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Analysis of Various Issues for 5G Infrastructures

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Abstract

5th Generation Cellular technology is not just one more technical innovation, rather it is going to be the the most prominant platform for the other innovations to get it happened. Mobile networks are changing the way people communicate and access information. Network access at anytime and anywhere is transforming the telecom industry. 5G technology will enable flexible, reliable, and secure wireless networks to connect people with all applications, services, and things, thus leading human race into the era of "Everything on Mobile". The 5th Generation of the Internet in Telecommunications will open the new doors to the Internet of Things (IoT), Industrial Internet of Things (IIoT), Artificial Intelligence (AI), Machine Learning (ML), Neural Networks, etc. But for the last several years since its designing and implementation strategies, 5G technology has been embroiled in various social and technical controversies. The testing of 5G in different countries of the world has shown that in future the user will get the expected data speed but the time to come will show how much the power level of high frequency signal harms human health and other services. Initially 3rd Generation Partnership Project (3GPP) and ITU have combinely proposed two way of infrastructure for the implementation of 5G i.e. SA architecture and NSA architecture with pros and cons with both. This analytical paper narrates the different issues that may arise upon the implementation of 5G infrastructure. The severity of issues related to multiple frequency bands availability, health hazards, airline frequency band conflict as well as coding discrepancy will be different for Stand Alone infrastruction option and for Non Stand-Alone infrastructure choice.

Keywords: 5G Cellular Technique, Beamforming, Massive MIMO, SA architecture & NSA architecture.

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Overview of 5G

The world needs better, reliable, easy and fast communication technology everyday. So, we are experiencing the exponential evolution in mobile network technologies like 1G, 2G, 3G, 4G and now we are infront of the 5th Generation (5G) of wireless Mobile Network Technology which will change the whole world's scenario with its Higher Multi-Gbps data speeds, Vast number of Network Capacity, Ultra Low Latency, Reliability, Increased Availability, and very great user experience to large number of users. With these kinds of features in 5G, the users will experience a much lower lag in live streaming, faster and quicker downloads, faster game play, so it will significantly impact on daily lives. With 5G pushed over a VoIP-enabled device, people will experience a level of call volume and data transmission as never before. The expected connectivity rates and features of 5G will make business more efficient and give consumers access to more information faster than ever before. The 5G technology is not founded by any people or any single company but it is the contribution in innovation of multiple R&D Engineers of so many companies like Qualcomm, Verizon, etc. to serve the globe with faster Data Rates. With the possibilities of C-Band, a mid-band spectrum that offers a transformative mix of coverage and performance that will make 5G even more accessible to customers. The advantage of Private 5G networks not only limited to improve security, bandwidth and speed but it will change how we work in ways us never though possible.[1]

The key features of 5G include:[2]

- 99.999 % Availability
- 1 ms Latency
- 1000x bandwidth per unit area
- 90% reduction in network energy usage

Up to 100x number of connected devices per unit area (compared to 4G LTE)

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The next section of research paper illustrates the basic physical layer architecture of the most promising 5G system.

Physical Layer Architecture of 5G TeleCommunication System

Figure 1 shows the generalized architecture of next generation wireless communication system which comprises mainly input data transmission, PN sequence generator for randomizing the input data, different diversity techniques like Time, Frequency and Space, M-Ary multi level modulation technique and 5G communication channel. This network initiated by input data transmission which may by speech signal, image signal and video signal. This input signal is given to randomizer which is initiated by Pseudo Random Number Generator that uses mathematical formulas to produce sequences of random numbers. Using a seed state, these numbers start from an arbitrary starting state. Within a short time, many numbers are generated and if starting point is known to us, it can also be reproduced later. Therefore, these numbers are deterministic, efficient and provides initial security as well.[3]

Further this randomized data is given to different inner and outer coders that are providing time diversity technique. Basically, this type of diversity technique introduces the redudency in the system and useful for the reduction in Bit Error Rate thereby increasing the overall capacity of the system as per shannon's equation C = B * log2(1+ S/N). In 5G network, randomized data is coded by means of Polar and LDPC coders.[4]

This encoded data is further given to Multy level higher order modulation technique where M represents a digit that corresponds to the number of conditions. For higer data rate, M = 256 order Quaderature Amplitude Modulation can be chosen for 5G communication. This digitally modulated data is processed with Filtered Orthogonal Frequency Divison Multiplixing (F-OFDM) which uses the concept of frequency diversity technique. In general, the basic Orthogonal Frequency Division Multiplexing technique is used to increase the throughput of modern wireless communication system while in Filtered OFDM, the frequency band can be divided into multiple sub-bands. The main advantage of creating these sub-bands is introduction of flexibale cyclic prefix. It means the subcarrier spacing in each subband is different and each subband has its own cyclic prefix (the length of each CP may vary as well) and each subband is applied by its own filter. So the flexible cyclic prefix will give more reduction in bandwidth.

Finally, these multiplexed data is processed with another key technology for achieving greater spectral efficiency which is known as massive MIMO (Multiple Input Multiple Output) technique. Massive MIMO is also characterized as large-scale MIMO in which the number of antennas at the base station is much larger than the number of devices per signaling resource. The considerable number of base station antennas relative to user devices results in huge diversity gains in spectral efficiency. Moreover, with the implementation of beam forming technique, diversity gain can be further imporved. This enhanced data is transmitted through 5G communication channel. Tapped Delay Line (TDL) and Clustered Delay Line (CDL) channels are used for better support to MIMO processing.[5]

On the receiver side, reverse analogous process would be performed by different blocks shown in Figure 1. According to above physical layer architecture, various network operator giants accorss the globe have decided to practically implement this structure with two different methodologies and meanwhile various issues have got flashed out in different different parts of the world. The following section of this paper is centred on the different issues related to implementation of 5G system with two different infrastructure techniques.

Various Issues Related to Implementation of 5G System Infrastructure Methodologies

In today's era people all over the globe have become technoholic persons that too having craving of latest technology whether its requirement or comfort. Logically any modern technology is always come with two sides like coin i.e. pro and con. Only the sense of right and wrong of human will make it boon for life. In this paper both the sides of the most emerging wireless technology i.e. of 5G is discussed

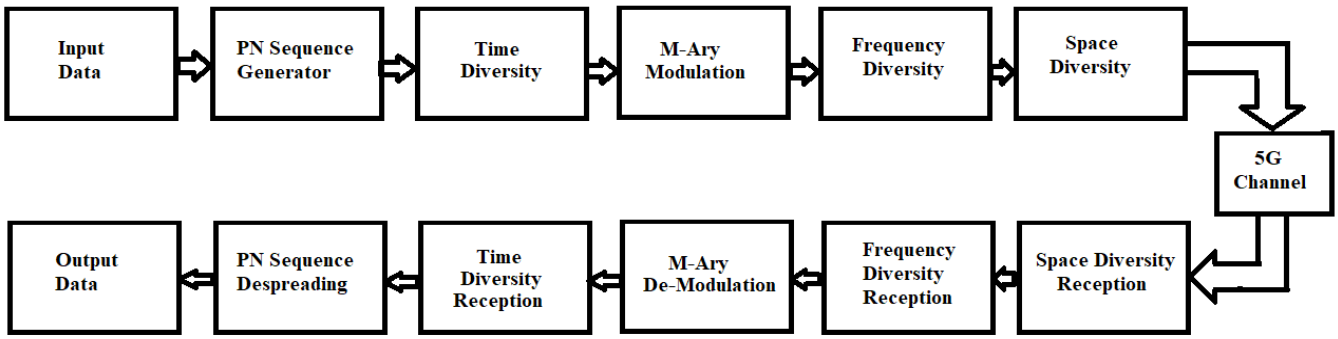

Figure 1: Basic architecture of 5G system

which is being taken into consideration according to the societal requirements and the belief for the same. Generally as per the language of layman, wireless communication and cellular communication are analogous to each other but in real sense they are not and because of this difference only, the evolution of 5G technology has got realized. 5G technology is the amalgamation of data transfer in wireless i.e. wireless technology and 1G, 2G, 3G, et.al, i.e., cellular technology. In 1st generation of mobile communication, the task was only limited to voice communication only. Then after every decade, newer generations have continuously come up as 2G for additional feature of SMS, 3G with access of netwok, and 4th generation for various application support, live video streaming and what not. But again human is not satisfied with this all, rather he/she wants more with as much as high speed as possible and that has provide platform for 5G emergence. This feature of 5G is the brighter side of innovation but as mentioned earlier that all innovation always comes with two sides, so the darker side lies within this requirement of high speed only.[6]

To avail this feature of the highest speed in latest cellular technology i.e., whether it is existing 4th Generation or the upcoming 5th Generation technology, various diversity techniques in time, frequency and space domain are utilized. Moreover, for 5G communication, high range of radio frequency band has been assigned which is of around 5.5 GHz. Now for high frequency signal transmission, power level of the signal must be increased to overcome losses encountered as high frequency signals will always get more attenuation. From this requirement only, the controversy related to 5G infrastructure and implementation has raised. The high power level of radio signal is generally hazardous to human health. So people have started to raise queries in front of cellular service providers regarding the same and initiated the first controvery against 5G implementation.[7]

As a whole, if issues regarding the 5G technology infrastructure implementation are going to be summeried then mainly there were four issues raised by different communities and/or different platforms.

1. Frequency Band Related Issues
2. 5G signal dispute with airlines
3. 5G health issues and Covid-19's Controversy
4. 5G coding controversy

These issues might have different effects according to the implementation of two proposed infrastructure methodologies through which the layout of 5G infrastructure is going to be implemented. Basically according to various analysis, 5G network is going to be laid out by mainly two infrastructure methodologies.[8,9]

1. Standalone (SA) Architecture
2. Non Stand-alone (NSA) Architecture

Figure 2 shows the two different layout arrangements of 5G architecture with respect to 4G LTE sysem. As shown in figure with respect to first column of 4G architecture, Stand Alone layout is altogether independent 5G system architecture, whereas the middle column of the figure representing Non Stand-Alone layout provides partial 5G services with the use of existing 4G infrastructure.

The SA Architecture used in the 5G network is completely new architecture from the current architecture, which will provide the 'Real 5G' experience to mobile data subscribers. Here, the Mobile Network Operators (MNOs) will establish a whole new structure to serve the new transmission and receiver network with reduced antenna size, a small coverage area compared to earlier networks, and highly increased channel bandwidth. The increased channel bandwidth will give a new insight to the subscriber in terms of internet data speed. 5G Standalone is a completely virtualized and cloud-native network (CNA) network that is utilized to expand and direct applications. It also supports advanced network-slicing functions. The 3300-3800 MHz frequency band is used for pure 5G SA Communication.

If the wireless service is provided without an end-to-end network, and so the signal travels through the same channel as the previous network system, it is known as Non-StandAlone (NSA) network. The 5G network can use the NSA system by relying on 4G LTE infrastructure instead of StandAlone architecture. However, this condition has its own merits as well as demerits. Using the NSA model, telecom service providers can give 5G a quick start as it will not require a massive and expensive infrastructure to be developed. This will imply faster outreach by 5G. But faster growth will be at the cost of its efficiency. Using the previous infrastructure, the latency will be reduced to 4G with a major increase in throughput but not up to the level 5G has promised to be. Hence, the NSA model is a good option for initial stage growth, but it is not preferred when it comes to an increased number of nodes to be connected on the same network with minimum latency. In the NSA architecture of 5G, the MNOs will slightly increase the bandwidth of the current 4G LTE network instead of giving real 5G channel bands. So, this will start the 5G at an early stage but it cannot give us a "Real 5G" experience as SA architecture is giving us.[10,11]

The succeeding session of the paper discusses the different issues that have been in the point of discussion since long along with their severities with the two infrastructure methodologies.

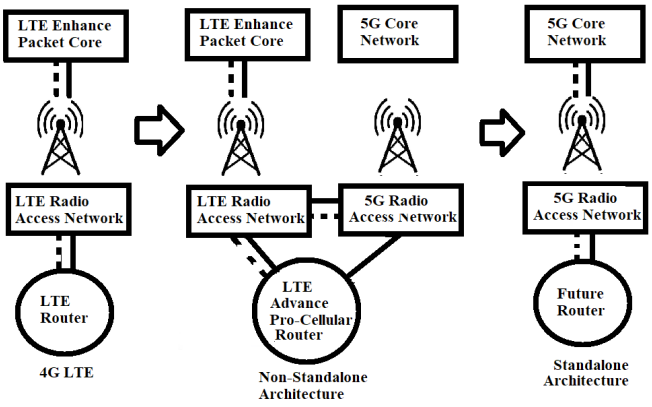

Figure 2: Layout of SA and NSA architecture

Frequency Band Related Issues

At the inception of 5G network designing only, various organizations and/or industries of different countries were always in dilemma regarding the choice of frequency. From the starting itself, multiple frequency bands with comparatively large gap in between were proposed by different industries and were kept into implementation. Initially 3.2 GHz to 4.2 GHz range was proposed for 5G implementation wherein some of the countries have selected lower range whereas the others have chosen higher range to satisfy high speed demand but due to there might be the chances of intereference of this band with the other already existing applications' band. So this has come up with one of the prominent issues.

Moreover, as 5G infrastructures have been thought of being implemented with two different options i.e. SA and NSA, that itself is carrying frequency band differencies. In Stand Alone implementation, as discussed in previous topic, frequency band range is from 3.3 GHz to 3.8 GHz whereas in Non Stand-Alone architecture, the MNOs are going to maximize the efficiency of existing 4G networks by imparting 5G experience from them with extended range of frequency. NSA 5G NR will be operated with new frequency ranges:

- Range 1 from 0.4GHz to 6 GHz - extended with 4G LTE frequencies.
- Range 2 from 24 GHz to 52 GHz - mm-Wave band.

So lot many options i.e. choices of frequency range are available that itself may create interference or overlapping related issues in the implementation which may require adaptation of sharp filter or re-identification of frequency band.[12-14]

5G Signal Dispute with Airlines

The frequency band set by the Federal Communications Commission (FCC) for 5G starts at 5.5 GHz. Almost all countries have limited 5G band to 3.7GHz. But the desire for faster service is that the superpower has selected the band of 3.7GHz to 3.98GHz for 5G and the last frequency of the band i.e. 3.98GHz seems to be mixed with the starting frequency of the radio altimeter of the airlines i.e. 4.2GHz (Figure 3). The question also arises as to why there is a possibility of mixing even though the two frequencies are different. The answer is filters and harmonics. The filters used to start and end any frequency band are not really sharp enough to transmit only the frequency of the band we have defined and stop all other frequencies except that. Thus, due to the limitation of the actual filter, the last frequency of the 5G band in the US, i.e. 3.98GHz, transmits harmonics of its next frequency. But if the power level of the signal is low then it has no effect. Now if the signal power of 5G is kept high to get more coverage then the signal frequency of both 5G and radio altimeter can be mixed. In airlines, radio altimeters are used to measure the height of an object from C level and it operates in the 4.2 to 4.4 GHz frequency band. The speed of a plane depends on its height and when landing at a certain altitude its speed has to be reduced at landing. Now if the signal strength of the 5G tower in the vicinity of the airport is high then the 5G signal starts mixing with the radio altimeter signal and it becomes very difficult for the pilot to distinguish the radio altimeter signal from the 5G signal or in some cases the radio altimeter shows the same error. In such circumstances, there is a possibility of an accident during the flight landing. And that's why the FAA, the Federal Aviation Administration, has warned American mobile operators AT&T (American Telephone and Telegraph) and Verizon to come up with an immediate solution to prevent the 5G tower's signal from mixing with the radio altimeter.

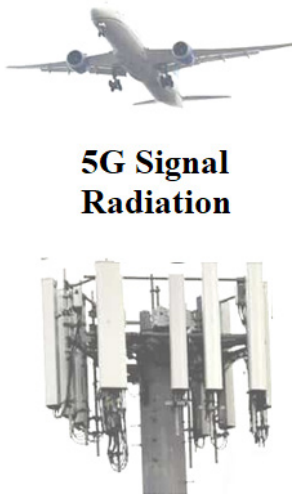

Figure 3: Radiataion interference of 5G signals with airline signals

Solution: People want fast cellular service and also safe airlines. Both the mobile operators have agreed to reduce the power level of the 5G tower near the airport for the immediate solution of this problem as the service equipment for the fixed frequency band has not been ready yet. But for the long term solution, a filter will be fitted with a radio altimeter that can isolate the frequency of the mobile tower. Because 6G technology is still coming.

Further this issue may be prominent as still there are two choices for the service providers to move with Stand Alone infrastructure option or Non Stand Alone infrastructure.

5G Health Issues and Covid-19's Controversy

Two years back in the year 2020, 5G techonology plans have been come across the challenges from medical field also wherein in United Kingdom, some of the inciedances of attacking and damaging the 5G cellular towers were appeared. Some of the rumours related to health hazard and short term immunity loss that may invite Corona (Covid-19) have got flooded like any thing so the people were being aggravated to oppose the upcoming technology by damaging the infrasture related to it. In spreading of such rumours, the main element was the high power requirement of 5G radio signals at high frequencies.[15,16] As per some the medical facts

Figure 4: Health Hazards due to 5G

and findings, people were convinced that such a large power level radiation may cause damanging of tissues and/or cells of body (Figure 4). But by the time researchers and cellular service providers have conveyed that the speed and coverage enhancement will be achieved by the basic technologies used in the implementation of 5G system such as beam forming[17-20] by keeping power level within standard limits only.

Further in view of infrastructure type, for Non Stand Alone architecture, the above mentioned beam forming aspect might not be possible as here 5G system is going to be implemented by using modified 4G infrastructure. Stand Alone option will surely elemenate this issue with the use of beam forming.

5G Coding Controversy

Basically, any modern cellular sytem architecture is going to be studied, for example as shown in figure 2, i.e. 5G system architecture, it can be seen that along with modulator, multiplexer and diversity mechanism, one most important block is also available which coder. Speed and capacity of wireless system are highly affected by coding techniques used in the physical layer of cellular system.

At the desgining stage of 5G system, during the discussion forum inititated by 3GPP (Third Generation Partnership Project) and International Telecommunication Union (ITU), the two super powers China and US have proposed two different coding techniques for 5G technology that had raised the big controversy.

The Chinese company Huawei introduced the Polar Code for 5G. Huawei has hired a scientist for Polar code; Dr. Erdal also presented the award to Erican. According to a Chinese vendor, A research paper on Polar Code published by Dr. Erdal Erican in 2006 has opened up many new avenues for data-rate and system reliability, and the inclusion of Polar Code in 5G will provide better bandwidth and best service quality with zero error. . Interestingly, at exactly the same time, the United States giant Qualcomm announced that the LDPC Code i.e. low density parity check code will be more useful for 5G technology. This is where the 5G coding controversy started - between the most dominant companies in China and the United States.[21]

At that time to sort out the issue, 3GPP had inititated polling among the technical members. But one would be surprised to know that since both the coding techniques are very powerful, voters also gave equal importance to both the techniques and did not even decide which technique to use in 5G. 3GPP finally decided that both coding would be used in 5G to satisfy both the international parties i.e. LDPC for data channel in 5G and Polar code will be used for the control channel.

Again NSA infrastructure might not be able to provide this coding related capacity and speed enhancement as it uses altogether different coding techniques whereas with SA infrastructure, one can expect the above mentioned advantages.

Conclusion

- This article discusses various issues related to application of multiple frequency bands, health hazards, interference among already existing radio wave applications as well as choice of security algorithms which may arises while practical deployment of 5G cellular system.
- Along with this, paper also includes the two different architecture approaches of 5G structure realization that is Stand Alone architecture and Non Stand Alone architecture and impact of above mentioned issues in both.

References

[1] Open Signal (2021). Understanding the mobile experience on T-Mobile's standalone 5G network." [online]:https://www.opensignal.com/2021/02/18/understanding-the-mobile-experience-on-t-mobiles-standalone-5g network.
[2] Pekka Pirinen (2014). A Brief Overview of 5G Research Activities. IEEE 1st International Conference on 5G for Ubiquitous Connectivity.
[3] Qualcomm. 5G Mobile mmWave Technology Evolution. [online]: https://www.qualcomm.com/videos/5g-mobile-mmwave-technology-evolution
[4] Mahadik S, Patil S, Powar S. (2022). Implementation of Global System for Mobile Communication-Based Smart Weather Monitoring System for Agricultural Environment. https://smsjournals.com/index.php/SAMRIDDHI/article/view/1969.
[5] Open Access Source : Search - MATLAB & Simulink (mathworks.com)
[6] D. Gomez-Barquero *et al*. (2019). 5G for Broadband Multimedia Systems and Broadcasting. *IEEE Transactions on Broadcasting*, vol. 65, no. 2, (351-355), doi: 10.1109/TBC.2019.2914866.
[7] Michal Chage. (2021) 5G Technology Trends to Look at in. Articalbase.com

[8] Ericsson.com. Non-standalone and Standalone: two standards-based paths to 5G. (2019). https://www.ericsson. com/en/blog/2019/7/standalone-and-non-standalone-5g-nr two-5g-tracks
[9] Standalone (SA) and Non-Standalone (NSA) 5G Architectures: The various paths to 5G revenues and profitability. https://www.affirmednetworks.com/sa-and-nsa-5g architectures-the-path-to-profitability
[10] Standalone (SA) and Non-Standalone (NSA) 5G Architectures: The various paths to 5G revenues and profitability.ailable at : https://www.affirmednetworks.com/sa-and-nsa-5g-architectures-the-path-to-profitability/
[11] What Are Standalone And Non-Standalone 5G Networks? https://commsbrief.com/what-are- standalone-sa-and-non-standalone-nsa-5g-nr-mobile- networks/
[12] Open Signal. Understanding the mobile experience on T-Mobile's standalone 5G network. https://www.opensignal.com/2021/02/18/understanding-the-mobile-experience-on-t-mobiles-standalone-5g-network
[13] OPPO. 5G SA versus 5G NSA: What's the Difference? https://support.oppo.com/ in/ answer/?aid=neu11996
[14] MasaudShah, Hammad M. Cheema. SIW Antenna for 5G In-Band Full Duplex Applications. (2020). IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting
[15] Bharghava P, Muthusamy P. MIMO Antenna for 5G Applications with Polarization Diversity. (2019). https://smsjournals.
[16] Sedani, B. S., Kotak, N. A., & Borisagar, K. R. (2021). Critical Review on Effect of 5G Technology on Covid-19 and Human Health Issues. *Journal of Scientific Research*, *13*(2), 695–705. https://doi.org/10.3329/jsr.v13i2.49514
[17] Avnet Abacus. 5G beamforming: an engineer's overview. https://www.avnet.com/wps/portal/abacus/solutions/markets/communications/5g-solutions/5g- beamforming/
[18] What is 5G beamforming, beam steering, and beam switching with massive MIMO. https:// www.metaswitch.com/knowledge-center/reference/what-is-beamforming-beam-steering-and-beam-switching-with- assive-mimo
[19] 5G Technology World. The basics of 5G's modulation, OFDM. https://www.5gtechnologyworld.com/the-basics-of-5gs-modulation-ofdm
[20] Concepts of Orthogonal Frequency Division Multiplexing (OFDM) and 802.11 WLAN. https://rfmw. em.keysight.com//wireless/helpfiles/89600B/WebHelp/Subsys- tems/wlan-ofdm/Content/ofdm_basicprinciplesoverview.htm
[21] RCR Wireless News: Intelligence on all things wireless. https://www.rcrwireless.com/20160815/fundamentals/mmwave-5g-tag31-tag99