8]. In [9] an algorithm proposed to manage interference between macro and femtocells by developing the FFR concept as to manage the interference as the following: if the femtocell inside the inner region and in low density it uses arbitrary FFR radio resource hopping but if the femtocells are in the outer region or inner region with high density then it uses orthogonal FFR radio resource allocation. The handover strategy between the macrocells and femtocells under the hybrid access mode in LTE network has proposed in [10], the authors introduce a handover algorithm for the hybrid access mode (registered and unregistered users) based on two factors (the velocity of the user equipment UE and specific stay time interval T), and they consider the capacity which the femtocell accepts and the SINR. They gave the priority for those UE velocities less than 30km/h and signal level more than the threshold. However, registered UEs have the priority for handover while unregistered UEs should wait for a threshold time interval, and then the next procedure of handover can conclude them. The simulation`s results showed a better handover results and minimized many of those unnecessary handovers. Frequent exchange of information between the small cells and their neighbor smalls cells or between small cells and macrocells is a direct consequence of non-uniform user traffic [11]. Self-organizing networks (SON) used to interact with handover problems, mobility management, and load balancing.

The large scale networks are divided into small cells, with features of SON, the network provides a link between the users for task synchronizations and self-optimization [12].

Handover mobility self-optimization in LTE network was proposed using handover parameters such as hysteresis (hys) and time-to-trigger (TTT), the authors in [13] proposed away to improve the performance of the network to be specific to increase the throughput and decrease the network jitter and delay, by tuned the mentioned parameters.

In [14] designed a strategy aims to overcome the of conventional received power (RSS)-based association strategies, by user mobility-awareness for mmW networks, which have proved five aspects: The ability to track the dynamic changes in the topology of the network and the conditions of the channel which made by the user mobility. The strategy considers the load distribution for a small base station (SBSs) so that the UE connection overcomes the small base station which is already congested. The need for periodic reassociation as a result of overcoming repeated handoffs between SBSs.The unusual aspects of millimeter waves have been considered such as NLoS propagation, sensitivity to blockage, and directionality effects. Each UE connects to an SBS individualistically.

The use of mobile devices has expanded enormously. As a result of that, conventional networks such as long-term evolution (LTE) and LTE Advanced will not be able to face future demands. The researchers come with the fifth-Generation mobile communication system (5G) which provides lower latency and higher data rates. 5G technology has been through many evaluated levels, one of those creative ideas proposed by [1], the researchers suggested a potential cellular architecture included the separation of indoor and outdoor to avoid potential loss through the buildings using distributed Antenna (DAS) and massive MIMO (multiple inputs multiple outputs). However, splitting the plane of SDN and changing the paradigm of 5G architecture from base station centric to user-centric (paradigm shift) is poised to achieve sub-millisecond latency as shown in figure (3) [15]. Small cell base stations (SCBSs) are controlling the user plane signaling to their mobile stations (ME) [3].

The enabler's key technologies introduced for next-generation network densification i.e., user-centric and cloud-radio access (CRA) mechanisms, device-to-device communications (D2D), techniques of advanced inter-cell interference cancellation, separation of control and user plane, and caching.

D. **Device-to-device communications (D2D)**

In conventional cellular networks, the communication between devices can only occur through a base station. However, in HetNets; the users communicate directly without using smart devices.

Recently, smart devices became ubiquitous; almost every user has a smart mobile device that paved the way for deploying D2D networks. D2D communications alleviate the load pressure of network loads, improve quality of service (QoS) and reliability. For service providers, instead of sending content to all users; it's preferable to send the content to some users to share it with the rest of the users, which alleviates the load pressure of the cellular network.

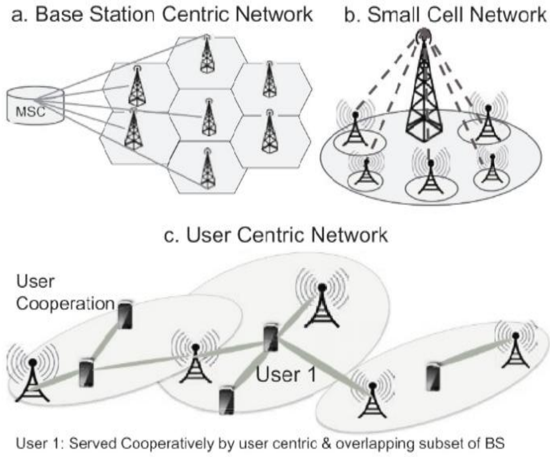

Fig. 3. Paradigm`s shifting from base station centric to user-centric

"Fig. 4"reveals the D2D communication scenario; Macro station node (MeNB) sends content to mobile user (MUE1); MUE1 spread the content to MUE2 which shares the content to MUE3& MUE4. İn the other hand, the MUE5 received content from MeNB then it shares the content to MUE6 which sends the content to MUE7. D2D communications (in-band and out-band) improve the performance of cellular networks; in terms of cellular coverage, energy, and efficiency [16]. D2D-aware handover, smart mobility management, and D2D triggered handover are solutions proposed by Nokia Research Centre [17].

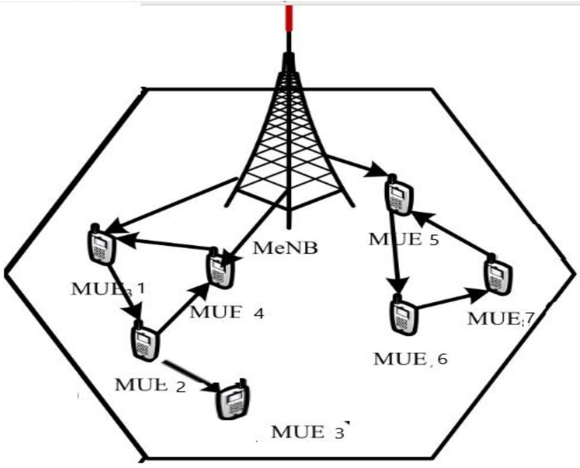

Fig 4. A scenario of D2D communications

İn cellular systems, D2D communications is an ideal technology for traffic offloading.

Trafic offloading categorized in terms of delay into two types (sensitive and tolerant). İn the delayed-sensitive traffic offloading, interactive and real-time applications are targeted [18], while in delay-tolerant, non-real-time applications are targeted such as e-mail, and used to deal with the traffic storms and promoting the performance of a network., which rises throughput by linear increase [2]. Many research papers confirmed that short-range D2D and joint cellular communications providing flexible transmission mechanisms [18]-[19].

E. **Distributed Antenna Systems (DAS)**

In DAS, dilevering a common signal from the same source to many RRHs that transmitted simultanously to provide more indoor/outdoor coverage. The signal foot print is increased across many transmit points and under-utlizes spectrum without any scope for spectral reuse which is unlike FR that foucses on capacity only. The relation between configuration and stratigies: in FFR, for each cell, a different frames is generated due to the different operated spectral bands for cells, therefore, the logical mapping between BBU and RRHs is one-to-one, which is currently the conventional maping in C-RAN. İn DAS, a single frame is transmitted by many RRHs which is achieved by using single BB, therefore, the logical mapping between BBU and RRHs is one to many.

1) Adaptive RANs

For more than forty years, cellular communications have relied on the stationary deployment of radio access. However, the densification of the network is one of the most promising ways to tolerate radio access networks (RAN) to deal with the expected increase of the traffic of data as well as with the tremendously increased crowding atmospheres such as conferences, malls, and stadiums [21]. Small cell base stations (SCBSs) are required for RAN densification due to the huge number of users and traffic generated is extremely raised even it is for a small duration of time. Recently the vision of 5G aims to place hundreds or thousands of SCBSs per km^2. On one hand, in the morning where people go to their work considered as busy hours for mobile operators, where the SCBSs capacity is needed unlike the time after work, the capacity of RAN turns out to be lower and many of the SCBSs becomes terminated. On the other hand, in residential zones, the capacity and density of RAN are needed in the evening when people come back to their homes. For those reasons, the moving SCBSs can provide adaptive densification and achieve advanced efficiency and lesser cost. Instead of installing small cell base stations on the business areas and residential areas which will be expensive for the operators while these only operate at s small duration of time, the idea of moving SCBSs will make it easier and less expensive by moving the SCBSs depending on the need i.e., densify the RANs on the business areas in the morning and in the evening at residential areas. This mechanism has increased the capacity of 150% and throughput 120% [4].

2) Cloud-based Radio Access Network (C-RAN)

One of the most cost-efficient ways proposed to deploy 5G small cells is a cloud-based radio access network which decouples the processing of baseband unit (BBU) from the remote radio head (RRH) and allows the centralization process of BBUs and scaled deployment of RRHs in form of small cells. Cell densification is the promised method which refers to increasing the utilization of spatial reuse for the small cells, each new cell is added expenses the operators or the service providers. This problem has been addressed by (C-RAN) [20]. the transmission power between their tiers as well as the coverage and path loss of the given tiers. Figure (1) shows the interference between the small cells and macrocells.

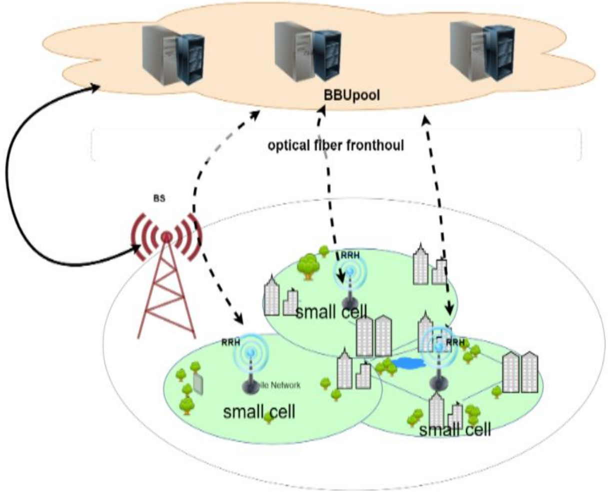

Fig. 5. Cloud-based Radio Access Network

Figure (5) demonstrates the C-RAN, where the BBU and RRH are decoupled so the BBU moved to datacentre introducing data signal processing and high-performance purpose as well as providing high optical transporting bandwidth to the antennas which called remote radio heads (RRH) unlike the conventional RAN which have the BBU and RRH matched together. The fronthaul is defined as the high-bandwidth optical transport which carries the signals between the RRHs and BBUs. The bandwidth of the fronthaul required to be higher than backhaul depending on the signal's nature [22].

III. SELF-ORGANIZING NETWORK (SON)

SON is a technology that has been designed to make configuration, planning, optimization, healing, and management of the network easier and faster by modifying the various parameters of the network supported by rollback algorithms [23].

The functionality and behavior of SON have been defined in the accepted recommendations of the mobile industry produced by a well-known organization such as the New Generation of Mobile Network (NGMN) and third Generation Partnership Project(3GPP). SON has been introduced progressively with the arrival of the fourth-generation (4G) in the radio access network, to limit gradually the impact of teeth trouble potential and to increasing the confidence as well of the system.

The existing 3G networks have been modified by SON for reducing the cost and enhance the reliability of service.

Long-term evaluation (LTE) is the first technology that uses SON features and then the technology has been adjusted for the previous technologies of radio access as UMTS. Specifications of LTE support the features of SON inherently such as detection of Automated Neighbour Relation (ANR) [23]-[25].

Deployment of SON helps the mobile operators to enhance the network services, for instance, saving the roll times of network, dropped calls are reduced, enhancing the throughput, minimizing the congestion, and saving energy and cost).

A. Architectural types of SON

SON has three architectural types which are: Distributed SON (D-SON), Centralized SON(C-SON), and hybrid SON.

1) Distributed SON (D-SON)

in this type, the network functions are always distributed through the element of the network edges or E-node elements [46]., which indicates a grade of localization functionality supported by equipment manufacturing of the radio cell.

2) Centralized SON(C-SON)

In this type, the network functions are concentrated on the network operational support system (OSS), (in some countries as the UK is a computer system used for network management) for allowing a wider overview of the coordination and elements of the network edges. C-SON systems are supplied in the network by third parties.

3) Hybrid SON

The combination of the elements of centralized and distributed SONs produced a hybrid SON[23],[25].

B. Subfunctions of SON

Self-organizing network functionalities are commonly divided into three major sub-functional groups, each one of them containing a varied range of use cases [23].

1) Self-configuration functions

Self-configuration struggles towards the paradigm of "plug-and-play" so that each newly-installed base station would be configured and unified into the network automatically and unified into the network. In other words, establishing the connectivity, and downloading the parameter configuration is software. The equipment vendors must supply the radio cell self-configurations software as apart of delivery. By using self-configuration, each small station is added to the network, it is directly registered and recognized by the network. The parameters of neighbour small cells (such as antenna tilt, emission power, etc) are adjusted to deliver a required capacity and coverage as avoiding the interference at the same time. [23], [25].

2) Self-optimization functions

Every small cell holds hundreds of parameters configuration that governors various cell site features. Each of the parameters can be changed based on network behavior, based on the observations of the UE measurements and the small cell. ANR is one feature of a SON that establishes the relations of neighbors automatically. Other features enhance the parameters of mobility robustness or random access in terms of the fluctuations of handover. A very expressive use case is when small cells automatically switch-off at night hours to save the operator's energy, to cover the whole area then the neighbor small cells re-configure their parameters. However, when the neighbor small cell can't cover the area demands, the sleeping small cells wake up to serve its users [23]. Capacity and Coverage Optimization (CCO), Mobility Load Balancing (MLB), Mobility Robustness Optimization (MRO), and RACH Optimization SON for Adaptive Antenna Systems (AAS) are self-optimization functions [23]-[25].

3) Self-healing functions

When small cells in the network turn out to be inoperative the mechanism of self-healing aims to reduce the failure effects, by adjusting the algorithms and parameters in the neighbor cells to support the inoperative small cell.[49].

C. SON and load balancing

SONs have been studied intensively to enhance the small cell user QoS, introducing load balancing algorithms were proposed in [27], [28]. İn [27] the authors proposed an algorithm for macrocells, small cells, and HetNets load balancing, which limits the released load of the full loaded cells to the neighbor cells.

To estimate the cell load status, the centralized SON (c-SON) has been introduced, which then decides the user handover for the proper cell for providing network load balance and avoiding performance oscillations. To define and estimate the heavily loaded cells, a threshold was presented.

The resource block utilization ratio was introduced as a method for measuring the cell load. However, the impact of the neighbor shifted load was considered to decrease the PingPongs (PPs) of the load among the cells.

In [28] an enhanced adaptive load balancing algorithm for small cells was introduced using SON, the parameters of HO are adjusted over the network by proposing "load balancing efficiency factor". the algorithm estimates the after-handover edge UE loads, and remaining available load of neighbor cells then specifying the operation sequence. However, the offloading from an overloaded cell to light loaded cell was restricted with conditions, one of these conditions was the difference load between the overloaded and light loaded cells is less than the gap threshold (0.1) to restrict moving loads between closed loaded neighbor cells.

IV. POWER CONSUMPTION FOR SMALL CELLS

Minimization of the power consumption and increasing the throughput are challenges that face the 5G networks. To minimize the consumption of network power many proposals have been introduced such as dense small cell deployment which offloads the macro station`s traffic instead of serving all the users in the cell, the load is divided into many surrounding small base stations which will decrease the load and consequently the transmission power will be decreased.

However, the power consumption of small base stations cannot be discounted, because saving its power consumption means saving the total power consumption of the heterogeneous network like the following:

In [29] three algorithms have been proposed that aim to consume the power of the heterogeneous network, the first algorithm based on the distance between the MBS and SBS. the transmission power is increased with the distance of the MBS and hence, the algorithm gives the deactivation priority for the closet SBSs to MBS and serving their users by MBS just to save power consumption of the SBSs, but in case the load of SBS is big by users density that costs the MBS power consumption more than the SBS consumed power when it`s activated.

The second algorithm is based on density which aims to deactivate the SBSs with lower density users and serve them by MBS so that their consumed power is low to be served by the MBS and activate the SBS when the power is consumed by MBS is more than that when the SBS is active. Those two proposed algorithms lead to the third algorithm which combines the previous two, if the SBS is close to MBS and the users are density then it`s deactivated to save the transmission power of serving the far users as long as the MBS consumes less power than SBS power consumption when activated.in the other hand, for those SBS which are far from the MBS and low user density, can be deactivated when the power consumption does not exceed the maximum power, and their power consumption is more than the MBS when they are deactivated.

The third algorithm showed the ability to save 20% of the daily power consumption of the HetNet without using small cell deactivation.

However, the antenna array system presented in [30] which was designed to be cost-effective, and an adaptive cell densification technique by sectorizing the cell into nine sectors to deal with the non-uniform and uniform angular traffic loads using fractional frequency reuse, the results have shown that when the base station`s load is less than or equal the minimum of threshold value there will be 40% energy saving.

To achieve the 1000 fold capacity increasing, ultra-dense small cell networks USNs is one of the techniques that deliver such a challenge in 5G.

it increases the deification of the network by deploying numerous Heterogeneous small cells which are described as low power and cost, SBSs categorized as plug and play, increase the throughput and coverage of network and improve the utilization of spectrum [5], [31].

The main challenge that every small base station is concerned about its performance and ignoring the damage that it causes to adjacent SBS.

However, SBS should be cooperative with others.

V. SMALL CELL HANDOVER LITERATURE SURVEY

When a User Equipment (UE) moving from one place to another with an ongoing data session or ongoing call, transferring the channel connected to the core network to another to keep the session or the call connected is calling handover (HO).

HO is considered one of the critical challenges that face UHDNs due to the closeness of small cells to each other and to macrocells to provide high data rates and capacity. Many types of research have been conducted deeply in the handover to avoid pinpongs,

HO failures, unnecessary HOs, reducing HO, improving the performance of HO [33]- [44], as well as to make load balance between small cells and HUDNs [32], [45]-[48].

İn this section,

we briefly reviewed the HO management; proposed methods, their features, and the challenges that face the proposed methods as in table (1).

Table I. Handover management literature review

Referenc e	Tech.	Proposed method	Features	Challenges
32	LTE	Calculation the distance of UE and load balancing	Calculation the distance of moving UE by using the RSS changes, releasing the load from the overloaded cell, and shifting to nearest neighbor cells	the accurate real UE distance Cannot be estimated due to changeable fading, increasing the number of handovers.
33	LTE	HO scheme-based distance for Macro and small cells.	Reduce the handover familiars and unnecessar y handovers	The distance of moving UE cannot be estimated accurately
34	5G HetNet	Minimizatio n unnecessary HOs algorithm	Minimize the unnecessar y handovers and signaling overheads of scanning	The computation al complexity be increased
35	5G	Mobility aware user association strategy	Tracking the channel condition, load balancing, and stopping recurrent scanning	The procedure of HO for the mmwaves has not been addressed and the accuracy of GPS for indoor situations is a big challenge
36	5G HetNet	Decouple the control and user plane	HO frequency was reduced	High computation al complexity
37	LTE,5 G	HO strategy of MMB along with multi-cell connectivity .	Minimize the number of handover familiars	Increase the complexity of UE and resources utilizations
38	5G	Markov chain is based on the strategy of handover managemen t.	Reduces the handover fails to 21% and delays to and 52 %	Effected on PP, frequent and unnecessary HO was not considered

39	LTE advance	HO detection with SO HO parameters algorithm.	Improve the performance of user mobility by reducing call drops and HOF	increase computational complexity
40	5G HetNet	User velocity aware HO skipping scheme.	Improve the UE average throughput in a two-tier cellular network	Estimating the UE path is challenging
41	LTE	Reducing the early HO scheme.	Reduce the operational expenses of the mobile operator, high energy efficiency. A super relative value to TTT was provided for an unbiased RLF and PPs	Increase the computational load
42	5G	Estimating the state along with DC	Reduce HO interruption time, increase the throughput and decrease HOFs	Correct tuning of MSE is required, DC increases the UE complexity and resource utilization
43	5G HetNet	Cashing technique, load balancing, and DC	Store the future data contents in advance, to use when wireless resources are not sufficient, offload UEs from heavily loaded cells, reduced HOF and energy consumption	Multi-cell connectivity increases the complexity of UE and resources utilizations
44	5G	Mobility management scheme based on location tracking	Eliminates the HO signaling overheads, provide proactive and seamless Handovers	Increase the computational complexity
45	4G,5G	Hybrid HO forecasting mechanism	Reduce the HOF and PPS and improve the HO decision mechanism	High utilization of resources
46	HetNet	Load balancing algorithm	releasing the load from the overloaded cell and shifting to nearest neighbor cells	The number of handovers is increased
47	HetNet	SINR based HOR analysis	The gap between SINR-free and SINR-based HOR indicates the effects of interference on HO procedure	
48	HetNet	Frequent HO mitigation algorithm.	Improve the QoE of the user, by reducing the HOs and improve the throughput	Increase the computational complexity

VI. SMALL CELLS MMWAVES:

Transferred data through optical fiber links provide data rates of multigigabit per second, whereas the deployment and cost are expensive in many applications. contrarily, wireless links technology can provide alternative effective cost to connect the areas that the fiber optics cannot reach. However, the demand for high data rates wireless applications and interconnecting the areas beyond the rollout of fiber optic have been increased which posed a massive challenge for 5G. To maximize the spectral efficiency, MIMO and OFDM technologies are used in the current generation 4G LTE advanced,despite theunexploited gigantic bandwidth to deal with future multigigabit per second imaging, multimedia, and mobile applications. Millimeter waves aim to release the 30 – 300 GHz spectrum with potential over 100 GHz of new fitting spectrum for mobile broadband which will reduce the cost, latency, and interference plus enabling mmwave backhauls and high dense small cell. In mmwave bands, the signals can travel only for a few kilometers and cannot penetrate the solid materials. Unlike the 3GHz signals, which can travel for many kilometers and able to penetrate the solid materials. However, this could be an advantage for low interference mmwaves communication with efficient spectrum reuse for dense network links and enhancing the security and privacy of the transmitters. For the commercial user, mmwave bands are evidenced by IEEE802.3C and sub-bands by IEEE802.11ad. [49].

The range frequency of microwaves defined as (6 to 60) GHz), in this band, some frequencies were reported as a common such as (10.5, 13, 15, 18, 23, 26, 32) GHz, which in many countries reported as congested especially (13,15, 23) GHz. Accordingly, a higher frequency is exploited, for instance, in the UK the bands (10, 28, 32, and, 40) GHz are steered to face the microwave demands [31]. New radio (NR) operates in the range of (1 GHz to 52.6 GHz) including licensed and unlicensed spectrum; it has key features such as spectrum flexibility, high-frequency operation, forward compatibility, besides ultra-lean design. New services are enabled by NR forward compatibility; in the future, it will introduce new technologies. Ultra-lean design refers to the utilization of always-on transmissions such as systems information broadcasting, always-on radio signals for channel estimation, and signals for detecting base station; to achieve high energy performance and data rates of the network [50]. In mm-W bands, the propagation loss increases, and to overcome such a problem, high gain is required which achieves better coverage and high availability. 5G mm-wave systems target small cells and use beam-tracking technologies, which present soft mobility and user tracking in the small cells. Latency and throughput performance were experimented using 5G mm-w proof -of – concept (PoC) (frequency = 73.5GHz, channel bandwidth = 1GHz) system for an outdoor LOS user device with speed up to 20km/h. However, the result of that workshop with interleaving frame structure confirmed a lower latency time of 3ms round-trip for (70 to 80%) in the trail course and over 1 Gb/s throughput achieved as well for 38% in the trail course. Moreover, using mm-W PoC having a frequency and (channel Bandwidth =2 GHz) with two-stream MIMO, single carrier transmission, and dual-polarization, in the mmW band, achieved higher data rates e.g. greater than 10Gb/s [8]. 5G mmwave cellular networks support multi-connectivity, in [51] authors proposed a novel measurement reporting system that allows macro basestation operates in legecy band to collect many reportson the overall channel propagation conditions periodically to make the right decisions when a multiple control-plane features are implemented (handover or intial access). The authors argue that the proposed method(based on uplink rather than downlink signals) enables much more rapid and robust tracking, enabling the use of digital beamforming architecturesto reduce the measurement reporting delay dramatically. Sending /receiving data between the core network and end-user, and mutual information exchanging through x2 interface between the small cells representing the backhaul of the 5G small cells, which can be via wired or wireless links depends on the requirement of the backhaul such as (SBs locations, the cost of backhaul, intensity of traffic loads. Etc). The wired backhaul is high cost depends on the distance and capacity, high data rates, and considered as reliable connectivity. However, the backhaul could be using mmwaves spectrum (60,70 to 80) GHz bands, microwaves band (6 and 60) GHz and sub 6HGz, sub 6 GHz, satellite technology, and TV white space (TVWS) which is selected based the environment propagation and parameters of the system (capacity, location, conditions of interference, coverage, cost, and the availability of the spectrum). Sub-6 GHz: support nonline of sight (NLOS) propagation and ubiquitous coverage through obstacles, as a result of features of NLOS, point to multipoint, the connectivity of backhaul is possible at the interference cost. The license of the sub-6GHz spectrum responsible for interference management. Furthermore, using sub-6GHz for backhaul links is highly cost, traffic crowded, and vulnerable to interference. [31].

A. Mmwaves and Massive MIMO in 5G

Coverage and capacity of 5G network increased by MIMO and the throughput of the cell becomes more unified and faster as well. The studies showed that the median burst is 52mb/s when 4x4 MIMO is used, while it increases to 195 Mb/s when using 5G NR massive MIMO which is 3.8 times faster. The cell edge burst rate is 27 Mb/s when 4x4 MIMO is used, while it increases to 79mb/s when the massive MIMO which is 29 times faster. According to Frankfort simulation [24],[25], table (1) shows the gains of 5G over 4G in the 5G NR sub-6GHz non-standalone (NSA) network. However, Tokyo simulation for 5G sub-6 GHz standalone (SA) network showed that 5G downlink median burst rate has increased 3.7 times over 4G (from 6 Mb/s to 122 Mb/s), while the cell edge burst rate increased 3.8 times (from 45 Mb/s to 171 Mb/s). On the other hand, the uplink cell edge burst rate increased 42.5 times (from 0.4 Mb/s to 17 Mb/s). 5G NR mmwaves have proven the wrong skeptic that the mobile can never use mmwaves as stated in the table (2) (Real-world user experiences with standalone 5G NR, JUN 26, 2018). Dense small cells using mmwaves with spatial reuse for around range (150m to 200m). to deploy 5G NR, spectrum aggregation is essential to address the gaps of mmwaves coverage. Carrier aggregation (CA) is used across spectrum bands (sub-6GHz), FDD and TDD bands for better coverage and capacity, and used for spectrum types as well such as (licensed and non-licensed) bands. 5G (NSA) using dual connectivity that combines enhanced mobile broadband (eMBB) and 5GNR together, whereas 5G (SA) using dynamic spectrum sharing and carrier aggregation. Table (3) illustrates the difference between NSA and SA networks [45].

Table II. Burst rates of 4G &5G devices in different networks

Burst Rates	4G device in 4G network	4G device after4G network	5G device in 4G network
Median	56 Mb/s	102 Mb/s	493 Mb/s
Cell edge	20 Mb/s	39 Mb/s	184 Mb/s

Table III. Mmwaves proved limits

skeptics	Proven
Costly and limited coverage	Signified coverage with co-siting
Used for line-of-sight (LOS)	Operated in NLOS
Lacking large form factor	Commercializing smartphones

Table IV. Non-Standalone 5G NR vs. Standalone 5G NR

Non-standalone 5GNR	Standalone 5GNR
Controlled by enhanced packet core (EPC).	Controlled by 5G next-generation core (NGC).
4G radio network.	5G sub-6GHz radio network
Control and data over LTE link.	Control and data over 5G NR link.
RAT using 5G mmwaves and/or sub-6GHz .	RAT using mmwaves.

VII. CONCLUSION

heterogenous ultra-dense networks (HUDNs) refers to the connection of different cells such as Macro, Micro, Small, and Pico cells together in order to improve the network`s performance, increase the capacity and coverage, and face the user`s risen demands that can be achieved by increasing the nodes on licensed and non-licensed bands. The closeness of small cells of each other produces interference. FFRmanages the radio resource to address the cross-interference. D2D communications used to alleviate the load pressure by sending a content to a user, the same content can be shared to the rest users to improve the QoS and reliability. D2D communications is an ideal method for network traffic offloading. DAS is used to provide more coverage by transmitting a common signal from one source that delivered to multiple RRHs simultaneously. C-RAN decouples BBU processing from RRHs to centralize the process of BBU and RRHs information of small cells. Configuring, planning, optimizing, healing and managing the network foritself by modifying various parameters by roll back algorithmscalling SON in order to enhance the network performance easily and faster. We pointed out for many proposals introduced to improve the power consumption of small cells. However, we presented a literature review of HO and mobility of small cells to reduce HO failure (HOF), and ping pong (PPs) and improve the small cell load balance. Enabling mmwaves aims to reduce the cost, latency, and interference. In the other hand, enabling high dense small cells with multi connectivity and mmwaves backhauls. Spectrum flexibility, high-frequency operation, forward compatibility and ultra-lean design are features of NR. 5G coverage and capacity increased by MIMO and throughput becomes faster, and more unified. Studies showed the median burst is 3.8x faster when using 5G NR massive MIMO than using 4x4 MIMO. The median burst is changed based on the device technology (4G or 5G) and the infrastructure of the network its self (4G or 5G) network. Mmwaves proved it can operate in NLOS, signify coverage with co-sitting and commercialize smartphones.

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