Facing The Callenges in 5G using DPA-MaIMaO Architecture

Boddu Praveen, I.Chandra, D.Subitha

ABSTRACT---To provide alternatives to problems in the design of User Equipment, an architecture that switches between cellular information and WiFi, a study was performed on present techniques in use and presented a cost-effective cellular-WiFi design methodology using Multiple Array of Antennas where the beam can be electronically guided. Detailedoperation of how both Cellular data and WiFichangedsimultaneously and utilized concurrently was examined.

Keywords: User Equipment, Beamforming (BF), Massive MIMO, WiGig

I. INTRODUCTION

Wireless technology was introduced to mobile phones at t he start of the 1970s and was named the first generation.To this day multiple generations of techniques have evolved. Cellular technology was started with Analog signals and it was utilized only for speaking over phone. Mobile wireless communication of the 2nd generation is based on digital format of signals and supports text messaging in which the messages were encoded and decodedbased on different encoding schemes adapted the mobile company [1]. UMTS is Third-Generation cellular communication standard. This technology depends on the conversion of packets into digital format in which packets are grouped and sent through air medium.Fourth generation incorporates 3G with fixed web speed to help remote portable web to overcome thedemerits of 3G.It additionally expands the data transfer capacity and reduces the expense of resources[2]. 4G technology was a combo of GSM and UMTS technologies and hence packet transfer speed was increased. Today a tremendous research is being done by researchers on 5G Technology for achieving higher data speed[3]. Implementation of multiple wireless standards and technologies on single Nodeor Mobile Device is desired[4]. But, execution of 5Gtechnologyis limited by technological barriers like expensivelicensed 5G bands such as (28,37,39)GHz and WiFi millimetre Wave bands(57-71GHz). As 5G bands have high frequency, wavelength at this frequency is in millimetre range. Hence, the challenges associated with implementing 5G are designing hardware and also mmWaves cannot travel longer distance.In this article a cost effective cellular wifi with multiplexing methods and architecture was performed to analyze potential wireless user equipment designs. As said earlier, 5G bands cannot travel much distances. Hence, multiple hotspots have to be placed around the user equipment.

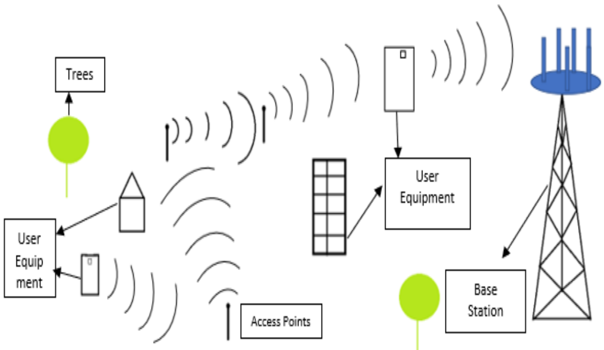

Fig.1 Arrangement of hotspots for mmWave transmission

II.LITERATURE SURVEY

Mmwave 5G antennas for smartphones were suggested by devidas s thosaretalTechnology for beam switching with embedded mmwave phased antennas. The author proposed Antennas that can be configured again for 5G handset. To achieve an integrated mmWave phased array reconfigurable antenna, initially antennas of both polarization configurations were fabricated and then combined with other Radio Frequency and digital architecture[5].

EvangelosMellios et al. discussed various features of 5G cellular communication systems. Propagation parameters like LOS, attenuation losses,lossesthat contributes to buildings penetration were compared over 0.5-100 GHz range and results were presented. These results will help to design efficient 5G handset antennas[6].

Luca Aluigi et al. proposed a 28GHz in which RF beams were formed(Beamforming Technology) for 5G handset.This beamforming systemrelies on array of microstrip antennas and a 2x2 TRX beamforming core chips. A 7.5dB microstrip antenna and a power amplifier that delivers 13.5 dBm was considered by Luca Aluigi et al.so that, the proposed system delivered an EIRP of 34.5 dBm[7].

Tiago Varum et al. presented a planar microstrip array antenna design for 28GHz frequency band having 4x4 configuration with beamforming capabilities. The antenna that was proposed has smaller dimensions and can be adopted for 5G mobiles. The scattering parametrsof antenna were obtained via simulation and with help of analytical tools, the input and output powers were measured. This antenna was observed to be having a gain of about 18dBi and is presented as solution for beamforming application scenarios[8],[18].

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Barry Mulvey et al.investigated three technologies,the RF Micro Electrical Mechanical switch, Energy harvester and the RF Saw filter that will improve the system to be used for 5G [9].

ArvindKumaret.al,carried out an assessment regarding slot antenna performance at dual bands. The results of simulation showed that,proposed transceiver has a transmission capacity of 1.5GHz with low ɤ which increases ŋ of signal at receiving port. The Voltage signal Wave Ratio is observed to be <2 through which it was interpreted that this transceiverwas highly directional[10],[22].

The author SyedaFizzah et.al designed a mmwave antenna on PETE substrate for the5G applications to meet the demands for high bandwidth 5G advanced networks with suitable integration in variable applications[11].

The author A.Ijazet.Al explained how various frame design parameters, provider requirements and traits of radio environment depend on each other. Based on this interdependency, the author A.Ijaz et.al, has provided guidelines for 5G numerology to support huge connection density[21]. These guidelines could be used to design frame for another 5G communication[13],[19].

The author JuwadMohamood et.al hasinvestigated on opportunities to accommodate terrestrial 5 G in greater mm wave frequencies above 31GHZ and to the detriment of present and anticipated developments in satellite communication in frequencies below 31 GHz around the world[14].

The author NaserOjaroudiparchindescribed the layout of a linear array doublet for multi-user MIMO applications. Two pairs of off-center dipole panels were used for the suggested model in the cellular handset PCB's bottom and bottom areas with a size of 60 X 120 mm2. This doublet meets the general demands such as compact, high-gain, high-efficiency and good beam steerable radiation beams for 5G wireless use[15].

III.METHODOLOGY

It is Complicated to design mobile phone for 5G bands when compared to that of design for 4G bands. UE refers to Antenna design, Radio frequency design and modem design. Now a days, requirement for Network speed has increased due to high end applications such as Virtual Reality, UHD video streaming, vehicle communications etc. Losses due to propagation, severe human blockage, human shadowing problems, losses during penetration and weaker diffraction are major technical barriers to 5G and also the wave can'tmove lengthy stretches either.

Beamforming technology and huge MIMO systems can resolve the above-named difficulties, but issues such as hardware design can occur.

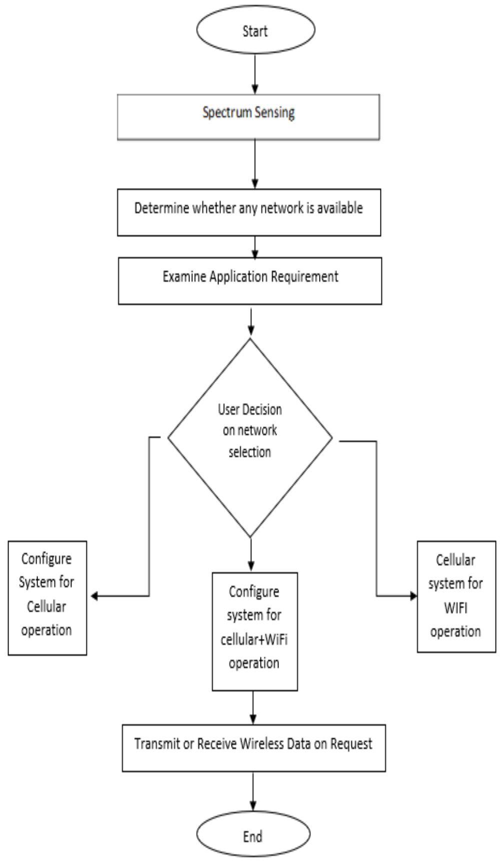

Fig.2 Flow of working of DPA-Massive Input Massive Output architecture

In above figure(2), the working flow of multiplexed DPA-Massive Input Massive Output architecture. Various steps includes spectrum detection, determining network availability, examining application requirement, network selection, configuring operations of Cellular and WiFi, and enablinglow cost cross-layer architectures. Spectrum detection is the method of tracking the accessibility of a particular frequency continually to verify the lack or existence of user equipment. Spectrum sensing determines the availability of networks. Next step is to determine the requirement of bandwidth for a particular application. Network is chosen with the client's choice and then the system is configured to either cellular or WiFi or Cellular+WiFi.

IV.DPA-MAIMAO ARCHITECTURE

DPA-MaIMaO stands for Discrete Phased Array-Massive Input Massive Output Architecture. With this architecture multiple beams are available at the User Equipment as well as at the ground station. Consider the issue of human blockage (Fig.3(a)) on the design of the UE for 5G. The BF modules which are meant for mmWave Beamforming are placed at the central part of the rear housing of Smartphone. But, because of blockage due to human hand, an attenuation of 30dB-40dB is caused.

Fig.3(b) shows an alternate method in which two Beamforming modules are accommodated at top, bottom edges of the Smartphone. But it helps to fix this issue only partly and when the phone is kept horizontally it becomes ineffective.Fig.3(c) depicts the proposed architecture where a minimum of 8 Beamforming modules are placed at the rear housing of the smartphone. This architecture makes the human blockage issue less serious and increases the potential to sink heat

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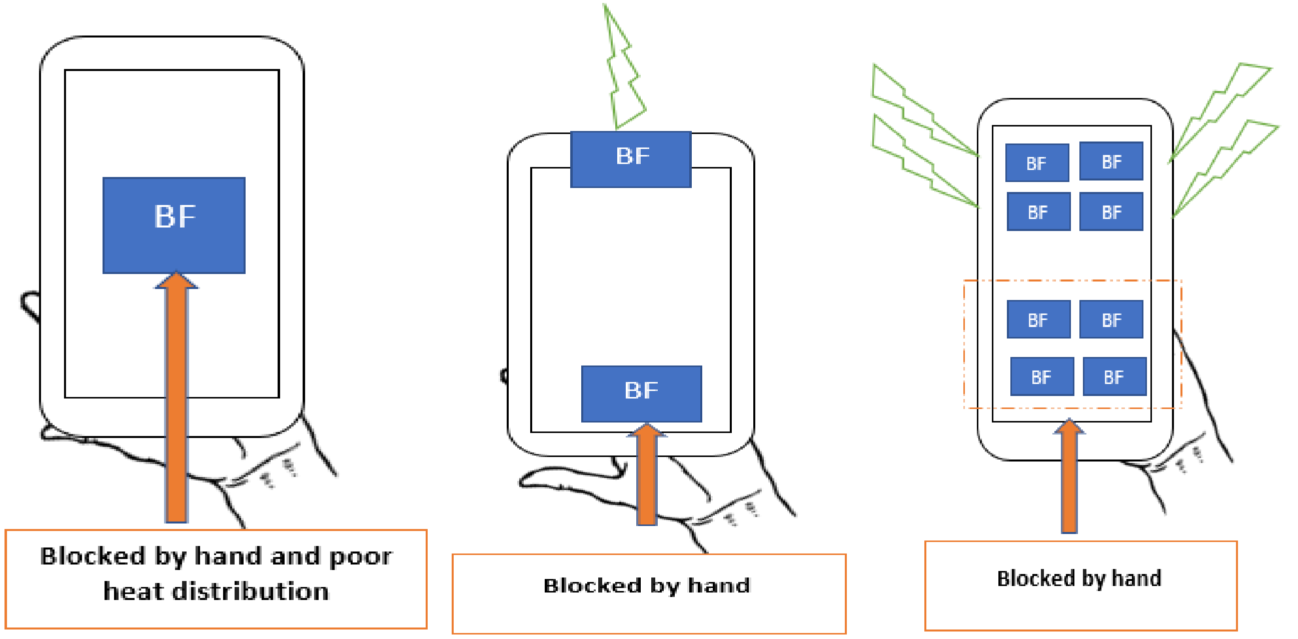

Fig.3 5G Handset with (a) Standard Beamforming hardware design, (b) Beamforming modules arranged attop, bottom edges of the Mobile, (c) ProposedDPA-MaIMaO architecture

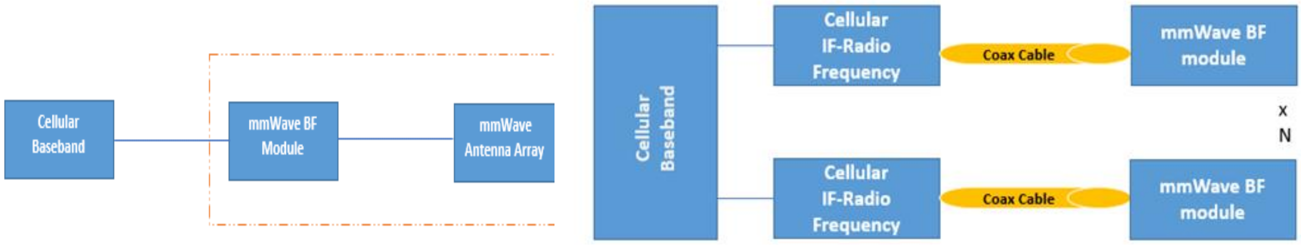

Fig.4 Hardware modulespresent in (a) StandardBeamforming Technology, (b) Proposed DPA-MaIMaO architecture

As per Fig.4(a) Standard beamforming design generally uses direct conversion modules for cellular intermediate to radio frequency, whereas this suggested architecture consists of various Mmwave beamforming modules that are attached by coax wires to intermediate radio frequency converters. These BF modules convert 5 G bands to intermediate frequencies.

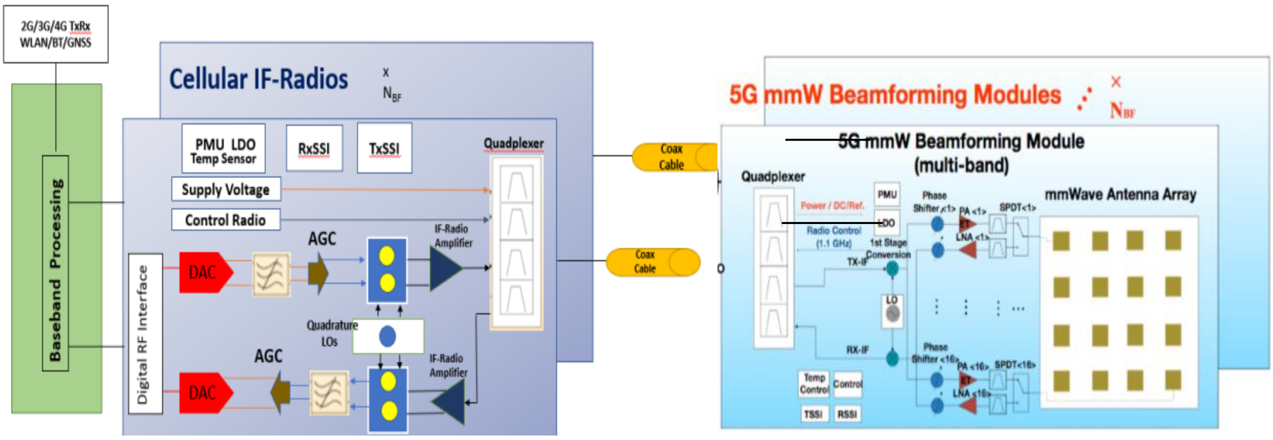

Fig.5 Circuit and system implementation of DPA-MaIMaO for 5G UE

Figure 5 demonstrates the cellular multi heterodyne transceiver and mmwave beamforming module block diagram. The cellular multi heterodyne transceiver module processes radio frequency and baseband frequency measurements. As said earlier, coax cables interconnects BF modules with IF-radio and baseband functional modules, which are placed on a PCB which is the baseboard. These functional baseband modules can manage both precodingtransmission[17] and reception combo.This can viewed in above figure(fig.5) and makes 5G User antenna highly reconfigurable. As visualized in Fig. 3, the amount and the bf module placement will comply with the bandwidth criteria and therefore the architecture of DPA-MIMO is adaptable.However, an edge-to-edge space of five times the normal wavelength is maintained to achieve sufficient spatial isolation and channel capacity.In accordance with various wireless norms, beamforming and IF modules could be used.Temperature Sensor is to track the devices temperture. Rxssi and txssi evaluate and specify the sample power obtained and the input power transferred. Quadplexer is used for single frequency multiplexing of multiple frequencies.

V.WIFI CO-DESIGN FOR 5G USER EQUIPMENT

Now a days WiFi technology is increasing its bandwidth and is not limited only to the 6GHz bands like WiGig, but also employs 60 GHz bands(In evolving stage). Current techniques like LTE-LAA cannot fulfill the specifications of this WiFi/WiGig standards. If 5G cellular mmWave techniques meet WiFiWiGig standards, they will combine and form a powerful aggregated band whose performance is boosted by at least 10 times the present LTE-LAA technique.

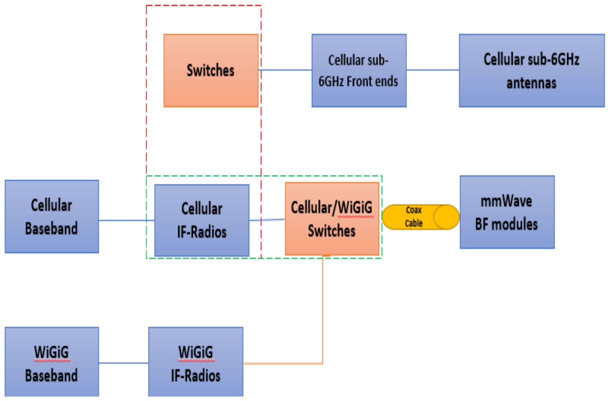

Fig.6 Combination of 5G cellular and WiFi(WiGiG)

Because of restricted user-end hardware area, it is commercially essential to integrate different wireless techniques. When a UE is operating on two standards, multiple BF modules is required and 5G UE designers has to design such that they should be sufficient within limited hardware area. It is better to utilize lesser number of BF modules as much as possible because, they are expensive and power consuming.

As in Figure(6), a WiGig/Cellular mode switch is placed between coax cables and cellular Super heterodyne receivers as well as WiGig Super heterodyne receivers. It is therefore possible to multiplex the bf modules and use them for wifi or wigig or 5 g cellular features.Cellular super heterodyne transmitters can be reused for cellular sub-6 ghz front ends and antennas by allowing the switches linked to them. With this proposed architecture, WiGigtransreceivers and 6GHz cellular functions can be triggered simultaneously on request to allow some BF modules to be used for WiFi (WiGig) purpose and some for Cellular functions.

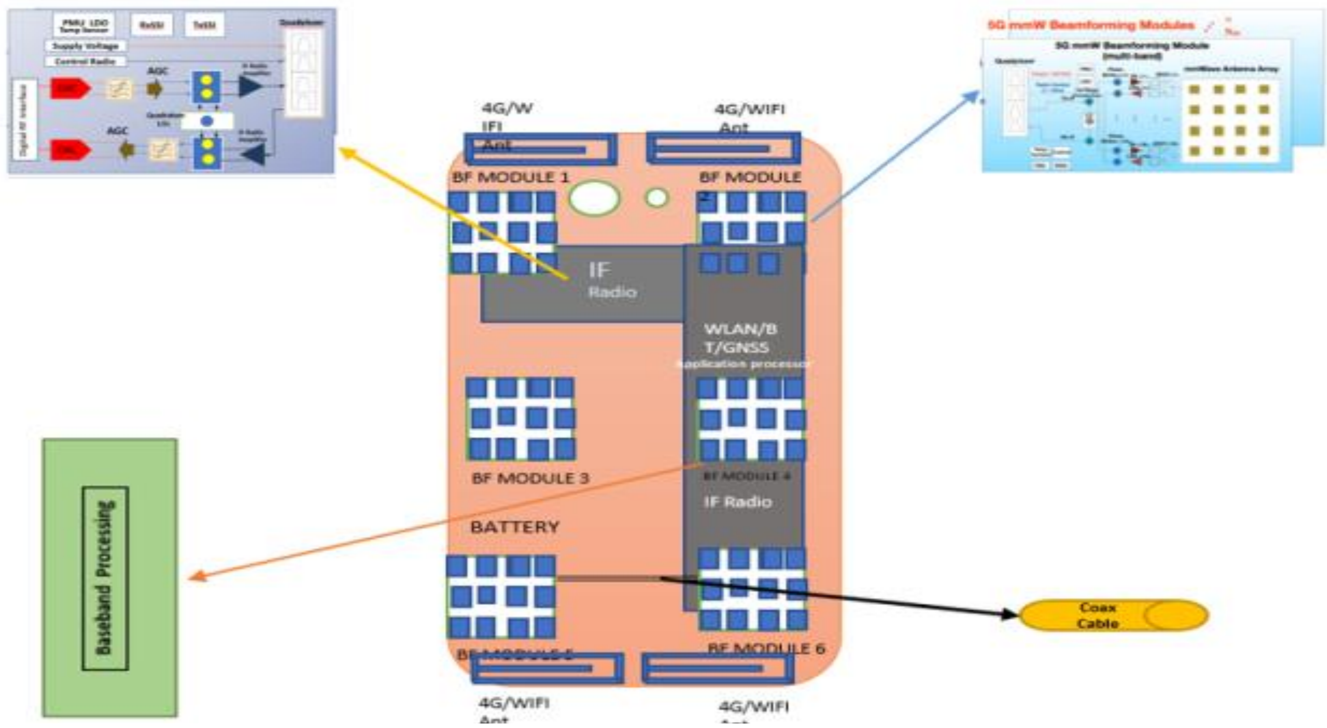

Fig.6 Positions of Beamforming modules and connections

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The suggested DPA-MIMO design circuit diagram is shown in Figue(6). A total of N Beamforming modules, cellular IF-radios and N_{WiGig}WiFig IF-radios were used. While designing the UE , it should be noted that the size of N_{WiGig} should be greater than N_{BF}. WiGig and WiFirequires different modems and low-layer MAC designs. The design of cellular modem will be complex as it has to be compatible for both 3GPP legacy standards and 5G NR waveforms such as OrthgonalFreqeuncy Division Multiplexing(OFDM) based multicarrier waveforms. Other critical considerations for multiplexed cellular wifi architectures include multiple-band phased antenna array layout and multiple-band power amplifier layout.

VI.OPERATION OF CELLULAR WIFI CO-DESIGN

As mentioned earlier, a multiplexed DPA-MIMO architecture uses multiple BF modules, 5G sub-6GHz front end antennas, cellular super heterodyne Receivers, WiFi/WiGig Intermediate Frequency-radios, etc. A higher MAC layer structure and cross-layer layout of physical-MAC layer(PHY-MAC) should be closely considered so as to allow cooperation between Cellular and WiFi or other mobile systems. As depicted in Fig.7, a cellular MAC block should be able work with a WLAN MAC block to enable switching between cellular-WiFi. In addition to this, a 5G super carrier aggregation includes a wider variety of frequency bands ranging from below 6ghz licensed / unlicensed to over 6ghz licensed / unlicensed band.

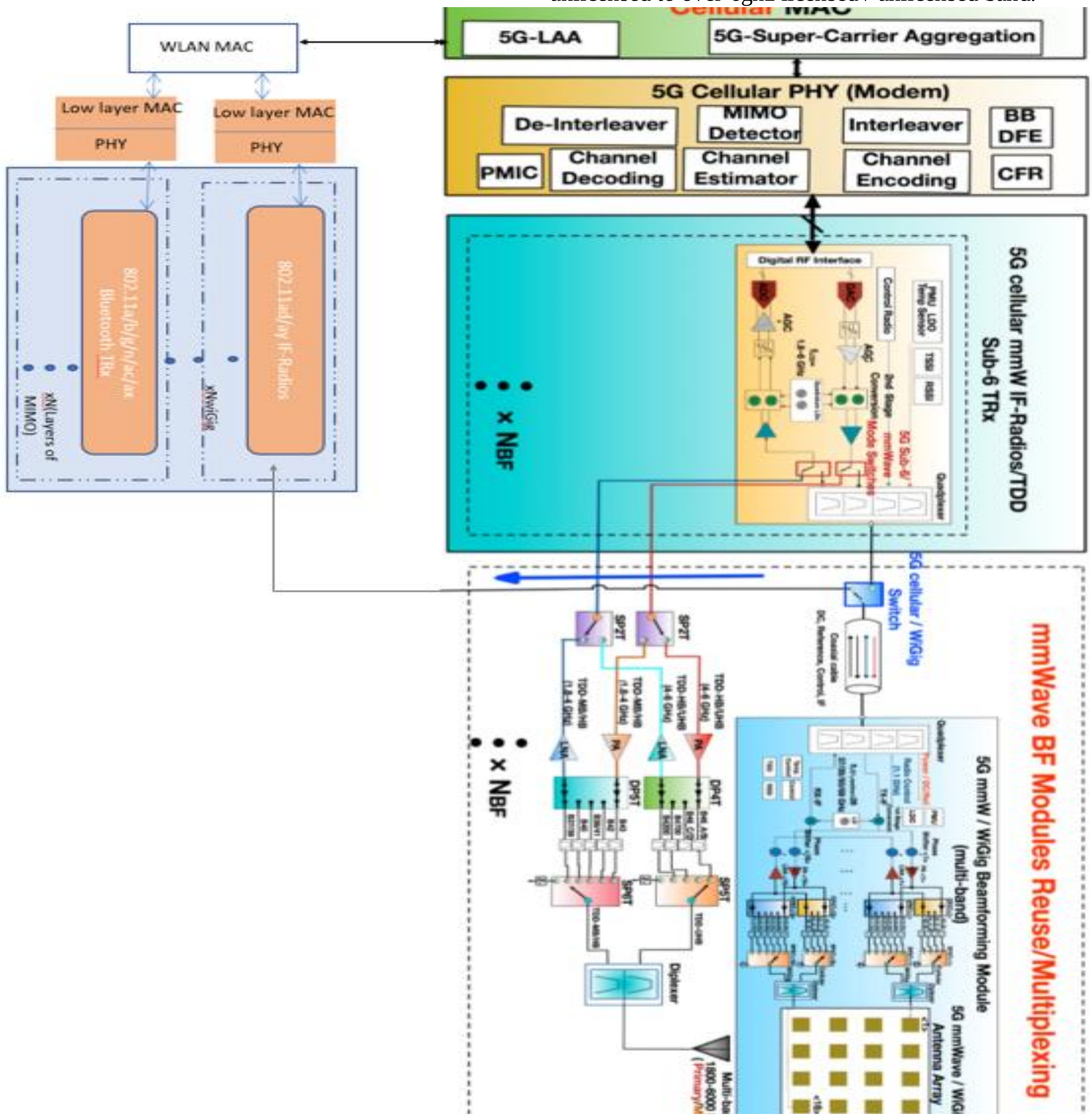

Fig.7 Layout and different layers of the architecture

VII.RESULTS AND TABLES

Table I: Comparison of various communication parameters for N_{array}=64 and N_{array}=256

N_{array}	64	256
Total Antenna Array Gain	23	29
Noise Figure	7.0	70
SNR before installing Beam Forming modules	7.7	-1.0
SNR after installing Beam Forming modules	19.8	25.8
For BW=200MHz SISO Maximum Throughput (Mbps)	989	1240
MIMO Maximum Throughput (Mbps)	7912	9920

Comparison of different communication parameters is provided in the above table for two different ' No.of Arrays. It was observed that the noise figure is independent of Number of Array modules. SNR was significantly reduced with increase in Number of Array modules before and after installing the Beamforming Modules(BF). Maximum data per second was increased at high rates after installing BF modules.

This paper has introduced techniques for cellular-WiFi co-design and enabling them concurrently. Detailed circuit and the working flow of the proposed architecture was presented. With above said techniques it is possible to increase the network speed up to 5Gbps. It is possible to switch between cellular network and WiFi or can be used simultaneously. This paper addresses future equipment design for 5G bands

VIII.CONCLUSION

This paper has introduced techniques for cellular-WiFi co-design and enabling them concurrently. Detailed circuit and the working flow of the proposed architecture was presented. With above said techniques it is possible to increase the network speed up to 5Gbps. It is possible to switch between cellular network and WiFi or can be used simultaneously. This paper addresses future equipment design for 5G bands and WiFi or can be used simultaneously. This paper addresses future equipment design for 5G bands. andWiFi or can be used simultaneously. This paper addresses future equipment design for 5G bands. design for 5G bands.simultaneously. This paper addresses future equipment design for 5G bands. increase the network speed up to 5Gbps. It is possible to switch between cellular network and WiFi or can be used simultaneously. This paper addresses future equipment design for 5G bands

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