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5G New Radio and Cloud Radio Access Network

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***Abstract*— In upcoming years, data communication and technologies are profoundly merging, and different wireless access technologies has become successful in its deployment. It can be anticipated that the forthcoming 5G technology can never again be characterized for a single business. 5G provides a multiple service and integrates multiple technologies to meet the needs of a wide scope of big data and improves the user experience by providing smart and customized services. 5G New Radio (NR) is the worldwide standard for a proficient 5G air interface. It is equipped for conveying fundamentally quicker portable broadband experiences, stretch mobile innovation to connect new enterprises. This paper explains the overview, evolution of CRAN, new radio architecture of 5G, new radio protocol stack of 5G, 5G network interfaces, CRAN architecture, functionalities of CRAN and deployment use cases of CRAN. CRAN architecture is capable of addressing various difficulties that operators face when trying to support increasing end-user needs towards 5G. The principle behind CRAN is to separate the base stations into radio and Baseband Units (BBUs). This gives various advantages like providing flexibility and reducing the expenses. It is a novel centralized technology which is dependent on softwarization and virtualization that can address issues in legacy networks. It is nothing but the virtualization of base station functionalities using cloud computing. This outcomes in an architecture with low-cost AP's, which are known as radio units and are managed by a reconfigurable centralized cloud. It is considered as one of the promising technologies for the future generation mobile and wireless communication.**

Index Terms: NR- New Radio, UP- User Plane, CP- Control Plane, CRAN- Cloud Radio Access Network, RU- Radio Units, DU- Distribution Units, RRH- Radio Remote Heads, AP- Access Points, SDN- Software defined networks, NFV- Network Function Virtualization, VRAN- Virtualized Radio Access Network

I. INTRODUCTION

The advancement towards cellular networks is described by an exponential development of data traffic. It is evaluated that cellular network will develop continuously and this development is brought about by an expanded number of cell phones and tablet users [3]. Therefore, to fulfil developing client requests, network operators need to increase wireless network capacity. Reducing the cell coverage area was proposed as an answer since network resources can be reused among small cells more frequently, thus increases the total network capacity. However, it builds the issue of inter cell interference. There is a gap between mobile device capacities and those required to run complex applications. So as to confront these difficulties, cloud-based RAN was proposed. It comprises of decoupling the Base Band Units from Radio Remote Heads and move them to the cloud by enabling centralized operation and management. Traditional base stations should be simplified for cost-effective and power efficient remote radio units by centralized processing, which is significant for implementing large scale small cell frameworks. Also, the centralized processing provides efficient network management. There is a demand for advancement in technologies to support applications and services of future in all aspects of living style of people which is increasing continuously. Additionally, with the fast advancement of wearable devices, IoT's and networking technologies, numbers of smart devices to access wireless communications should improve the ability of existing networks. It is estimated that the data traffic in 2020 will reach 600 times that in 2010, which brings the new challenges and needs for development of future mobile wireless systems [4].

Connectivity capacity: Traditional wireless technologies primarily give interpersonal communication. With the ascent of IoTs and related technologies, more gadgets can get access to internet networks, with the expanding requirements for communication among people and things or between things. 5G is capable of providing a universal solution to connect anything's, at any time to anywhere in the world.

Network performance: With the advancement in technologies, the new applications and services are able to access the mobile network, and user will expect simple and quick access to variety of information. In any condition, clients can easily get access to multimedia resources, or a wide range of valuable information progressively through 5G network.

Resource optimization: Traditional wireless technologies depend on hardware/ infrastructure upgradation to improve their QoS. But this methodology increases the cost of services, yet additionally effectively prompts a waste of resources. 5G ought to have the option to brilliantly recognize the communication situations, progressively assign network resources and give the best connectivity and network performance as required, to improve the proficiency of existing resources.
To address these difficulties, research on next generation wireless systems i.e., 5G, has become the new focus on academics and business. By 2020, 5G will be the main portable communication innovation to meet the information needs of the human culture by interconnecting the remote world without hindrances. The remaining sections of this paper are described as follows. Section 2 describes about the literature review. Section 3 brings the evolution of CRAN. Section 4 gives the NR 5G network architecture. Section 5 and 6 explains 5G Protocol stack, interfaces of 5G. Section 7 and 8 provides CRAN architecture and its functionalities. Section 9 explains

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the deployment/ use cases of CRAN and Section 6 presents the conclusions of this research.

II. RELATED WORK

In the paper [2], authors introduce the conventional definitions, essential functionalities and difficulties of CRAN. The paper [4] gives a concise overview of advantages and disadvantages of CRAN design and further advancement in this field. The paper [5] gives review of every single realized procedure to understand a framework that is able to help a CRAN network. The principle target of the paper [6] was to focus on various difficulties and continuous research work on Optimization in Fronthaul and Backhaul Network using CRAN. In paper [7], authors conduct an overview of two network systems i.e., CRAN and Fog network. The performance change between the CRAN and Fog has been exhibited and the consequent switching strategy has been proposed to guarantee adaptability. The paper [8] presents the traditional wireless technologies and studies the advantages and difficulties of CRAN, Heterogenous-CRAN, and Fog RAN. More strikingly, a progressive network architecture dependent on cloud computing and centralized processing is received as a standout amongst the best contender for 5G era. The paper [9] presents an overview on the 5G network architecture and some trending innovations that are useful to improve the architecture of 5G and to fulfill the needs of clients. This paper explains that the principle center is around the 5G network architecture, MIMO, and Device-Device communication. The authors in the paper [10] proposes a RAN architecture with tight incorporation of various RAT's which supports accumulation of traffic streams from/to various sources. The NR architecture helps to obtain good throughput and expanded reliability. The article [11] gives an outline of 5G RAN key structure considerations, and useful advancements as recognized and developed by key players in this field. Research on 5G projects has been recognized that there is a demand for a new air interface to work in higher frequency ranges. In the paper [12], authors propose a RAN architecture which integrates the new air interface with 4G to empower cross air interface enhancements, gives quicker versatility and multiple connectivity features.

III. EVOLUTION OF C-RAN

Traditional RAN gradually advanced to CRAN by three stages Distributed Unit centralization, Distributed Unit pooling and Virtual Radio Access Network. Pooling and Virtualization of Distributed Unit/Distributed Unit cloud can be seen as two distinct periods of Distributed Unit cloud. The figure 1.1 shows the evolution of C-RAN step by step.

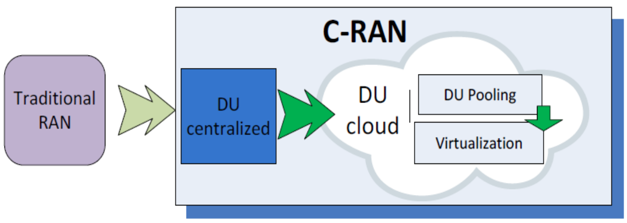

Figure 1.1: C-RAN evolution step by step

DU centralization is the initial step through collecting the parts of RAN in a solitary area. Radio Frequency sites are associated with the RAN utilizing fast speed and low latency links. This initial step can begin from an ordinary RAN and doesn't require huge advancement. Distributed Unit pooling is the second development step. It brings the ability of load balancing among Distributed Units. The primary advantages of pooling are on CAPEX, upgraded adaptability and failover mechanisms. Virtual Radio Access Network is the last advancement step where resources are virtualized. There has been no generally acknowledged meaning of VRAN up until this point. The fundamental attributes of VRAN are the utilization of standard innovation for economy of scale and to minimize network costs. Another viewpoint is to make applications autonomous of the equipment.

IV. NEW RADIO NETWORK ARCHITECTURE FOR 5G

The new radio architecture of 5G is as shown in the above figure 1.2 and is characterized in the 3GPP specification. 5G New Radio is developed to help different administrations, deployments and devices. The g-NodeB gives new radio User Plane and Control Plane terminations towards the User Equipment for example 5G devices, and it is associated to AMF/UPF of 5G Core network via NG interface. The capacity of AMF is to get access control and portability, access authentication and authorization, connection and reachability management which is implemented in Mobility Management Equipment and this may vary with various use cases. The functions of 5G NR UPF are Packet routing and sending, Packet inspection, handling the QoS.

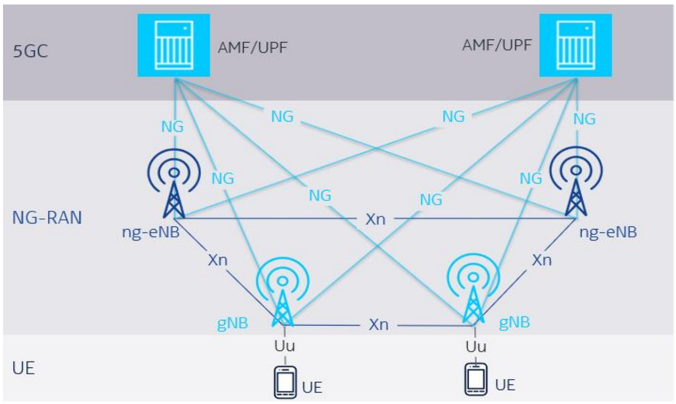

Figure 1.2: 5G NR Architecture

The ng-eNodeB gives LTE UP and CP terminations towards the User Equipment and is associated to the 5G Core Network via NG interface. The new radio 5G architecture includes different interfaces like Xn, Ng, E1 and F1. 5G devices connects with 5G-RAN via radio interface, RAN further communicates with 5G Core Network. User plane protocols implements PDU Session service that carries user information. CP protocols controls the PDU Sessions, connections among User Equipment's and the network based on aspects like, controlling different transmission resources, handovers etc. A g-NodeB consists of g-NodeB-CU (Central Unit) and multiple g-NodeB-DU's (Distribution units). F1 interface associates between g-NodeB-CU and a g-NodeB-DU. 5G RAN interfaces

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are logical interfaces and architecture is scalable and highly flexible. 5G new radio architecture is supported by technologies like SDN, NFV, Cloud Computing and network slicing.

V. NEW RADIO PROTOCOL ARCHITECTURE FOR 5G

The below figure 1.3 shows the protocol stack of new 5G radio architecture. The protocol layers of gNB consists of Physical layer, Media Access Control layer, Radio Link Control layer, Packet Data Convergence Protocol layer, Radio Resource Control layer, Service Data Adaptation Protocol layer. The detailed functionalities of layers are explained as follows,

Physical layer: This layer frames the foundation of any wireless innovations. The NR physical layer is adaptable and versatile structure to help differing use cases with outrageous requirements. The key functionalities of this layer are modulation, decoding, power control, error detection, OFDM operation, Fast Fourier Transform/ Inverse Fast Fourier Transform and channel coding.

Media Access Control layer: A fundamental functions and services of this layer includes, logical and transport channel mapping, Error correction, Priority dealing with between User Equipment's by methods for dynamic scheduling, MUX/DEMUX of MAC Service Data Units (SDU's), Padding, handling QoS.

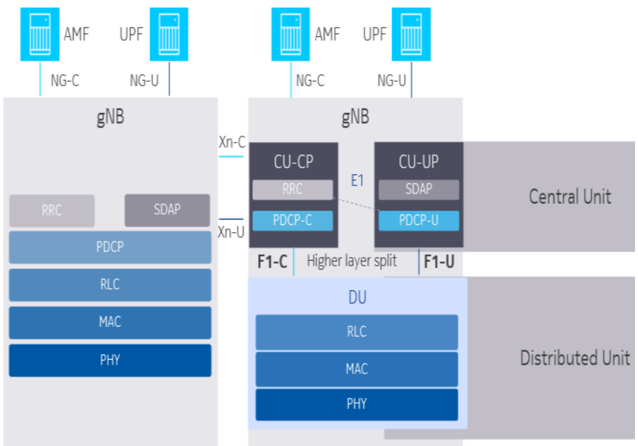

Figure 1.3: Protocols stack of 5G new radio architecture

Radio Link Control layer: Primary functions and services of this layer includes:

- Transferring upper layer PDUs.
- Sequence numbering
- Error Correction
- Segmentation and re- segmentation

Packet Data Convergence Protocol layer: The fundamental services and functions of this sublayer for the UP includes:

- Sequence Numbering.
- Compression and decompression of header.
- Transferring user information.
- Ciphering and Deciphering.

The fundamental services and functions of this sublayer for the CP includes:

- Sequence Numbering.
- Encryption, Decryption and integrity protection.
- Transferring CP data

Radio Resource Control layer: The fundamental functions of this layer includes:

- Paging initiated by 5GC or NG-RAN.
- Broadcasting network data.
- QoS handling.
- Radio link failure detection and recovery.

Service Data Adaptation Protocol layer: Mapping of 5GC network information flows with certain QoS necessities to parametrized radio transmissions. The principle functions of this layer are to mark QoS flow ID in both Down Link and Up Link packets.

VI. 5G NETWORK INTERFACES

gNB: The node that provides NR UP and CP terminations towards the User Equipment and connects to 5GC via the NG interface. 5G NR g-NodeB architecture functional split has been described in 3GPP as follows:

Central Unit (CU): Logical node that incorporates non-real time functions of the 5G g-NodeB.

Distributed Unit (DU): Logical node that incorporates real time functions of the 5G g-NodeB. Its activity is controlled by the CU.

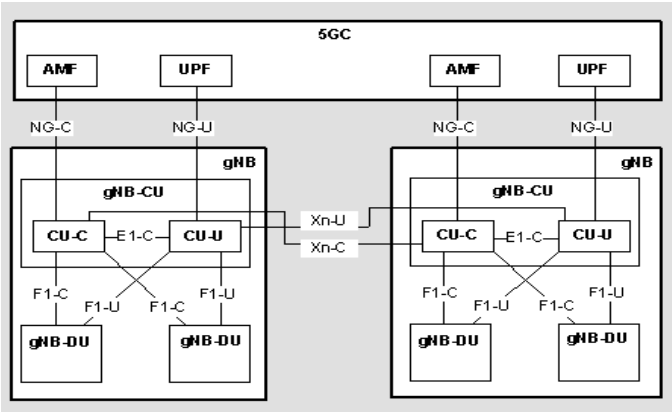

Figure 1.4: 5G NR Network Interfaces

The 5G new radio network interfaces is as shown in figure 1.4 and explained as follows:

Xn Interface: It exists between the BS between g-NodeB and g-NodeB, between g-NodeB and ng-eNodeB and between ng-eNodeB and ng-eNodeB. It is classified as Xn-U (Xn UP interface) and Xn-C (Xn CP interface). The Control Plane Functions are, Interface management, error handling, Mobility

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management, secondary node addition, reconfiguration and so on. The User Plane Functions are Data Forwarding and Flow Control.

NG Interface: It exists between 5G Core Network(5GC) and BS g-NodeB and ng-eNodeB. NG-C is a CP interfaces RAN and 5G Core and associates with Access Mobility and management Functions. NG-U is a UP interfaces RAN and 5G Core and associates with UPF. The division between the Radio and Transport Network functionalities are determined in the NG interface to encourage the introduction of future innovation. The capabilities of NG interface are, to manage intra-RAT and inter-RAT handover and exchange of Non-Access Stratum messages among User Equipment and Access Mobility and management Functions.

E1 Interface: The interface between the CU-CP and CU-CP of g-NodeB. E1 interface helps the trading of signalling data between the endpoints. It empowers trade of UE related data and non-UE related data.

F1 interface: It characterizes between association of a g-NodeB-CU and a g-NodeB-DU. It helps in CP and UP division. And it isolates Radio Network and Transport Network Layer. F1 interface empowers trade of UE related data and non-UE related data.

VII. C-RAN ARCHITECTURE

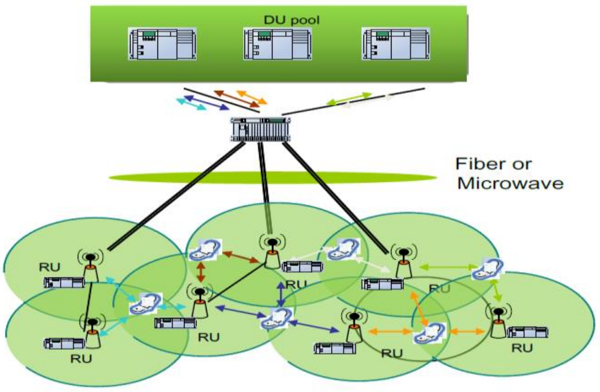

Figure 1.5: CRAN architecture

The C-RAN consists three sections as shown in figure 1.5 i.e., the remotely distributed Radio Units, Distributed unit cloud and Antennas and provides high data transfer capacity and low latency which interfaces the Radio Units to the Distributed Unit Cloud. The DU cloud consists of Digital Units which are called as Baseband Units which are incorporated in one physical area for giving resource accumulation and pooling. Various Radio Access Technologies can be deployed on CRAN physical framework. The Radio Units is responsible for the radio functionalities for RF transmission and reception. It incorporates RF amplification, filtering, Analog to Digital and Digital to Analog conversions and interface adjustment. It associates by means of optical transport network systems to atleast one Distributed Unit clouds or to different Radio Units. The optical transport network is made out of the physical fibres and cross connectors. The DU Cloud is made out of numerous indistinguishable Distributed Units interconnected together. It gives the ability to aggregate the power of distributed units together and distributes power to the real time functions of base stations as indicated by system load.

VIII. FUNCTIONALITIES OF CRAN

CRAN has several functionalities like:

Resource sharing:
It is one of the key highlights of CRAN for expense and power sparing. Dynamic task relocation is a possible answer for resource sharing.

Virtualization:
In the recent IT industries, virtualization plays a significant job in cloud framework. Virtualization gives virtual environment to guest Operating Systems and applications and partition between various Operating Systems in spite of running on the same physical hardware. CRAN is one sort of space explicit cloud technology and can profit a great deal from virtualization innovation. For instance, one processing unit can keep on running in a virtual machine. Moreover, some core network applications and services can likewise keep on running in Distributed Unit cloud.

Multiple-Radio Access Technology support:
CRAN ought to have the capacity for multiple radio access technology support in the equivalent Distributed Unit cloud for inter-RAT resource sharing. Multiple Radio Access Technologies are GSM, UMTS, LTE and 5G. In deployment, even though the capacities might be not quite the same as RAT to RAT, developers ought to coordinate them in one physical hardware for different Radio Access Technology support. The DU unit cloud should be sufficiently adaptable to help different RATs. Software Defined Radio based Distribution Unit can be used to process protocols. On the other hand, depending upon design, Distributed Unit may require a physical accelerator to off-load tasks.

Reliability:
Concerning General Purpose Platform based Distributed Unit, numerous methods exist for reliability and quality improvement, for example, data integrity and predictive failure analysis. Virtualization can give certain dimensions of dependability to DU. It can isolate the mal-function tasks and evade the accident of entire DU.

Operation & Management (O&M):
Old base stations contain physical equipment as well as logical services. For O&M, the designers should maintain the physical equipment and logical services at the same time. For CRAN, another solution is suggested. The physical equipment's and logical services are proposed to be isolated totally. Base Station is simply sensible and gives remote administration. Physical equipment turns into a resource pool to help remote administration. So, the management of C-RAN on Operation Supporting System is additionally isolated into two sections: Physical Resource Management and Logical Service

Management. In view of BTS work, OAM designers can only maintain the logical service.

Network sharing:
To utilize the spectrum range and resources, network sharing has been empowered by controllers for limiting environment impacts. Network sharing is a prerequisite for conventional RAN as well as for CRAN. It can bring a few advantages for administrators, for example, reducing cost in RAN by sharing the radio sites and decreasing the quantity of Radio Units for a same coverage area, Balance between investments and returns for rural area.

IX. C-RAN DEPLOYMENT USE CASES

The different deployment use cases of CRAN are as follows:

Large/medium scale CRAN deployment:
A few administrators/operators will have plentiful access fiber resources, additionally they have rich aggregative fiber. It implies that Common Public Radio Interface information among Radio Unit and Distribution Unit can be transmitted for large area. More DUs can be isolated far from radio destinations and be brought together to the main office. In this manner, some key issues need profound research, including how those centralized Distribution Units develop to Distribution Units cloud and how the fibre between Distribution Unit centre and radio sites are improved.

Indoor coverage:
A conventional indoor coverage solution depends on a distributed antenna system fed by repeaters which combines radio signals from one large scale Base Station. This old solution conveys high obstruction to full scale base station cells and can't supply substantial system capacity. Implementing distributed Base stations, utilizing Radio Unit as a signal source for indoor distributed antenna system and is appropriate for indoor/open air inclusion. Radio units for indoor inclusion can have the equivalent DU with open-air large-scale sites dependent on the Base Station design. At the point when a building has low limit necessity, indoor and open-air sites can utilize co-cell innovation with various Radio Units to decrease indoor/outside handover to improve network quality. At the point when a building needs vast capacity radio units for indoor they occupy free cells by including baseband resource processing and programming update.

Hot spots:
Stadium coverage is a one of such examples. It is portrayed by a high traffic request in a moderately large area. Similar sort of circumstances is in real transportation centers, for example, train/ bus/ subway stations. There will be High user density of 80,000 individuals with high information limit per user and to provide coverage to large areas many small cells are required.

Railway/ metro/ highway:
To lessen the User Equipment's hand over between neighboring cells while moving, which results in voice administration or information download breakouts in the railway/metro/highway situation, various Radio Units in various sites utilizing CRAN design can co-operate with one another and numerous full-scale chain cells can be consolidated to a very large-scale cell.

X. CONCLUSION

The improvement of the 5G networks has been advanced at a rapid pace. 5G Radio Access Network's empowers the network densification and centralized operation of the RAN over heterogeneous systems. 5G New Radio is a new radio access technology developed by 3GPP for the fifth generation mobile network. It's meant to be the global standard for the air interface of 5G networks. It will deliver significantly faster and more responsive mobile broadband experiences and extend mobile technology to connect. To fulfil the regularly growing requirement in mobile networks and in the meantime, to make cost and energy efficient solution, new thoughts are required. With its efficiency and cost saving advantages, CRAN is a major technological establishment for 5G mobile networks. Applying the idea of NFV, CRAN mobile networks are following towards virtualization and cloudification. Separating hardware from software empowers software to organize different components, including Base Band Unit pool and network resources. Such an adaptable, self-organized network considers for different optimizations. In CRAN BTS functionalities are part between cell sites and the centralized pool. It is a difficult to locate an ideal splitting point just as assuring efficient interconnectivity between the parts. To finish up, CRAN is an architecture that is significant for considering for 5G to address its performance and minimize implementation costs. Centralization and virtualization to be sure offer cost savings. CRAN can give further advantages as far as progressively isolated and decoupled scalability for the different parts of the RAN functionalities. Eventually, CRAN provides operator an opportunity to co-execute RAN functionalities with other network functions on a generic platform which will empower them to offer new and exciting services more quickly over the future mobile networks that will shape the foundation of the Networked Society.

REFERENCES

[1] Checko, Aleksandra, Michael S. Berger, Georgios Kardaras, Lars Dittmann and Henrik Lehrmann Christiansen. "Cloud Radio Access Network architecture. Towards 5G mobile networks." (2016).

[2] L. Gavrilovska, V. Rakovic, A. Ichkov, D. Todorovski and S. Marinova, "Flexible C-RAN: Radio technology for 5G," *2017 13th International Conference on Advanced Technologies, Systems and Services in Telecommunications (TELSIKS)*, Nis, 2017, pp. 255-264. doi: 10.1109/TELSKS.2017.8246276.

[3] O. Chabbouh, S. B. Rejeb, N. Agoulmine and Z. Choukair, "Cloud RAN Architecture Model Based upon Flexible RAN Functionalities Split for 5G Networks," *2017 31st International Conference on Advanced Information Networking and Applications Workshops (WAINA)*, Taipei, 2017, pp. 184-188.

[4] Chen, Min & Zhang, Yin & Hu, Long & Taleb, Tarik & Sheng, Zhengguo. Cloud-based Wireless Network: Virtualized, Reconfigurable, Smart Wireless Network to Enable 5G Technologies. Mobile Networks and Applications. 20. 10.1007/s11036-015-0590-7.

[5] M. Hadzialic, B. Dosenovic, M. Dzaferagic and J. Musovic, "Cloud-RAN: Innovative radio access network architecture," *Proceedings ELMAR-2013*, Zadar, 2013, pp. 115-120.

[6] B. Mahapatra, A. K. Turuk, S. K. Patra and P. Maiti, "Optimization in fronthaul and backhaul network for cloud RAN (C-RAN): Design and deployment challenges," *2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES)*, Paralakhemundi, 2016, pp. 1009-1014.

[7] S. Hung, H. Hsu, S. Lien and K. Chen, "Architecture Harmonization Between Cloud Radio Access Networks and Fog Networks," in *IEEE Access*, vol. 3, pp. 3019-3034, 2015.

[8] Guizani, Zeineb & Hamdi, Noureddine. (2017). CRAN, H-CRAN, and F-RAN for 5G systems: Key capabilities and recent advances. *International Journal of Network Management*. 27. e1973.

[9] Gupta and R. K. Jha, "A Survey of 5G Network: Architecture and Emerging Technologies" in *IEEE Access*, vol. 3, pp. 1206-1232, 2015. doi: 10.1109/ACCESS.2015.2461602.

[10] S. Chandrashekar, A. Maeder, C. Sartori, T. Höhne, B. Vejlgaard and D. Chandramouli, "5G multi-RAT multi-connectivity architecture," *2016 IEEE International Conference on Communications Workshops (ICC)*, 2016, pp. 180-186. doi: 10.1109/ICCW.2016.7503785.

[11] P. Marsch *et al*., "5G Radio Access Network Architecture: Design Guidelines and Key Considerations," in *IEEE Communications Magazine*, vol. 54, no. 11, pp. 24-32, November 2016. doi: 10.1109/MCOM.2016.1600147CM.

[12] Icaro Leonardo Da Silva, Gunnar Mildh, Johan Rune, Pontus Wallentin, Jari Vikberg, Paul Schliwa-Bertling and Rui Fan, "Tight Integration of New 5G Air Interface and LTE to Fulfill 5G Requirements",2015 IEEE 81st Vehicular Technology Conference (VTC Spring), 2015, pages: 1-5.