Ex-cogitate Millimeter Waves in 5G Network for Smartphone

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Abstract- Considering fastest emerging technologies of the smartphones, transmission speed has become the point of consideration. This paper prescribes a scenario of mmWave 5G antennas for smartphones. Considering Practical design &solutions related to integration of mmWave phased-array antennas using the beam switching capability is investigated in descriptive form. By considering the experimental on proposed methodologies, there comes the two types of mesh-grid phased-array antennas featuring the reconfigurable horizontal & vertical polarizations are fabricated and designed, measured at the 60 GHz spectrum. Later the antennas are integrated with rest of the 60 GHz RF and digital architecture to create the integrated mmWave antenna modules and are implemented within fully-operating cellular handsets under plausible user Scenarios. The effectiveness of the 5G network, its current limitations & future required research areas are presented in mmWave 5G antenna design technologies are studied using mmWave 5G Network

Keywords — ***mmWave, 5G, wireless, antenna, cellular handset, Wi-Fi, Multiple input multiple output (MIMO), distributed phased arrays based MIMO (DPA-MIMO).***

I. INTRODUCTION

This paper is about the emerging trends of technology in wireless world, evaluating from 4G to Fifth generation i.e 5G Network. Continuous demand and the growing competition in the world, it's been necessary to survive in the market and achieve success. Thus there is a need to switch from 4G network to the 5G network to fully utilize the greater network speed and capacity, various countries like US, Japan, China, and South Korea have commenced large-scale research and have developed efforts to launch 5G wireless broadband network in early of the 2018 all over the world.

Considering the increasing difficulties of frequency allocation, there comes the need of utilizing the millimeter-wave (mmWave) for implementing the 5G network. Companies have been gaining support from governments, industries and the intelligent people. The Federal Communication Committee (FCC) in July 2016 announced new rules that would facilitate the adoption of the development of 5G wireless networks. It includes opening up 11 GHz of spectrum above the 24 GHz frequency with upcoming plans of additional 18 GHz of spectrum encompassing of mmWave frequencies in the future endeavour. The announcement by the FCC specify clarity in future research and development of mmWave 5G network. It states the realization of a mmWave-based mobile network is an unprecedented and enormous challenges. In comparison to the sub-6 GHz frequencies, signal attenuation properties associated with propagation, atmospheric characteristics and dielectrics become much more severe. In accordance to the wireless link budget, there's a key to identify methods which would maximize the EIRP (Effective Isotropic Radiated Power) of the mmWave 5G TX (transmitter), minimize RF sensitivity of the mmWave 5G RX (receiver) while limiting total power consumption.

The Wonbin Hong is with Pohang University of Science and Technology (POSTECH), Pohang 37673, in Korea. The rest are with the Samsung Electronics, Suwon 443-742, Korea. Naturally the main focus of mmWave of the 5G network is on the following factors:

1. Efficient silicon and compound semiconductor circuits and an integrated chips (ICs)
2. Large-scale mmWave phased-arrays and beam-switching antennas are used to maximize the antenna and amplifier that gains within the mmWave 5G wireless link budget.

The combined efforts of companies and government have initially triggered a new areas of applications featuring a relatively relaxed size and power consumption constraints such as a mmwave 5G backhaul, which access the base stations. These applications are further specified with the aid of a significant mmWave 5G antenna research efforts including planar phased-arrays and grid-array antennas, substrates integrated waveguides (SIW) and planar lens topologies. Many of these breakthroughs in mmWave antennas are expected to be incorporated in the first deployment of mmWave 5G radio infrastructures in 2018 and beyond it.

This paper describes the overview of 5G Network considering 4 design criteria for mmWave 5G cellular handset antennas

II. LITERATURE REVIEW

The main Aim of implementing the 5G network. Is overcoming the limitations of the 4G Network in various aspects like super-fast speed over transmission of data. The technologies used in 5G Network are full duplex radios, multi-radio access technology association, millimeter waves solutions for 5G cellular networks, and use of Cloud Technologies for 5G Radio Access Networks and Software Defined Networks **(SDN),** Device to Device Communication **(D2D),** Internet of Things **(IoT).**

A vast group of publications is relevant for 5G and multiple articles are coming out every month. Thus, the literature I have selected in this paper is restricted to the most popular articles that are been published every month. Especially, IEEE Communications Magazine has issued a two-part feature topic on 5G in February and May 2014 and the papers therein are briefly summarized here.

A. Points discussed in IEEE communications magazine of Feb 2014 of 5G Technology.

The Magazine describes the ideal future system should have EE improvement for each SE point, larger win-win and smaller EE-SE trade-off region and smaller slope in EE-SE trade-off region. No more cells is another statement that suggests 5G to shift from cell-centric thinking towards soft user and C-RAN centric designs. It covers the deployment of massive MIMO in form of an irregular antenna arrays where the antenna elements can be embedded into the environment thus it makes base stations virtually invisible. Finally, full duplex radio is proposed as one useful technology component for 5G Network.

Similarly to the previous article, Boccardi et al. in [1], listed five disruptive view points towards 5G. The conventional base station based cellular structures like uplink/downlink, control/data channels are expected to provide a way to more agile device-centric architectures where a diverse nature of traffic and network nodes can be handled in a better way. Additionally broad bandwidths are available in millimeter waves (mmWaves) and it should be consider into usage. Massive MIMO (Multiple Input Multiple Output) have potential for 5G as it's a scalable technology at node level and enables new deployments and architectures. Now-a-days devices are getting more intelligent and that must be reflected both at node and higher level of architectural. Consider an example, D2D connectivity and a mobile device caching have implications on system design of 5G. An integral part of a 5G network must provide a natural support for the machine to machine (M2M) communication in such a way where the number of devices connected can be extremely large and highly reliable and required latency must be low.

B.Bangerter ta ar st. [2] states these following observations: 1) Macrocellular capacity increases likely to reach the limits 2) Measures for mobile performance is required in updating and 3) The rapid variety of both the radio access technologies as well the devices is constantly increasing. 5G era requires co-optimization of the networks, devices, and applications in order to achieve the required improvements in service performance & efficiency.

C.-X. Wa, F. Ha [3] he differentiates indoor and outdoor scenarios that would be in a 5G cellular architecture design to avoid the high wall-penetration losses that may occur. Thus the Distributed antenna system (DAS) and massive MIMO technologies would help to overcome of this losses. Indoor coverage for 5G network will be provided by using various short coverage wireless technologies like femtocells, Wifi, Visible Light Communication (VLC), and the mm-waves on the other hand, outdoor users can be served by using the heterogeneous architecture which includes a large MIMO networks, mobile femtocells as well the cognitive radio networks for 5G.

B. Points discussed in IEEE communications magazine of May 2014 of 5G Technology

The article by S. Ch and J. Zh in [4] proposes a idea of change in the evolution paths towards 5G network. It states that the past generations have been dominated by a macrocell development and it is coordinated with macro/local coexistence and that would be more fruitful direction for the future.

V.Ju K. Ma W. Zir B. Pa V. Br describes the improvements in the spectral efficiency and coverage of the cell edge users are the main targets described in [5]. There is a tool for achieving the goal to obtain smart combinations of small cell deployment and joint transmission coordinated multipoint (JT CoMP), and also the massive MIMO techniques with affordable complexity for 5G.

P.Ro C.Be de do M. di gi. [6] Describes the fact of Cloud technologies that are rapidly emerging in modern Internet usage and will inevitably have a role in 5G radio access networks. It presents a radio access network (RAN) as a service (RANaaS) concept for flexible centralized processing platform for 5G Network.

III. Proposed System

It describes various aspects that can be implied in 5G Network, each aspect is explained below:

A. Implication of antennas in smartphone.

The antennas plays a major role in capturing the range for 5G network. Thus consider the design of antennas for smartphone using mmWave for 5G cellular handset. Antenna includes a pair of extremely low profile mmWave phased array antenna modules and a 60 GHz have been designed and investigated experimentally after implemented in conjunction with the entire 60 GHz radio architecture inside cellular handset.

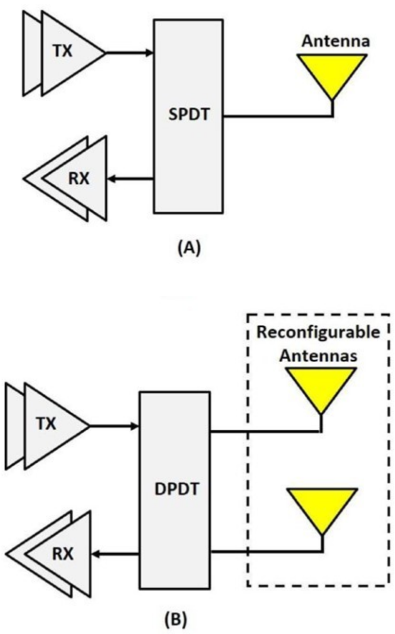

Fig. 1. mmWave 5G front end configuration for cellular handset antennas. (A)SPDT configuration (B) DPDT configuration.

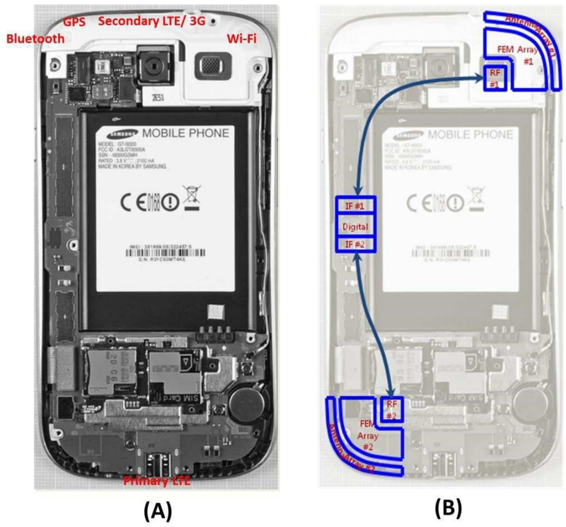

Fig. 2. (A) Conventional placements of antenna for smartphones, (B) Proposed mmWave 5G antenna and radio layout.

For minimization of the antenna real estate, TX/RX antenna switching mechanism is used for both configurations that enables the RF phase shifters to share the TX/RX paths for per RF chain. The DPDT (double pole double throw) switch configuration enables additional functionality for mmWave 5G antennas that can be reconfigurable for polarization or pattern in comparison to the SPDT (single pole double throw) switch configuration for antennas in 5G handset.

B. Implication of Radio Access Network

This radio access network as a service is implemented as an application software which utilizes the cloud platform.

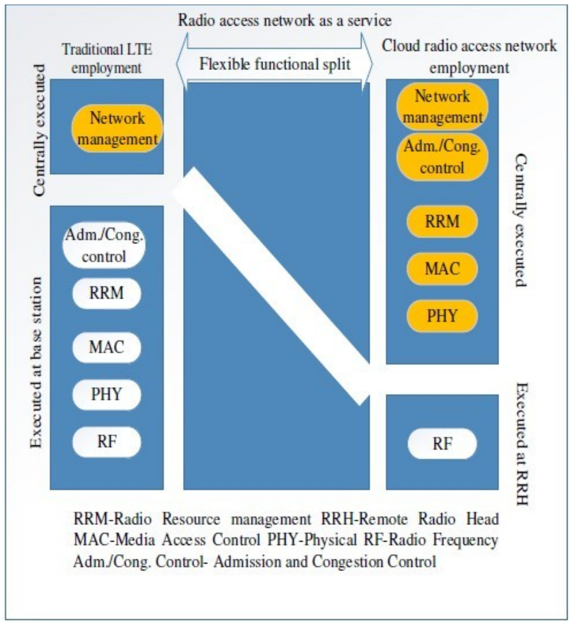

Fig. 3. Flexible functional split in Radio access.

Fig. 3 depicts traditional LTE on the left side where all functionalities up to the admission/congestion control are locally employed at the base station where as the right side depicts the cloud radio access network approach where only the front-end of radio is locally employed and rest all functionality is centralized. But in most of the cases radio access network as a service doesn't fully centralize all radio access network functionalities.

IV. System Architecture for Smartphone

The design principle used in BeamForming (BF) is antenna arrays, whereas MIMO antenna is used for spatial multiplexing. They differ from each other. The appearance of upcoming 5G phone will be similar to 4G handset except the arrangements of sim on the board will be eliminated by implementing eSIM or virtual sim i.e it will be be integrated on a chipset rather than providing physical SIM slot.

The fig 4. Illustrates the DPA MIMO architecture that would be implemented on a smartphone where eight identical 8-element phased array based BF modules are distributed and placed in the backside of a mobile handset.

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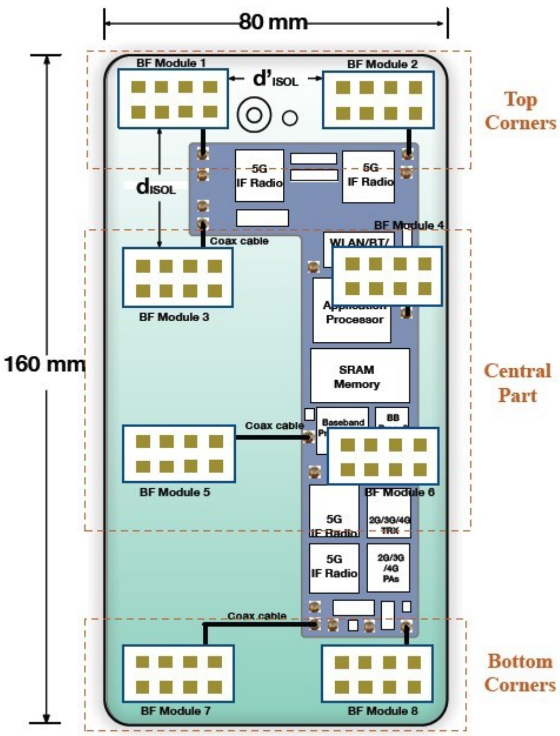

Fig. 4. Illustration of DPA MIMO architecture for smartphones.

Consider in each BF module, embedding of one RF transceiver chain would realize an active phased array of NANT=8 antenna elements. Let's consider an example for estimating the effective isotropic radiated power (EIRP) by simply assuming that a PA has an output power of PPA, and the output power is then splited into NANT equal parts and fed into a NANT-element phased array. At the phased array output, we can obtain an EIRP which is 10log10(NANT) (=9) dB higher than PPA. Furthermore, if we remove that PA and place one PA in the front-end path of each antenna element, and the output power of all PAs is maintained at PPA (not scaled down with the increased number of front-ends [6]), the EIRP can be boosted to be 20log10(NANT) (=18) dB higher than PPA. Therefore, in this scenario, NPA (=NANT) PAs Contribute the extra 10log10(NANT) (=9) dB gain on top of the first EIRP, but at the cost of higher power consumption.

From perspective of the wireless hardware design the distributed phased arrays (DPA) based architecture helps the heat dissipation which is largely contributed by the PAs. In the state-of-the-art PA design for 5G phased arrays, the power added efficiency (PAE) is below 20% as a result the majority of the DC power will be converted in thermal energy which will lead to increase inner temperature of a mobile handset and which further leads to a critical failure of the entire system of cellular handset. This issue persist when multiple mmWave Pas will be integrated in BF modules and handset will be operated at a cell edge or with a heavy traffic load. By arranging the mmWave BF modules in a distributed manner, it can mitigate largely this self-heating issue. In such condition a cooling device will be required, however it is difficult to the attenuation can be as high as 30 to 40 dB for the 73 GHz band.

V. CONCLUSION

This paper concludes the detailed information of the upcoming Fifth Generation (5G) Network that would be implemented in future era of the the 5G smartphones. Studied the mmWave 5G antennas for cellular handsets and the DPA-MIMO architecture of 60 GHz phased-array. Overview of the IEEE communications magazine for 5G. The future 5G handset will consist the eSIM that will highly increase the demand of the new smartphones. The design parameters and mmWave 5G benchmark is investigated. Performance enhancements are mainly expected from a combination of network densification (e.g., small cells, D2D), increased spectrum beyond 6 GHz frequencies and enhanced the wireless communication technologies using massive MIMO, antennas, eSIM, Radio access network.

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