Inter-cell Channel Allocation Between Small Cells and Macro Cell Based on Spectral Sensing Method in Heterogenous Cloud Radio Access Network (H-CRAN) in 5G

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Abstract

In a Heterogenous Cloud Radio Access Network (H-CRAN), which consists of multiple access points (APs) providing smaller coverage and a high-power node (HPN) providing ubiquitous coverage, mobile machines can connect to multiple APs and a HPN by coordinated multi-point transmission (CoMP) concurrently to achieve ultra-reliable and low latency communication. However, the current network association (priorly known as handovers), which only focuses on switching between two base stations, may not be an efficient scheme in the H-CRAN. Coexistence of different cell types, Macro cell, Small cells and Remote Radio Heads (RRHs) are advantageous for Mobile Network Operators (MNOs) as this specific network association significantly increases network coverage, capacity, scalability, data rate, spectral and energy efficiency. In this work, proactive approach of workload allocation between small cell and microcell of H-CRAN is proposed and validated by the simulation model designed in INET 4.2 under OMNET ++ 5.5.1. The simulation results prove that the proposed method is evidently better than the existing method in terms of Access Point power, Diversity gain and End-to-End delay.

Index Terms_ RAN, H-CRAN, 5G, Macro cell, Deployment of Small cells, Workload allocation, Remote Radio Head, Cell edge, Baseband Unit pool, Low-latency and ultra-reliable communication, Network association, Spectral sensing method

1. Introduction

The mobile network has seen huge growth in data traffic, customer capacity, the number of apps, and the polymorphism of operation scenarios. From 2016 to 2021, Cisco expected a seven-fold increase in global mobile data traffic, with the vast majority generated by mobile devices [1]. Mobile Network Operators (MNOs) need to find efficient Quality of Service (QoS), enhance spectrum efficiency and maintain good revenue, whilst reducing both Capital Expenditure (CAPEX) and Operational Expenditure (OPEX), to meet end-user demands beyond 2022 and optimize legacy networks on future demands [2]. The main expectations from 5G are high data rate up-to 20 Gbps, low transmission delay between 1 to 10 ms and millions of devices connectivity per square kilometre [3].

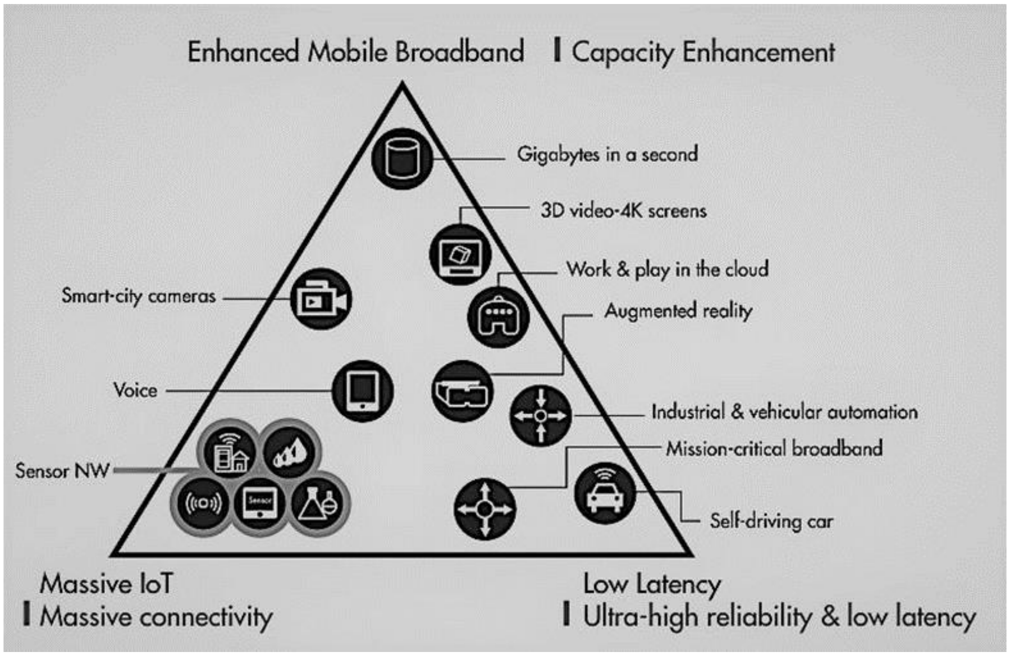

Figure 1 5G expectations

Numerous technologies and strategies have been introduced for mobile networks of the fifth generation (5G), especially for the Radio Access Network (RAN) domain, in order to counter traffic development, create cost-effective networks and provide better quality for large end-users [4]. Some of them can be categorized into the following:

- Implementing innovative transmission technologies to improve the bandwidth performance for higher data ability such as Beamforming, millimeter wave (mW) transmission, and Massive Multi-Input Multi-Output (massive MIMO) [3]. Design and application of these systems has advanced significantly, but they still face major technical challenges, including the difficulty of installation, interaction with the radio frequency (RF), environmental obstacles and antenna correlation.
- Combining Small Cells (Micro, Pico and Femtocells) and Macro cells and deploying them over current existing network infrastructure [5][1]. This network is also known as heterogeneous network. LTE also uses this network, but in contrast with the old RAN model, the heterogeneity in 5G RAN is far more complex than legacy network. However, the use of small cells increases energy consumption, CAPEX / OPEX, a number of interference and the frequency of handover [6].
- Use new software-defined network (SDN) and network virtualization (NFV) technology in order to automate the networks. However, there are wide shortcomings of the implementation of NFV and SDN in terms of safety, control, orchestration, isolation, allocation of resources, complexity, stability and scalability [7][8].
- Modifying and rebuilding of network infrastructure. RAN architecture in specific, through linking networking, connectivity, transmission and storage equipment to the network edge, end-users can access the low-latency and high-performance data and services [1].

Of the four categories listed above, the main focus is on the surveying state-of-the-art of various 5G RAN and Heterogeneous Cloud Radio Access Network (H-CRAN), small cells and improved workload sharing between small cells and macro cells.

2. Methodology

By contrast with the RAN systems in the existing LTE networks, the RAN design in the 5G mobile network is more heterogeneous. BSs density in the 5G RAN is expected to rise to 40–50 per square kilometer [9]. So, heterogeneous network is one of the best solutions to satisfy 5G expectations and needs beyond 2022 [9][4]. An effective architecture is needed where small cells and macro cells can co-exist and cooperate together.

In this paper, a cognitive small cell network architecture has been proposed that can balance the workload between small cells and macro cells by connecting them to the core via broadband network. In this type of network, the Remote Radio Head (RRH) allocates different number of channels to its adjacent small cells based on their user capacity and load. If the user load changes, the number of canals assigned to a small cell can be changed dynamically. The result is a dynamic and balanced cell network which extracts loads from macro cells and creates a cooperative network.

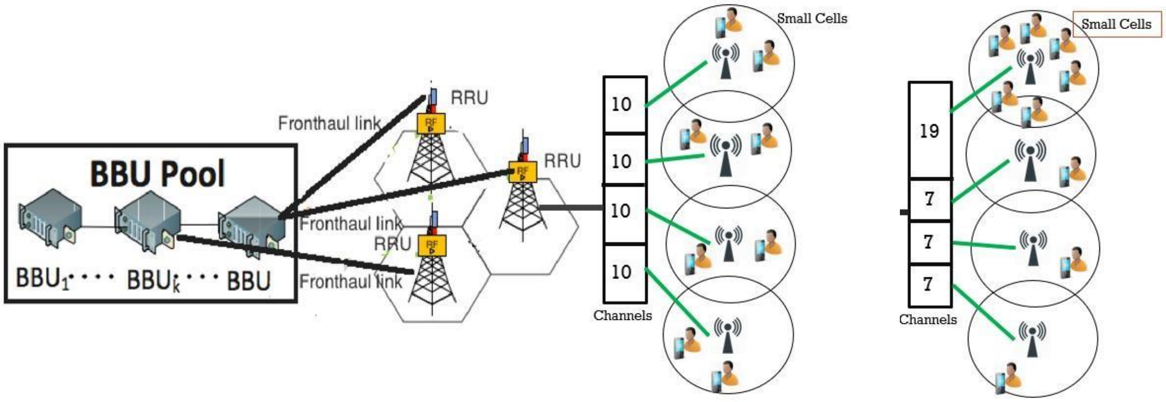

Figure 2 A cognitive Small Cell Network

The small cells are needed to be deployed at the edge of the macro cell network to improve the overall network efficiency. We've also proposed frequency reuse models for macro and small cell networks based on fractional frequency reuse and soft frequency reuse. In both cases, small cells share workloads with macro cells with minimum interference.

3. Evolution of Radio Access Network (RAN) Architectures

It is important to track the progress of new and past RANs to address the RAN architecture for 5G mobile communication.

3.1 The Base Station Subsystem (BSS)

The BSS is the cornerstone of the 2 G RAN architecture, standardized in the context of the Global System for Mobile Communication (GSM) [10][11]. BSS's main objectives are to provide network coverage for a desired area and to fulfill the roles of radio and mobility functions. The coverage area of all BSS extends across several small areas called cells. At least one fixed transceiver or Base Transceiver Station (BTS) serves each cell [12][7]. Cell size, shape, capacity and network coverage depend on the density and the topography of the users in one area. A cellular system allows a wide range of Mobile Stations (MSs) to connect with each other and with other mobile operator's MSs and fixed-line phones in its coverage area [13][10].

The principle of frequency reuse has been developed in order to accommodate a large number of MSs within a limited spectrum [14]. In this model, multiple BSs with enough distance (geographically / physically) will reuse the same frequency. Radio channels are scattered across the cells so that the presence of co-channel interference is negligible [2][15]. Figure 8 shows the idea of frequency reuse where same frequency can be reused by BSs that have significant distance between them.

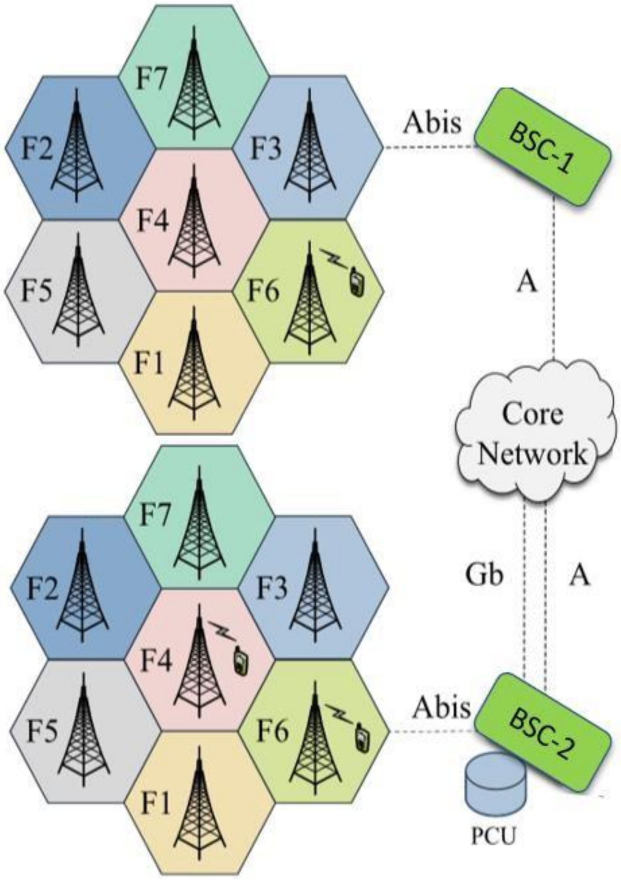

Figure 3.1 Frequency reuse planning in 2G

As shown in figure 3.1, the BSS is comprised of the BTS, the Air-Interface, the A-interface, the BSC, and the Abis-interface. BTS is the first component to connect directly to MSs wirelessly. It consists of antennas and mobile unit to communicate via radio link with MSs. The BSC handles the mobility and radio assets of all BTSs and their related MSs. A standard BSS consists of tens of BSCs and hundreds of BTSs. These nodes and all of the BSS infrastructure bridge the gap between the GSM core network (CN) and millions of MSs. The MSs connect with the BTS through Air-interface which makes it possible for MSs to connect with other MSs. The Abis-interface is used to connect BTSs to the BSC (usually an E1 connection). Which uses channelized Time Division Multiplexing (TDM) link where users receive 16/8 kbps connection, depending on the modulation scheme used for multiplexing. BSC is connected to the CN using the A-interface (multiple E1 link combination).

3.2 General Packet Radio Service (GPRS)

The GPRS uses packet switching (PCU, refer to figure 8) where many users share the available capacity to reduce bandwidth loss to a small level. The packet switching is more effective than the circuit switching with bandwidth utilization [16][8].

3.3 GSM EDGE Radio Access Network (GERAN)

The Radio Access Network for EDGE is GERAN, which was modified and implemented in GSM Phase 2+ Rel. 98. The 3GPP Rel.5 and Rel.6 further modified and improved the system [17]. The Rel.5 introduced a new interface called Iu, which connects 3G core network with GERAN [18]. This leads to a new GERAN architecture and major changes to its radio protocols as shown in figure 3.2

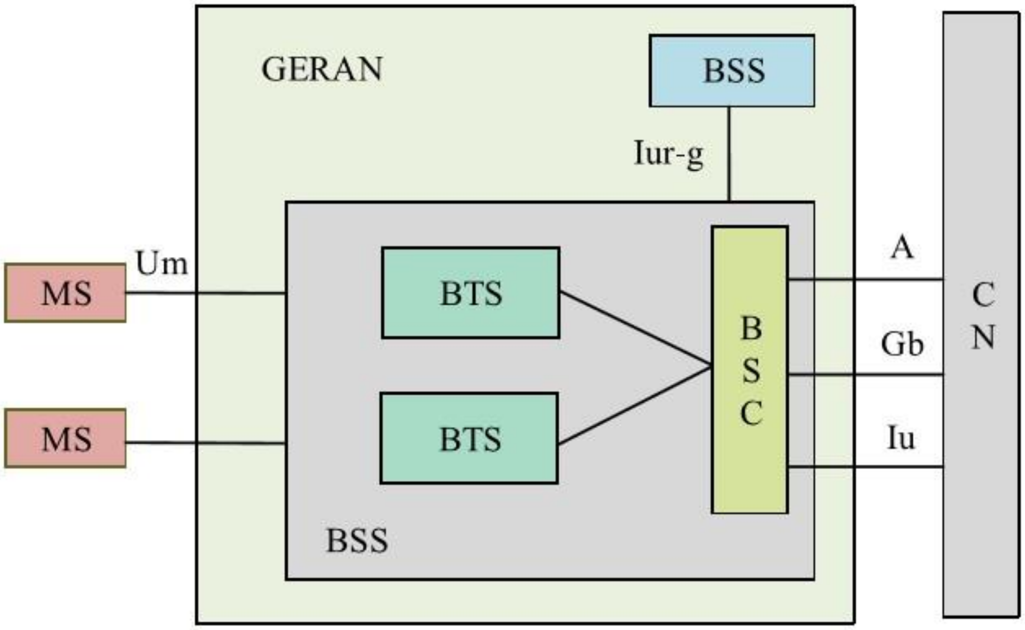

Figure 3.2 GERAN architecture in GPRS network

The Rel.6 introduces some major changes in the physical layer of GERAN. GERAN's main motive is to boost the GSM/EDGE data rates and to improve the experience of the end users [19]. The EDGE aims specifically to increase radio time slot transmission through the Gaussian Minimum-Shift Keying (GMSK) modulation used in the GSM/GPRS networks. GERAN radio interface uses 8-PSK (Phase Shift Keying) GMSK, which has a transmission rate of 3 symbols/bit instead of 1 symbol/bit as in GSM/GPRS. This development of the modulation system raises the average bit rate from about 20Kbps to about 60Kbps per slot.

The general structure of GERAN is shown in figure 3.2. The Um interface serves to link the MS with GERAN BTS, the Gb interface in GSM/GPRS serves to connect Serving GPRS Support Node (SGSN) and BSS, while A-interface connects BSS and 2G Mobile Switching Center (MSC). In GERAN, the Iu and the Iur-g are two new interfaces. The Iu connects GERAN to the CN. The Iur-g binds GERANs to RANs of other networks such as GSM/GPRS or the Universal Mobile Telecommunications System (UMTS) RAN.

3.4 UMTS Terrestrial Radio Access Network (UTRAN)

The UTRAN for UMTS network was released first in Rel.99 by the end of 1999 [19][20]. The UTRAN is based on existing standards and is therefore inspired heavily by existing RAN architectures [21]. The UTRAN consists of one or more radio network subsystems (RNSs), each consisting of at least one Radio Network Controller RNC and some BSs. In UTRAN the BS and the air interfaces are known as Node-B and Uu interface.

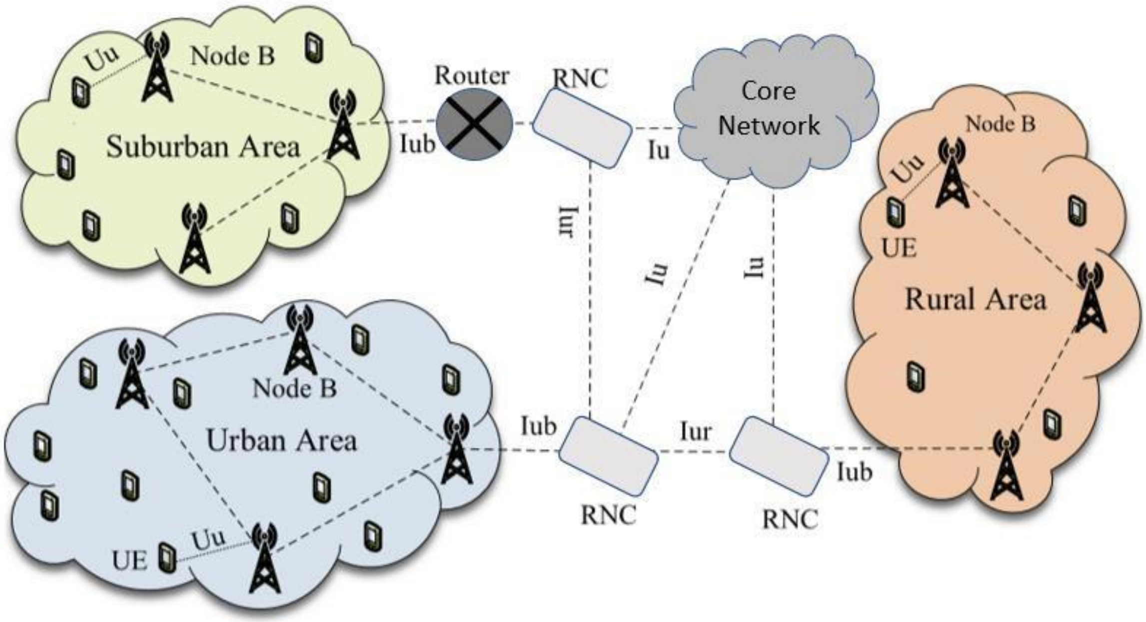

Figure 3.3 UTRAN architecture

The Uu interface is based on Wideband Code-Division Multiple-Access (WCDMA), which is comprised of Code-Division Multiple-Access (CDMA) and Direct-Sequence Spread Spectrum (DSSS). To achieve greater speed and support more device communication simultaneously compared with Time-Division Multiple-Access (TDMA) and Frequency Division Multiple-Access (FDMA). The RNC communicates with Node B and the CN via two communication links called the Iub interface and the Iu interface respectively. Two types of Iu interfaces exist: one for circuit-change CNs and the other for packet-change CNs. The RNC is the core element of UTRAN and is responsible for mobility control of UEs and radio resources management (RRM) for all linked cells. It is also the RNC that is responsible for Radio Barriers (RBs) deployment, release and management.

3.5 Evolved UTRAN (E-UTRAN)

In E-UTRAN, there is no centralized control but only base stations known as eNode-B [22][14]. Hence, E-UTRAN is also known as flat RAN. The eNode-Bs are interconnected by X2 interface, and through S1 interface to the Evolved Packet Core (EPC). All eNode-Bs are linked to the Mobility Management Entity (MME) and the Serving-Gateway (S-GW), via S1-MME and S1-U interfaces. LTE-Uu is the interface between eNode-B and the UEs.

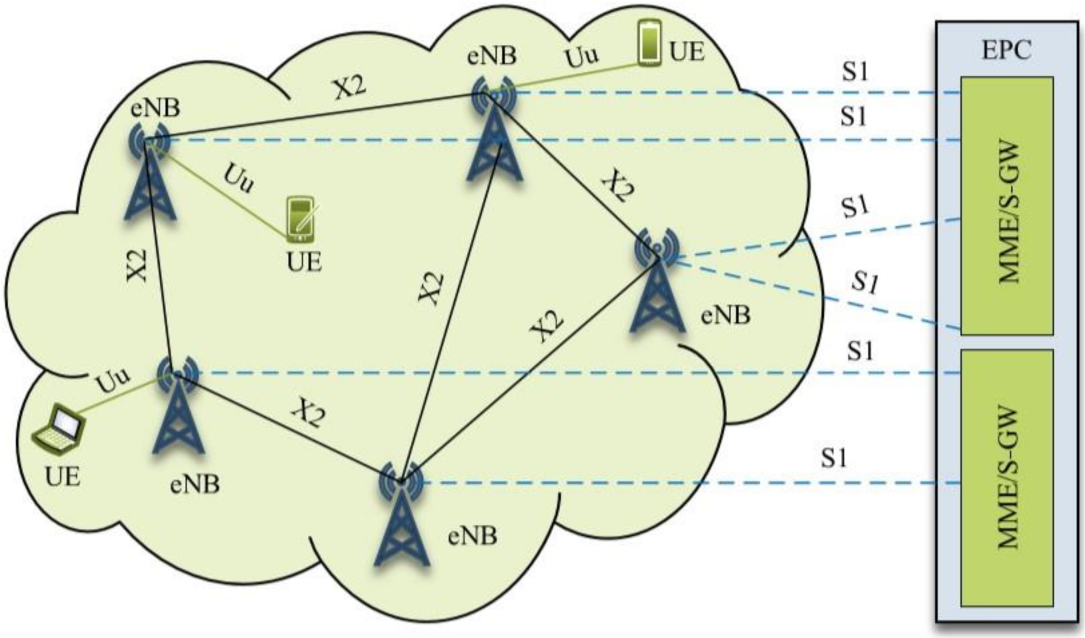

Figure 3.4 E-UTRAN architecture

Unlike the previous RANs, the E-UTRAN incorporates all functions including RRM, header correlation, stability etc. into eNode-Bs, which results in reduced latency and improved efficiency. In LTE, many nodes of the EPC, ex. MME/S-GW serve a single eNode-B via S1 link. This system offers the opportunity for load sharing and eliminates the risk of EPC nodes malfunction at a point. The Uu framework uses two different methods to enhance mobile data communications user experience, the downlink operates with Orthogonal Frequency-Division Multiplexing (OFDM) wave-form and the uplink operates with Single-Carrier Frequency Division Multiplexing (SC-FDM) wave-form. The S1 interface is divided into a control and user plane. The X2 link is used to extract two kinds of information, mobility and load/interference.

3.6 Distributed Radio Access Network (D-RAN)

In a conventional Macro BS, radio and signal processing units are isolated from one another in UTRAN and E-UTRAN [23]. Remote Radio Head (RRH) or Remote Radio Unit (RRU) is the radio unit that is positioned next to 3G/4G macro BS. The baseband signal processing unit is called the

Baseband Unit (BBU) or Data-Unit (DU), which is conveniently and situated in an easily accessible location. In terms of network specifications, BBU allocates network resources dynamically to their respective RRHs [24]. The RRH interacts explicitly with the end user and is limited to RF functions only. This architecture is known as D-RAN. Each RRH is connected via the Common Protocol Radio Interface (CPRI) transport network to their respective BBU, to transmit in-phase and IQ signals [25]. For the connection between RRH and BBU, which is known as the fronthaul, both optical and microwave can be used.

3.7 Cloud Radio Access Network (C-RAN)

In C-RAN, all network services are integrated in a central BBU pool [26][27]. The main concept behind C-RAN is to detach all BBUs into a central, unified, shared, cloud based, and virtualized BBU pool from their respective RRHs [28]. Each RRH is connected to its corresponding BBU pool via a fronthaul link as shown in figure 3.5.

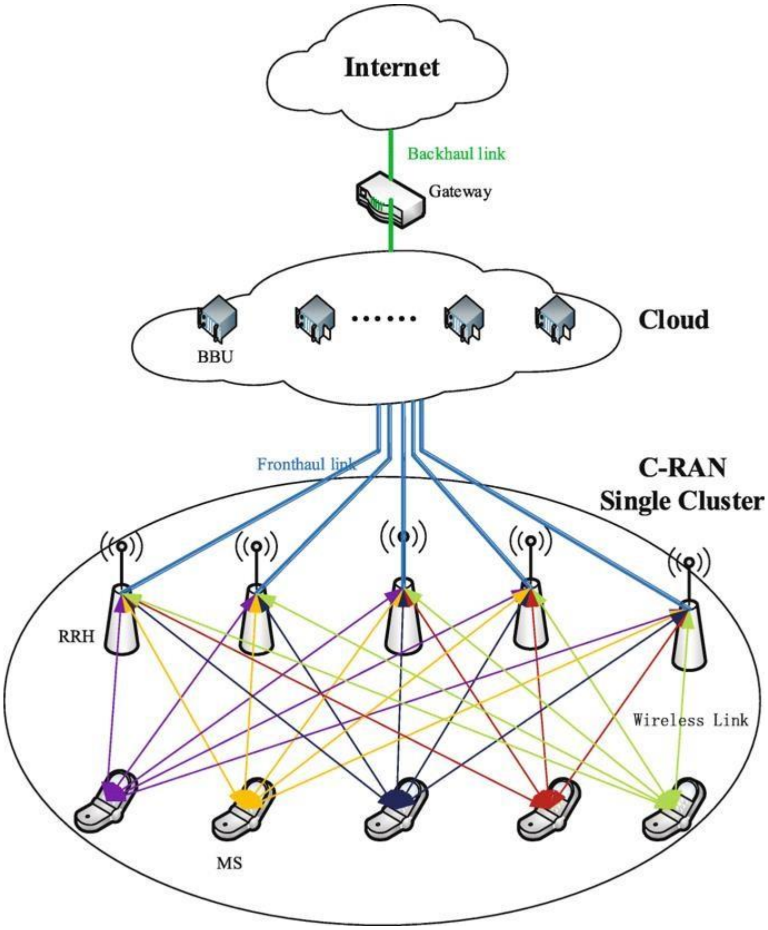

Figure 3.5 C-RAN architecture

Each BBU pool can support up to ten RRHs and can be linked back to the central network via a backhaul link. The C-RAN architecture lowers MNO's CAPEX and OPEX, eliminates power usage, increases scalability for network, simplifies network management and maintenance, boosts spectral efficiency and network performance and promotes load balance [29]. The C-RAN integrates cloud computing into the 5G RAN system. There are two kinds of C-RAN: fully centralized and partially centralized [30][31].

In a fully centralized C-RAN, all the operations relating to Layer-1 (such as sampling, modulation and demodulation, resource blocking, antenna mapping, data quantization etc.), Layer-2 (such as transport access control), and Layer 3 (such as radio-link resource control) are found in the virtualized BBU pool. Some of the major achievements of a fully centralized C-RAN to 5G cellular network includes easy network coverage extension, easy network capacity improvements, support for multi-standard activities, network aggregation, and support for shared signal processing in multi-cell networks [20]. However, two major challenges are faced by fully integrated C-RAN are: high standards for bandwidth and the propagation of the I/Q signal from the baseband to the BBU [32].

In a partially centralized C-RAN radio and baseband management functions are implemented into the RRH, and all high layer tasks are merged into the BBU. Partially centralized C-RAN demands low bandwidth between RRH and BBU, as the baseband signal processing is transferred from the BBU to the RRH [33]. Also faces some challenges such as poor efficiency in network upgrades and less accessibility of collaborative signal processing for multi-cell. Besides, C-RAN utilizes focal cloud arrange for handling client demands. Effective administration of cloud assets (e.g., calculation and transmission assets) is one of the significant difficulties in C-RAN.

3.8 Heterogeneous Cloud Radio Access Network (H-CRAN)

Recently, propositions were made to decouple control and user plane functions to increase the functions and performance of C-RAN architecture where control plane functions are only integrated into the Macro BSs [34][5]. This new RAN is called Heterogeneous Cloud RAN. Upcoming intelligent mobile machines (IMMs) including autonomous and smart vehicles, unmanned aerial vehicles, robots, etc. are expected to reach the amount similar to smart phones. The current wireless technology with supporting sensor and information infrastructures is still largely inadequate to accommodate the traffic volume and corresponding performance requirements, particularly networking delay [35]. Ultra-reliable and low-latency communication is crucial for the safety of intelligent transport system (ITS) as the delay performance of safety related messages should be no more than 50 to 100 ms and that is 1 ms in case of massive autonomous vehicles operation [36].

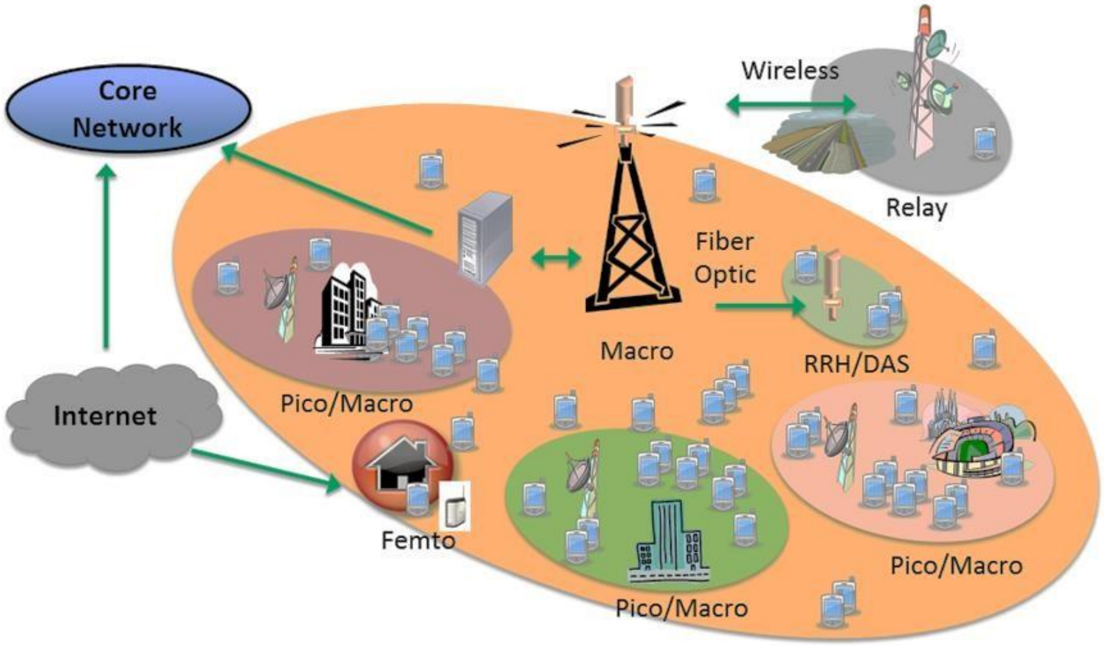

Figure 3.6 Heterogeneous C-RAN architecture

Spectrum scarcity and Network association of low delay guarantees are two major technological challenges to overcome to achieve this feat.

- Spectrum scarcity: With the development of physical layer technology, such as MIMO, beamforming, it seems like that transmission rate has almost approached Shannon bound and cannot be improved largely [35][37]. To solve this challenge by small-cell ultra-dense networking, the design of H-CRAN was proposed. In general, there are two major tiers of network in the H-CRAN architecture [38]. The first tier is composed of HPN, which traditionally can provide the ubiquitous services of IMMs. The second tier is composed of a group of distributed low power APs in the service area of the HPN. By decreasing the distance between IMMs and Aps, the spectrum efficiency and transmission rate can be successfully improved [39].
- Network association: The smaller transmission distance in H-RAN results in frequent network association (user association or handover) unlike the conventional handovers that happen only at the edge of a BS coverage [40]. However, under the heterogenous architecture, there are many distributed APs or RRHs and each of these has a smaller service region and thus edges are anywhere. Preventing the network from being occupied by control signals, a new handover scheme is necessary to be executed in order to coordinate the small cell networks which introduces the concept of virtual cell. It is achieved by connecting all the RRHs and HPN with the BBUs to create a large cell virtually and all the radio resources are scheduled and allocated by utilizing the cloud computing technology [41][42]. In this case, the different APs are transparent to IMMs. The number of network associations is successfully reduced.

4. Workload Allocation Between Small cells and Macro cells in 5G HetNet

Small cells that are deployed in Heterogeneous Network (HetNet) are low-powered wireless Base Stations (BS) operating within the range of 10 meters to a few kilometers, and uses licensed and unlicensed frequency spectrum [36]. Compared with a mobile macro cell these are "small" because of their shorter range and also because these normally have lesser simultaneous calls or sessions [43]. Small cells are usually used in homes and in small office/businesses. Small cells connect their users to the central network through broadband connections (such as DSL cable) [37][40]. Small cells allow network coverage in places where macro cell signal cannot reach or too weak. Furthermore, small cells take off some load pressure from macro cells which in turn, increases capacity and efficiency [32].

There are three possible access method configurations in small cells.

- Open Access: In open access configuration, any user can connect to the small cell network without any restriction. These cells are also called open Heterogeneous eNode-B (Open HeNB). This setup is suitable for public use cases such as shopping mall, stadium, bus stations etc.
- Closed Access: The closed access configured small cells allows only specific users to access to the small cell network. These cells are called Closed Heterogeneous eNode-B (Closed HeNB). This is suitable for private use cases such as home/office users.
- Hybrid Access: In hybrid access configured small cells, unsubscribed can get access to the network. However, these unsubscribed users are restricted with a limit to resource usage. This setup is suitable for use cases such as coffee shop/restaurants, or academic buildings etc.

4.1 Small Cell Deployment Architecture

The operators need to specify the architecture for a small cell Base Station in order to provide connectivity to end-users with a small cell. In general, a mobile phone user may connect to the core network by either connecting to the small cell, or macro cell. The small cells are connected to the core via RAN or through broadband cable. The macro cells are connected with the BBU pool and core through CPRI and backhaul connection. The small cells provide services to users that are stationary or less mobile. There are two kinds of layout in heterogeneous network architecture, High Power Nodes (HPN) or macro cells, and small cells or RRH cellular layout [42]

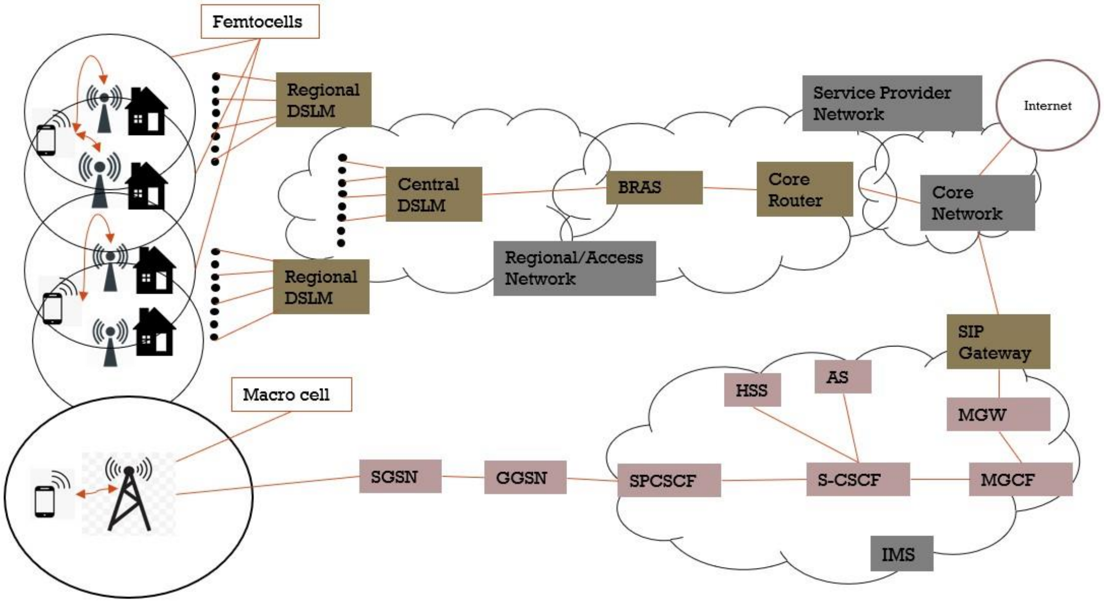

Figure 4.1 A general architecture of small cell deployment on current cellular architecture

As shown in figure 4.1, small cells are designed in such a way so that user data traffic moves through the public internet while voice traffic passes through the IP Multimedia Subsystem (IMS) network. Figure 15 shows a Session Initiation Protocol (SIP) and IP Multimedia Subsystem (IMS) network based small cell structure. IMSs are used because they converted through the SIP gateway. After the IMS passes through Media Gateway (MGW) and Media Gateway Controller Function (MGCF), it is connected with Public Switched Telephone Network (PSTN). The architecture guarantees end-to-end QoS call flow connection in small cell network. It is important to remember that IMS can be used only for voice connections. Since data traffic does not go through the IMS network, the small cell customers can enjoy various voice services at lower cost. Hence, in this architecture, users are able to get the best of voice communication by using IMS, SIP and data service by using broadband connection.

The small cell integrated cellular architecture can be divided into two types:

- The Legacy Mode, where the small cells are connected to the Radio Access Network (RAN).
- The Flat Mode, where small cells are directly connected to the central network.

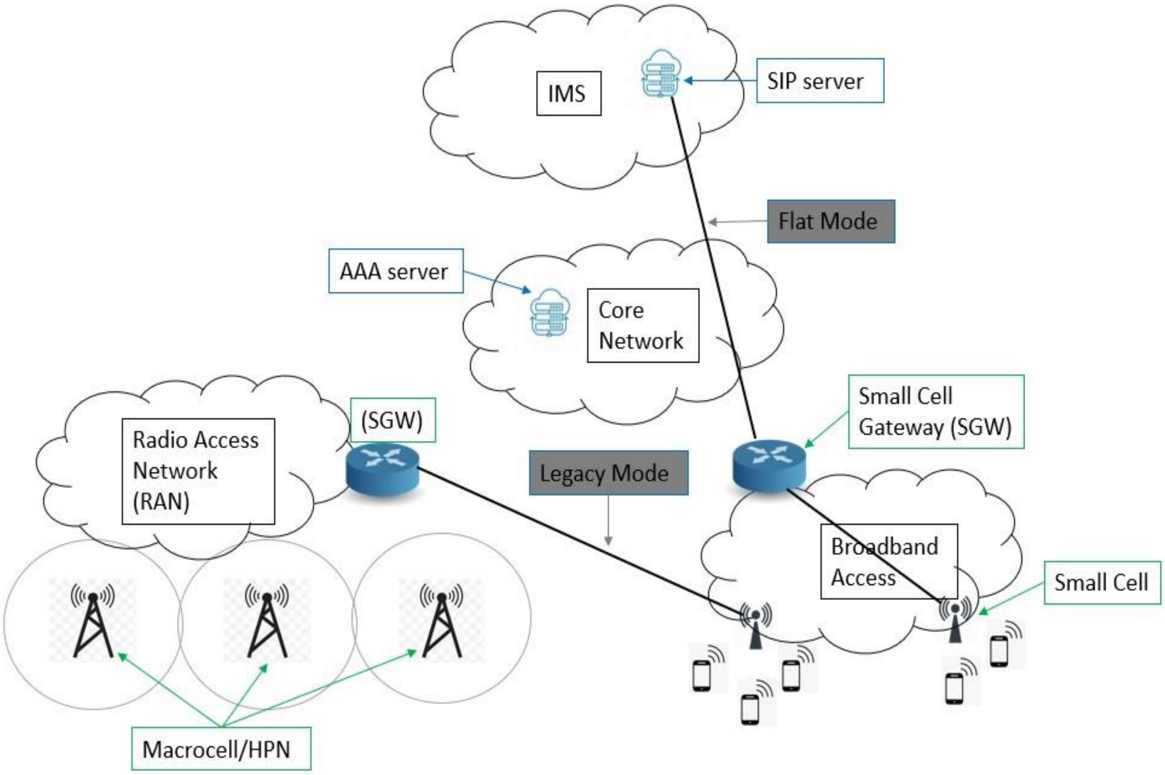

Figure 4.2 Two types of small cell integration

Small-Cell Gateway (SGW) is used in small cell for security purpose, IPsec is enabled in it by default. The flat mode reduces load pressure on RAN. Small cell integrated 5G architecture based on broadband connection and macro cell layout are discussed on [13].

4.2 Workload Allocation Between Small Cells and Macro cell

Deployment of small cells is advantageous for Mobile Network Operators (MNOs), because they increase network coverage, capacity, scalability, data rate, spectral and energy efficiency. By deploying small cells at the edge of macro cell MNOs can provide better coverage, connectivity and improved network performance to end-users along with high data rates while reducing loads from macro cells. In a heterogeneous network, expanding the network coverage or capacity is easy since control plane is decoupled from data plane, the MNOs only have to deploy new RRHs and connect those to the BBU pool.

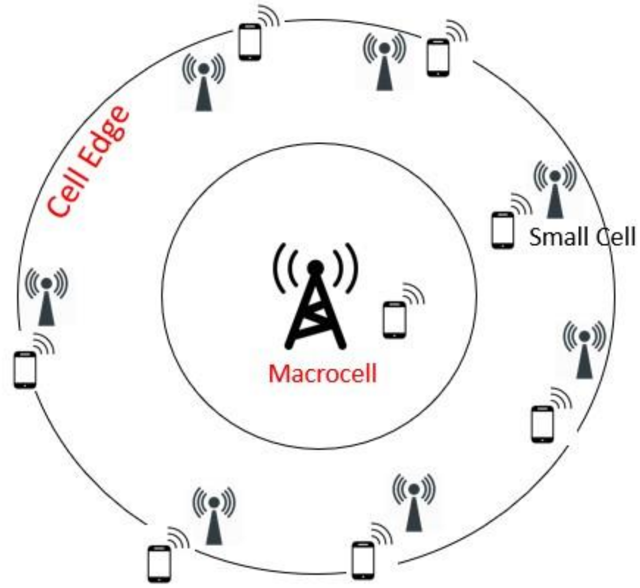

Figure 4.3 Deployment of Small Cells at Macro cell edges

In figure 4.3, macro cell region is divided into two regions, central region and edge region. At the central region, users can attain maximum quality cellular services while at the edge region the macro cell connection is weak and User Equipment (UE) requires more power to communicate with macro cell. This problem is solved by deploying small cells at the macro cell edges so that users can get maximum cellular services with minimum power consumption. These small cells work as independent cells but are integrated into macro cells. A cell needs to provide sub-channels to its users so that the users can communicate with that cell using the provided sub-channels. If two neighboring cells uses the same frequency for allocating sub-channels then interference will occur and in result, no users will be able to communicate with the cell because of the interference. Hence, comes the idea of frequency reuse. The frequency reuse method is adopted to eliminate neighboring cell frequency interference. In frequency reuse method, multiple adjacent cells in an area uses different frequency ranges so that frequency interference is at minimum. However, same frequency range can be used by multiple cells if these carry significant distance from each other.

In HetNet, multiple small cells are connected to a Remote Radio Head (RRH) through fronthaul connection. Fronthaul connection may include fiber link or direct microwave link. The RRH is connected to a virtualized BBU pool via Common Public Radio Interface (CPRI) which is connected to backbone network via backhaul link.

A cognitive method for inter-cell channel allocation between small cells and macro cell is proposed. The RRH that connects the small cells and macro cell allocates frequency channels to each cell based on their user load and capacity. The total number of channels are divided into a number of small groups, each of these groups contains several numbers of sub-channels.

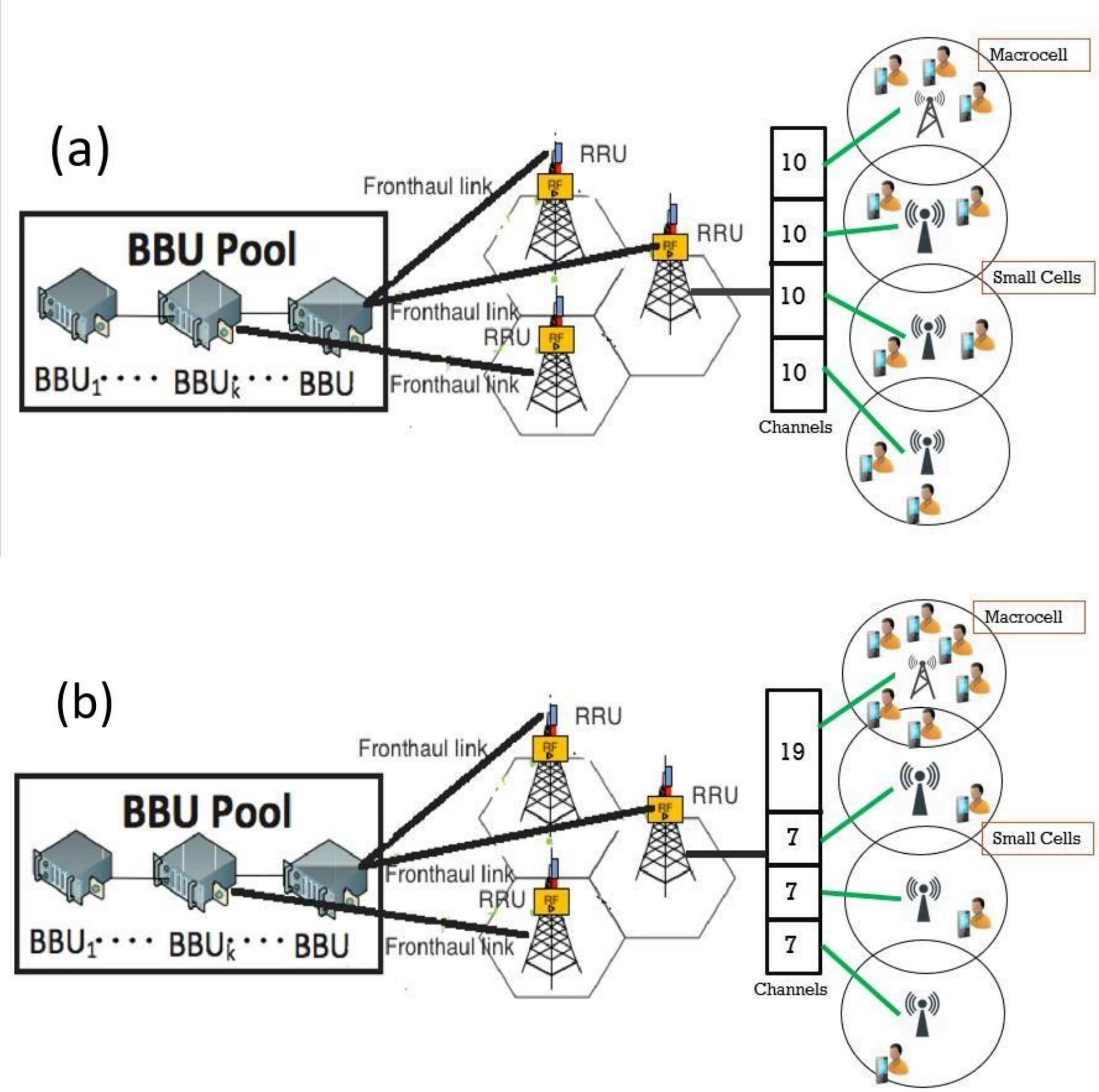

Figure 4.4 Cognitive channel allocation between small cells and macro cell

The RRH has the ability of sensing user loads on different cells through Spectral Sensing Method. Then based on the requirement, the RRH can dynamically allocate channels to different cells based on their load. In figure 4.4(a), the RRH allocates channels to each connected cell based on their user load. Likewise, in figure 4.4(b), when RRH senses increased user load through spectrum sensing, it dynamically allocates more channels to that cell.

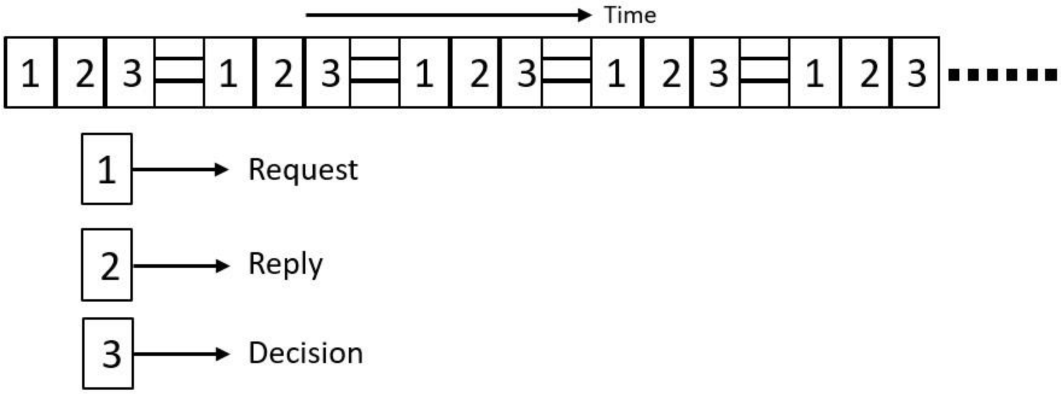

Figure 4.5 RRH spectrum sensing mode

The process is done through request-reply process as shown in figure 4.5. After periodic schedule, the RRH sends a request enquiry to the cells. The cells reply with their current user information. Then based on the reply, the RRH may change the number to allocated channels assigned to a cell.

5. Simulation and Result

5.1 Experimental Description

In order to validate the proposed method, a simulation model is developed and tested using INET 4.2 which is installed in OMNET++ 5.5.1. OMNET++ itself is not a simulator of anything concrete, but rather provides infrastructure and tools for writing simulations. One of the fundamental ingredients of this infrastructure is a component architecture for simulation models. OMNET++ simulations can be run under various user interfaces. Graphical, animating user interfaces are highly useful for demonstration and debugging purposes, and command-line user interfaces are best for batch execution.

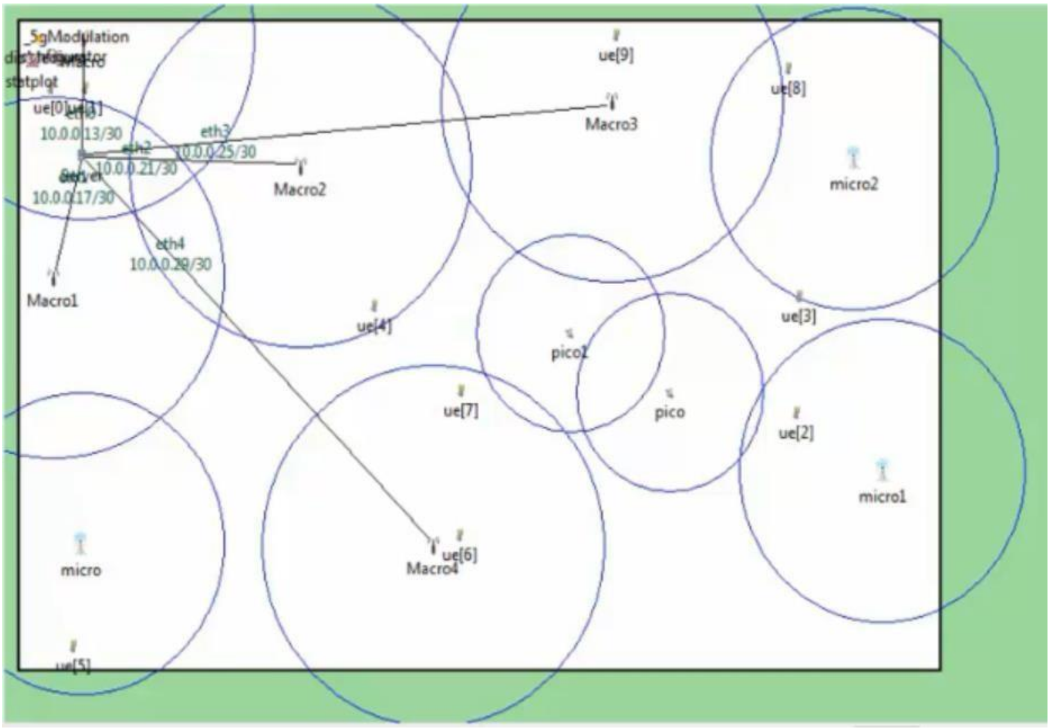

Figure 5.1 Topology Framework

Figure 5.1 illustrates the topology of the simulation model which is designed in INET 4.2. Two similar topologies are designed, where one topology denoted without the proposed method and another topology is applied with the proposed method. In these circumstances, the simulation work entitled as proposed and existing method. In this topology, 5 macro, 3 micro and 2 Pico cells are designed under 1 H-CRAN for both topologies. This simulation is verified for both 24GHz and 60GHz frequency of 5G network.

5.2 Access Point Power (AP Power) Comparison

Comparison between proposed and existing method in terms of Access Point Power (AP Power) is illustrated in Figure 5.2 (a), (b). The X-axis denotes the Frequency in GHz whereas Y-axis denoted Average Peak power in mw. In existing method AP Power for 24GHz band is 380mW and 60GHz band is 480mW (in figure 5.2 (a)), whereas 580mW for 24GHz band and 600mW for 60GHz band (in figure 5.2 (b)) is found in proposed method.

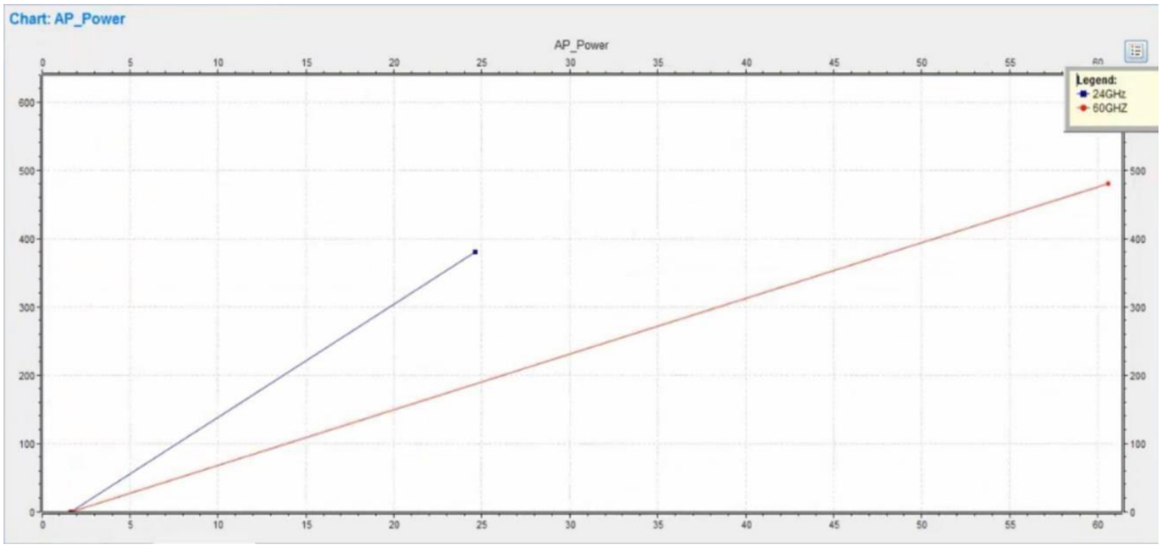

Figure 5.2 (a) AP Power (existing method)

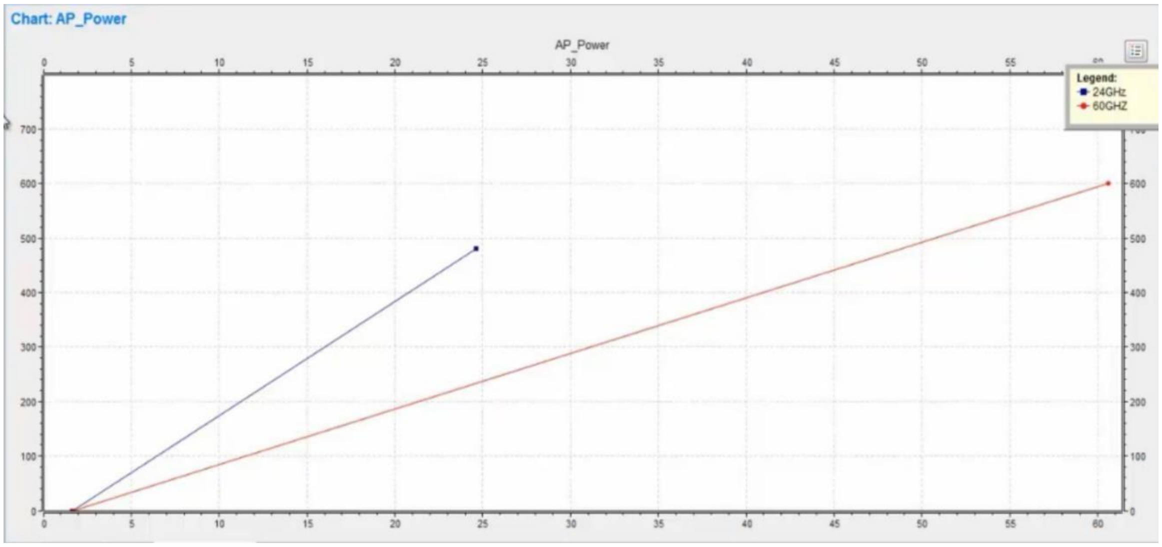

Figure 5.2 (b) AP Power (proposed method)

5.3 Diversity Gain Comparison

Comparison between proposed and existing method in terms of Diversity Gain is illustrated in Figure 5.3 (a), (b). The X-axis denotes the Frequency in GHz whereas Y-axis denoted Diversity Gain. In existing method Gain for 24GHz band is 8 and 60GHz band is 14 (in figure 5.3 (a)), whereas 12 for 24GHz band and 18 for 60GHz band (in figure 5.3 (b)) is found in proposed method.

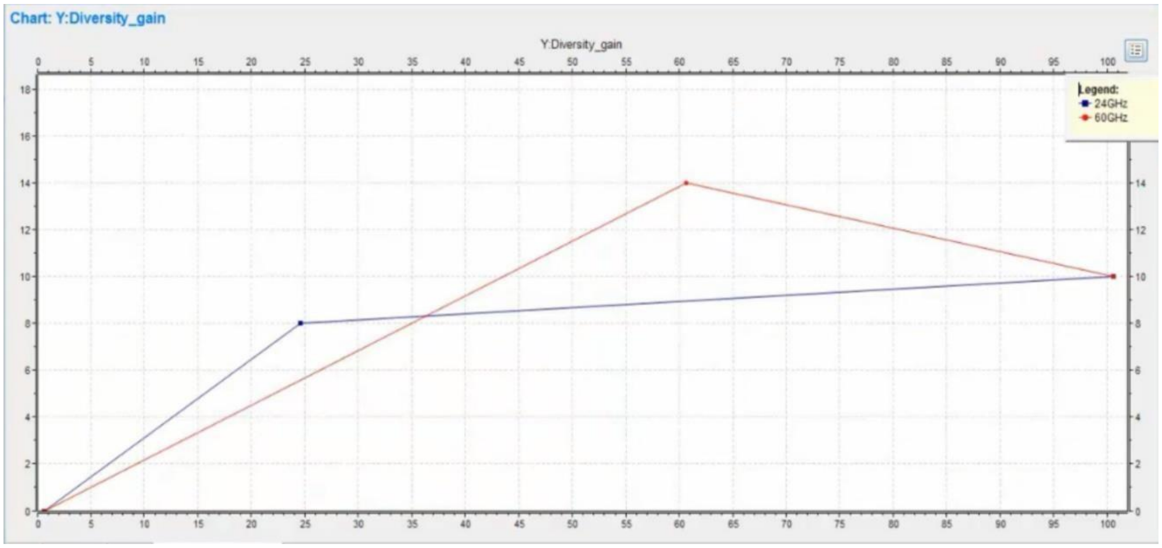

Figure 5.3 (a) Diversity Gain (existing method)

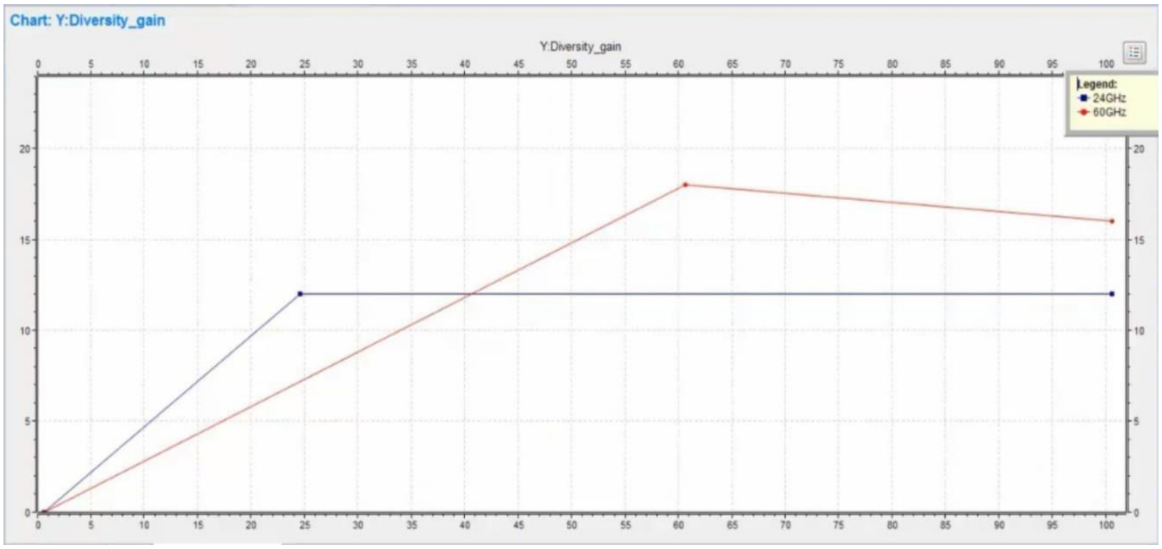

Figure 5.3 (b) AP Power (proposed method)

5.4 End to End (E2E) Delay Comparison

Comparison between proposed and existing method in terms of End to End (E2E) is illustrated in Figure 5.4 (a), (b). The X-axis denotes the Frequency in GHz whereas Y-axis denoted E2E delay in ms. In existing method E2E delay for 24GHz band is 600 ms and 60GHz band is 1000 ms (in figure 5.4 (a)), whereas 300 ms for 24GHz band and 800 ms for 60GHz band (in figure 5.4 (b)) is found in proposed method.

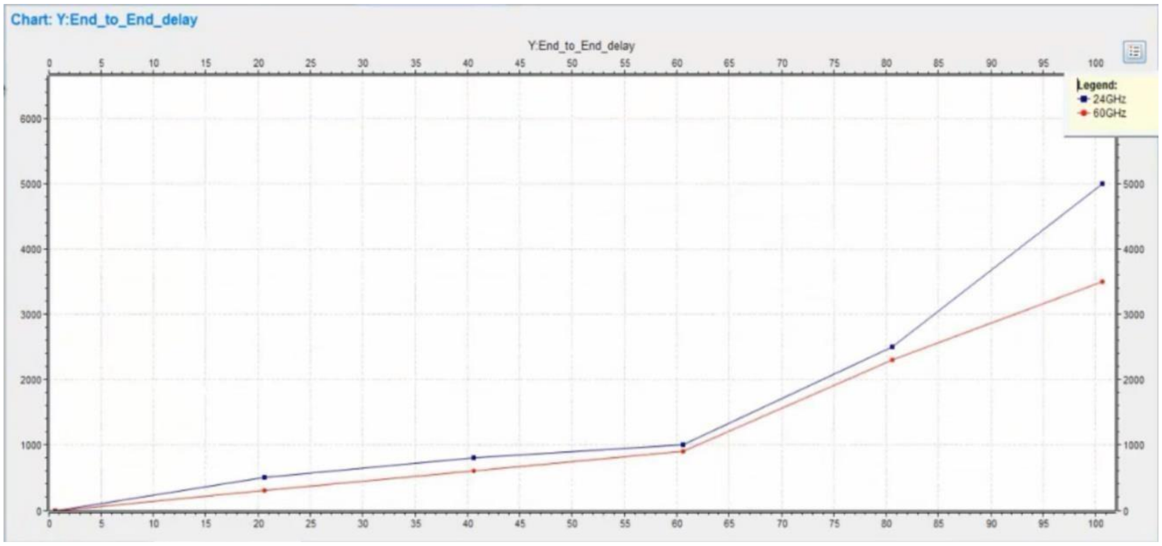

Figure 5.4 (a) End to End delay (existing method)

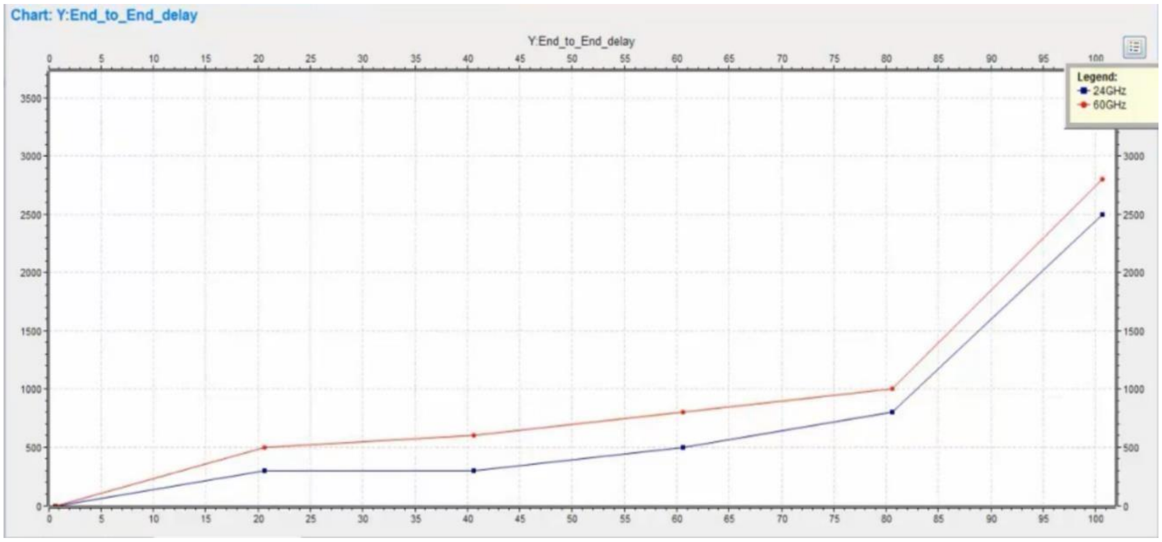

Figure 5.4 (b) End to End delay (proposed method)

5.5 Summary

	AP Power		Diversity Gain		E2E Delay	
	24GHz	60GHz	24GHz	60GHz	24GHz	60GHz
Existing Method	380mW	480mW	8	14	600ms	1000ms
Proposed Method	480mW	600mW	12	18	300ms	800ms

Recommendations, Concluding Remarks and Future Directions

In H-CRAN, enhanced cloud computing, centralized convergence of all BBUs, function separation between RRHs and BBUs and disengagement of the control plane and data plane lead to efficient mobile network management. Therefore, mobile operators only need to install new RRHs close to the user in scenarios such as increasing network coverage and increasing system capacity and connecting them to the BBU pool. In fact, it is also quite easy to implement flexible software solutions. For example, if a network operator is keen in improving RANs and promoting multi-standard services, then it can be possible by upgrading software via SDR.

In this paper, a cognitive method for workload distribution between macro and small cells in H-CRAN is proposed. The network association is regarded as dynamic resource allocation inn heterogeneous networks and is quite different from conventional network association of handover technology in cellular networks. The corresponding dynamic resource allocation problems are proposed to utilize radio resources and guarantee the low-latency and ultra-reliable communication with efficacious utilization of limited RRHs and HPNs simultaneously. The proposed proactive network association utilizes a minimal number of RRHs which profits by less informal exchanges and thus reduction of the delay in highly dynamic operation like vehicular networks.

Remote Radio Head (RRH) tackles the problem of spectrum scarcity by utilizing spectrum sensing tool (cooperative sensing) to take advantage of spectrum holes that are available in the frequency spectrum. The request-reply process that is used by RRH to dynamically allocate channels to each connected cell based on their user load. The necessity of sensing time adjustment in such systems as well as balancing the sensing-throughput tradeoff is critical and so performing sensing time, user association parameters and transmit powers of RRHs will be another low-complex iterative approach. The future directions of this work involve investigating heterogeneous nodes in terms of their different sensing capabilities and simultaneous multi-band spectrum sensing.

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