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Possibilities of 5G Implementation in India and Challenges: A Review

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Abstract
This paper describes about the 5G implementation in India and its chal- lenges. 5G is a new generation of cellular technology that aims to pro-vide high-speed, low-latency, and highly reliable communication services. It has three main use cases: enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC), and Ultra-Reliable Low-Latency Communications (UR-LLC). Despite the benefits 5G offers, there are several challenges to its implementation in India, such as lack of regulatory bodies, insufficient fiber infrastructure, poor last-mile connectivity, and complicated Right of Way regulations. To address these challenges, India needs to invest in fiber infrastructure and improve its regulatory framework.

Keywords: *eMBB, mMTC, UR-LLC*

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I. INTRODUCTION

5G cellular technology is used to achieve seamless coverage, high data rates, minimal latency, and highly dependable communications. Addition- ally, it aids in improving other systems' energy, spectrum, network, and otherefficiency levels. Along with offering features like faster and more depend- able access, it also serves as a conduit for information, connecting billions of Internet of Things (IoT) devices. New mobile communication network capabilities have been investigated using 5G technology. It permits the de- livery of higher quality video services with mobility and business automationat rapid speeds using billions of linked devices. Additionally, it allows for the delivery of vital services like telesurgery and autonomous vehicles on networks that are low latency and extremely dependable, and it helps to increase productivity with the use of high-quality, real-time data.analytics. The same network will be able to customise its requirements for each of these various use cases thanks to the 5G network, which was not possible with earlier generations [1].Enhanced Mobile BroadBand (eMBB), Ultra-Reliable Low-Latency Communications (URLLC), and Massive Machine-Type Com- munications (mMTC) are the three categories into which the services offered by the fifth generation (5G) wireless networks can be separated.[2].We will discussed it in specification of 5G from Fig. 1

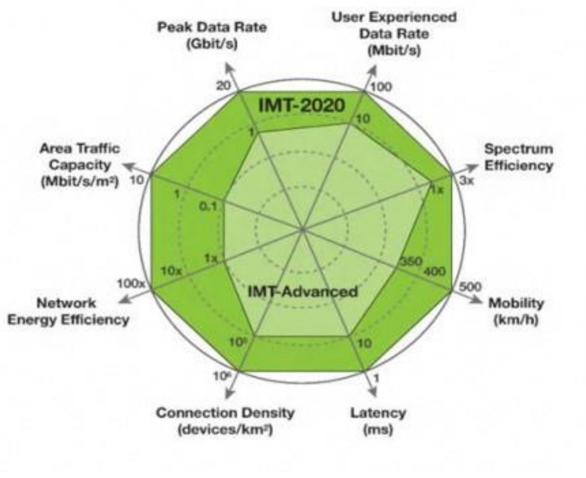

Figure 1: Comparison of design targets between 4G & 5G (Source: ITU)

II. NEED OF 5G

The rigorous service and network requirements of 5G will necessitate a significant rethink of the fundamental architecture. By just modernising the existing Long Term Evolution (LTE) core, it won't be possible to support all anticipated 5G use cases. The advantages of the new generation (NG) core include network information (NF) with various modulations, virtualiza- tion, service-based architecture, and separation of the control plane and user plane. Mobility management and session management are decoupled as part of it. from Fig. 2[1]:

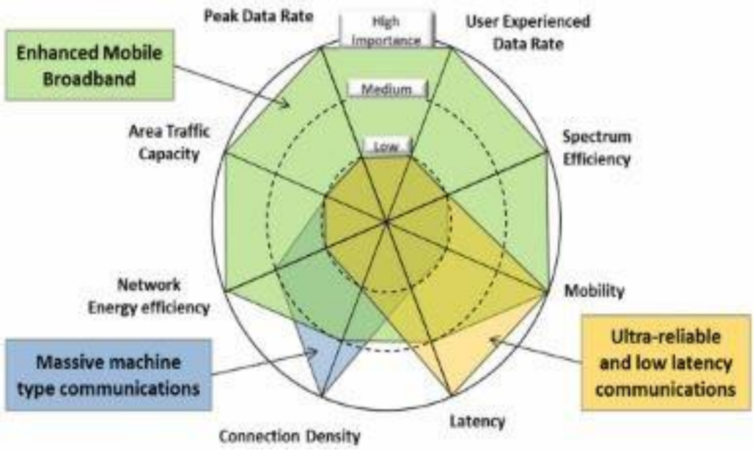

Figure 2: Key performance requirements in different usage scenario (Source: ITU)

III. TECHNICAL SPECIFICATION OF 5G

eMBB, mMTC, and UR-LLC are the three categories into which 5Guse cases can be divided.

eMBB : It addresses the use cases for data-driven multi-media material, information, and services. In addition to the present Mobile Internet apps, this utilisation situation also includes novel applications like 3600 Ultra-High Definition (UHD) video streaming, actual gaming, virtual reality, mobile cloud computing, video monitoring, etc. New specifications like hotspots and large distance connectivity are also included.[1]. One could consider the 4G broadband service to be a simple expansion of eMBB traffic. Massive overweights and a consistent, long-term device activation pattern are two characteristics. Since no multiple eMBB devices can use the same wireless resource concurrently, the network can schedule wireless resources accord- ingly. With a packet error rate (PER) of roughly 10^3, the eMBB service aims to boost data flow while maintaining minimal reliability. [3].

UR-LLC : The requirements for this use case are quite rigorous in termsof throughput, latency, and availability. Important communications will be transmitted with its assistance. Examples include the use of wireless control in corporate production processes, remote health care operations, automa- tion of transmission in a smart grid, transportation security, driverless cars, etc. [1] Last but not least, URLLC broadcasts are also irregular, but signifi- cantly fewer URLLC transmitters are possible than mMTC transmitters. A mix of planning and random access must be employed in order to support high dependability and irregular the URLLC broadcasts. Despite the short block lengths, URLLC transfer rate is quite slow, and a high level of relia- bility is the main need, with a PER frequently less than 10^5[3].

mMTC :In the mMTC use case, a very large number of linked devices are fre- quently sending a little amount of non-delay-sensitive information. Devices must be reasonably priced and have a lengthy battery life. IoT applications are covered by this use case. Wearable health monitors, smart homes, smartcities with smart grids, and smart transportation are a few examples. In contrast, a mMTC device employs a set, frequently poor transfer speed in the uplink and is rarely active.[1]. Although several mMTC gadgets may be connected to one base station (BS), only a few of them are operational and actively attempting to send data at any given time. The vast amount of po- tentially operational mMTC gadgets makes it impossible to commit resourcesto specific mMTC devices in advance. It is necessary to provide resources that can be shared via random access. The mMTC traffic arrival rate is represented by the average size of the current subgroup of mMTC gadgets, which is a random variable. The goal in the design of mMTC is to maximise the arrival rate supported by a given radio resource. The intended PER for a single mMTC transfer is frequently low, for instance, on the order of 10^1 [3].

Multicast vs unicast: eMBB sections use multicast transfer of information, whereas URLLC sections continue to use unicast transfer of information.[2].
The eMBB section seeks large bandwidth, whereas the URLLC section seekslow packet loss rate.[2].
Shannon's capacity vs finite blocklength capacity: Shannon's capacity can capture the best opportunity of an eMBB section, whereas the equivalents of a URLLC section is limited by countable block length ability because ofthe low payload.[2].

IV. NETWORK ARCHITECTURE OF 5G

Circuit switched speech services are offered through the Global System for Mobile Communications (GSM). Although at very slow data speeds, circuit switched modem connections could potentially be used for data services. The initial step towards an Internet Protocol (IP) based packet switching solution was the transfer from GSM to General Packet Radio Service (GPRS), employing the same air interface and connection technique. In order to obtain faster data speeds, Wideband Code Division Multiple Access (WCDMA), a new access method, was developed for the Universal Mobile Terrestrial System (UMTS). The UMTS access network mimics circuit switched and packet switched connections for phone and data services, respectively. In UMTS, the circuit switched core was still necessary for paging for incoming data services.To solve this shortcoming, the IP-based Evolved Packet System (EPS) was developed..from Fig. 3[1]

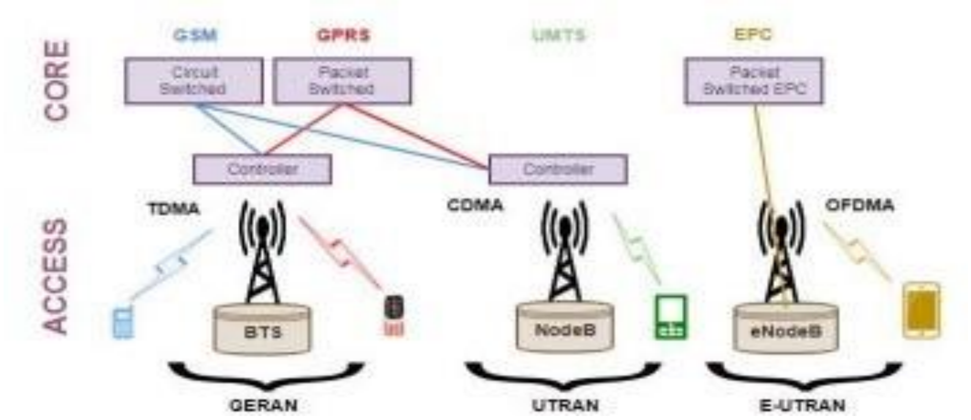

Figure 3: Network Architecture of evolution of GSM to LTE (Source: 3GPP)

1) Supporting the new business domains with network slicing

1.1) Network slicing allows business clients to get connections and data pro-cessing that are specially tailored to their requirements and that abide by a Service Level Agreement (SLA) set up with the operator. A few of the network's adaptable features include data rate, QoS, latency, dependability, privacy, services, and billing.[1].

1.2) In order to implement this notion, an operator would put up several vir-tual slices of the RAN, core, and transport networksfrom Fig. 4 on top ofthe same physical infrastructure.The providers could implement both a spe-cific network slice kind that caters to the demands of different verticals and number of network slices of diverse types that are combined into one product and marketed to corporate clients with a variety of requirements.[1]

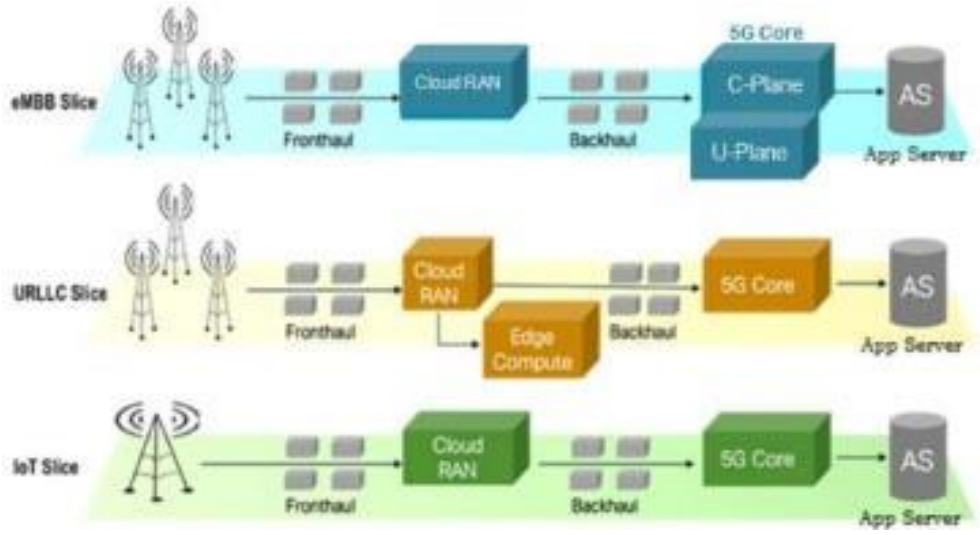

Figure 4: Network Slicing

1.3) Network Slicing offers a platform that is industry vertically optimised and efficiently satisfies the unique needs and business requirements of each vertical.According to the GSMA, the industries with the most potential for implementing network slicing include those in the government, entertainment and media, finance, smart city, customer, automobile, logistics, corporate in-ternet, and healthcare & welfare.[1].

1.4) A fully private system, a clone of a public system to test a new ser- vice that is exclusively utilised for that service can all be created via network slicing. The network creates a private system in the form of a network slice, which can be an end-to-end practically isolated component of the public sys- tem, while exposing a set of features in terms of latency, availability, band- width, etc. Because the slice owner will perceive the network connection as their own network, complete with transport nodes, processing, and storage, they will be able to manage a newly created slice locally. A slice might get a mix of widely spread and centralised resources. Applications are simply run, and data is stored by the slice owner from his or her management centre either remotely, in a dispersed management platform, or a mixture of both.[1].

2) 5G RAN

2.1) Due to the escalating needs for latency, traffic volume, data speeds, and reliable connectivity, mobile network capabilities are advancing quickly. In order to effectively address future needs, the LTE RAN design needs to offerenhanced resource merging, volume scaling, multilayer working, and spec- trum efficiency over a variety of transit system configurations. Cloud RAN architectures from Fig. 5 meet these requirements by utilising NFV tech- niques, data centre computing resources, and improved radio synchronization for scattered as well as centralised RAN installations.[1].

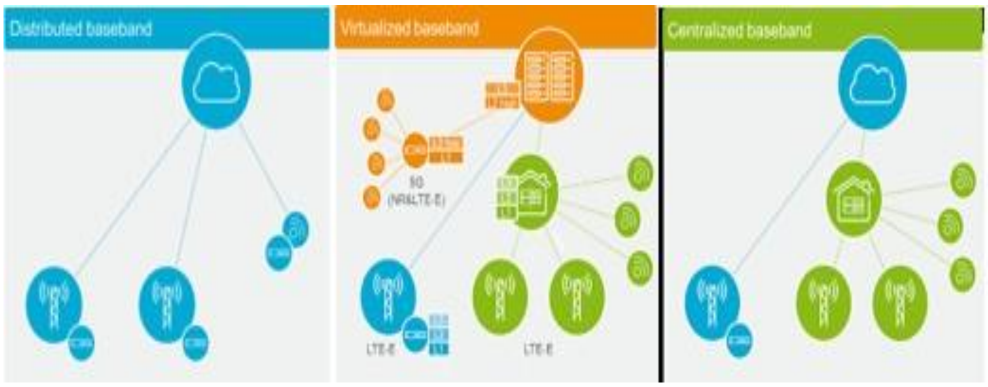

Figure 5: RAN Architecture(Source: Ericsson)

2.2) Distributed RAN18 (DRAN):The radio site acts as the connection point between the RAN and core network system in the DRAN architecture. The majority of LTE networks now only employ a dispersed baseband implemen- tation. DRAN architecture provides rapid adoption, simplicity in deploy- ment, and IP-based networking as a standard[1].

2.3) Centralized RAN(CRAN): According to the CRAN architecture, all base- band processing, including that for the RAN L1, L2, and L3 protocol levels, is done centrally and is accessible by numerous distributed radio sites. The transmission lines connect the central baseband units with the distributed radio units via Common Public Radio Interface (CPRI) fronthaul across specialised fibre or microwave networks. The CPRI fronthaul demands high bandwidths and low latency. Its primary application is to improve perfor- mance in extremely congested urban environments[1].

2.4) Virtualized RAN (VRAN):The virtualized RAN design facilitates coor- dination and centralization in mobile networks by utilising NFV techniques and data centre processing capabilities. It allows layer interworking, resource pooling, scalability, and strong mobility.Parts of the baseband process can be virtualized, which increases network flexibility by making it easier to growcapacity, introduce other services, and modify the network. The operators would be able to customise the networks to meet customer needs ranging from automated industrial machine control to dense urban, high eMBB band- width applications because to the greater adaptability of this split design. Both DRAN and CRAN networks can use VRAN[1].

3) 5G NR RAN interfaces:For the new 5G RAN structure, which includes the split structure, additional interfaces have been specified. The new fronthaul connection eCPRI, which is packetized, has taken the role of the CPRI to improve bandwidth efficiency and simplify deployment. The new IP-based connection between the Centralized Unit (CU) and Distributed Unit (DU) processing centers in VRAN needs lower latency for maximum performance,just like the traditional S1 backhaul link. S1/NG backhaul will preservemost of the characteristics of the current S1 backhaul, but with increased capacity.[1].

4) Transportation Network of 5G

4.1) Connection between equipment and/or devices at distant places is pro- vided via the transport domain. Fronthaul is the term used to describe the connection between the BS antennas and either a centrally located baseband (BB) unit or a distant incorporated radio frequency (RF) unit. Backhaul connects a base station (BS) to an access system or a control centre, for example, serving both ends of the transmission. The transport domain may also offer different consumer-facing connectivity options, such as a Layer 2 or Layer 3 VPN, in addition to providing bulk connections for the fronthaul and backhaul of the operator’s mobile network.[1].

4.2) Due to 5G RAN technology, transport networks now need to adhere to new criteria for both latency and bandwidth. It will therefore be neces- sary to automate and coordinate heavily both inside and between network domains. A concept known as RAN Transport Interaction (RTI), which provides network-wide improvement and service guarantee unites the radio, transportation, and packet infrastructure layer of a mobile operator’s net- work. A few instances of this collaboration includes-
Support for extending network resource distinction within the transport network to diverse industries
RAN load balancing with transport awareness and proactive congestion con- trol for better use Quality of Experience (QoE)
Ensuring equality among radio technologies within the transportation network[1].

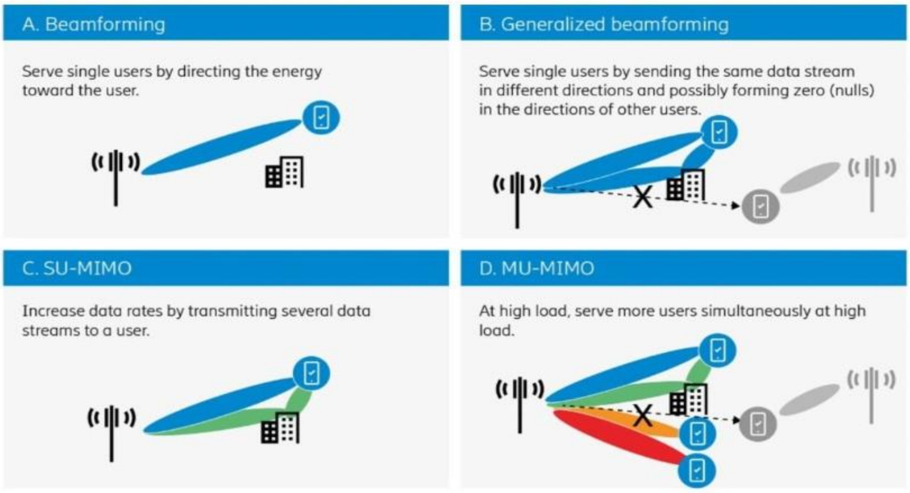

Figure 6: Beamforming and MIMO (Source: Ericsson)

5) MIMO and beamforming solution for5G

5.1) Due to recent technology developments, advanced antenna systems (AAS) are now a workable substitute for large-scale deployments in both the present 4G and future cellular networks. AAS enables contemporary beamforming and MIMO techniques, which are useful tools for boosting customer experi- ence, volume, and coverage. from Fig. 6. Both the uplink and the downlink network performance are greatly improved[1].

5.2When broadcasting several information streams using the same frequency and time resource, MIMO has the capacity to beamform each data stream. Beamforming is the ability to guide radio energy through the radio channel to concentrate it on a specific receiver. By changing the transmitted signals' phase and amplitude, it is possible to add appropriate signals to the UE receiver constructively. This increases the received signal strength and, as a result, the throughput for end users. Applying AAS features to an AAS radio results in noticeable performance gains because of the higher degrees of freedom provided by the additional radio chains, often known as MassiveMIMO.[1].

5.3)Large frequencies are necessary for 5G to deliver high data rates, how- ever these frequencies have unfriendly propagation. The use of cutting-edge antennas is crucial in overcoming the difficult propagation circumstances atthese frequencies.[1].

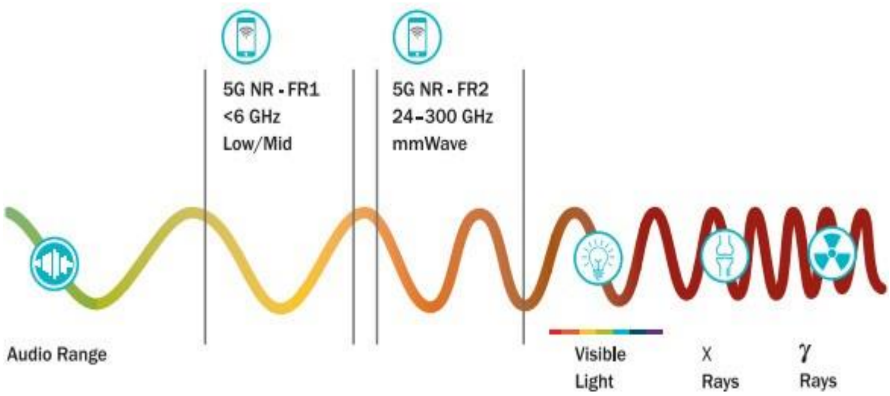

Figure 7: 5G Frequency Spectrum

V. SPECTRUM OF 5G

For the air interface of 5G networks, a new international standard called5G New Radio(NR) has been proposed by the Third Generation Partnership Project (3GPP), an umbrella group of top telecoms standards development organisations. There are two frequency groups under 5G NR:Frequency range 24GHz (FR1), with a minimum channel bandwidth of 50 MHz and a maxi- mum of 400 MHz. For information on the 5G frequency spectrum in relationto audible sound and visible light, from Fig. 7[4]

VI. CHALLENGES FOR IMPLIMANTATION OF 5G

A. Lack of Regulatory bodies in telecom sector of India:- : from the devel- opment of broadband during the last ten years. The opportunity to develop a unified broadband plan for the nation was greatly missed by the Indian telecom industry. It appears that India won't be able to build 5G anytime soon due to the lack of regulatory organisations. India's economic growth will be 13.8% faster if 5G is implemented, according to a World Bank estimate. India's telecom industry is significantly impacted by procedural delays and their numerous problems, in addition to a shortage of policymakers. Busi- nesses that lost money in the 2G spectrum fraud have obviously taught other telecom businesses not to fund any future projects in India.The introductionof 5G in India won't be a reality until there is a suitable regulatory body that will create the country's 5G road map [5].

B. India lacks in Fibre Infrastructure :-Any new generation of network imple- mentation depends heavily on optical fibre.The significance of fibre is crucial for the launch of 5G in India. It is crucial in providing more data capacity and enhancing voice call quality. India's poor service quality and call drop problems are caused by a lack of fibre infrastructure, which points to the na-tion's inadequate investment in backhaul and fibre infrastructureIn contrastto countries like the US, China, and Korea that place more of an emphasis on creating regulations that prioritise the development of fibre, just 20% of towers in India are backhauled, as compared to 80% in those countries.. A new research claims that India only deploys 15 million kilometres of fibre annually, well short of the current requirement of at least 50 kilometres.[5].

C. Last mile Connectivity:-India's lack of fibre infrastructure also has an im- pact on last-mile connectivity.In rural India, a project called NOFN wasstarted to improve last-mile connectivity among all 2, 50,000 Gram Panchay-ats. Only a few Gram Panchayats were connected after two years despite the fact that three telecom companies were appointed in the ratio of 70:15:15.

The adoption of 5G is still only a distant dream for India, sadly, due to inadequate last-mile connectivity in rural areas and inconsistent networking performance. 5G calls for network and speed upgrades[5].

D. Low speed of Data :-India's expensive rates and slow data speeds are another major barrier to the country's adoption of 5G. With 6.5 mbps as its average internet speed, India is now ranked 89th out of 147 countries. The current data speed provided by Indian companies varies, es- pecially in rural areas. High data speed is needed for downloading huge files,such as HD videos and games, but it is not always available in India. Dueto a lack of fibre infrastructure and last mile connectivity, India's average internet speed is only 6.5 mbps, which is less than the 1 TBPS required for 5G[5].

E.Right of Way (RoW) and the absence of a consistent legal framework:- Oneof the most divisive topics in the industry has always been the current regula- tory framework for establishing network infrastructure. Telecommunications service providers have experienced delays in the deployment of optical fibre cables (OFC) and telecom towers as a result of complicated state-by-state procedures, non-uniform levies, and administrative approvals. Although new RoW regulations and standardised procedures with appropriate fees were im- plemented in 2016, implementation has been delayed by obstacles.The devel- opment of considerable infrastructure is projected to be required by network densification in the future, as demonstrated by 5G use cases; although, any delays or irregularities throughout the RoW security process may further cause complex development and longer building timeframes.[6].

F.Limited giga-backhauling to accommodate future needs:- A robust back- haul network is a crucial prerequisite for 5G technology to deliver on its promises of high throughput and low latency. Less than 25% of the telecom sites in India are connected via the 1.5 million km of installed fibre.India ranks significantly lower than a number of other countries in the ICT Devel- opment and Global Connectivity Index, so it needs to speed up its digital transformations through the use of technology enablers like broadband net- works in conjunction with data centres, big data, cloud, and the Internet of Things. However, expanding the footprint of fibre and connecting 77–80% oftower assets in significant urban centres will require an estimated investment of USD 8 billion over a protracted, capital-intensive project. Furthermore, even though BharatNet faced its own set of difficulties during installation, the government continues to push for broadband connectivity in rural areas. It is essential that these initiatives are accelerated in order to create the necessary backhaul infrastructure for 5G. Additionally, India is yet to adopt cost-effective options like microwave backhauling based on the E-band and V-band, which is legal everywhere for ultra-high capacity gigabit backhaul- ing. Due to their relatively rapid deployment times and low cost, they could help the industry take the necessary steps to develop 5G networks[6].

G. Industry is being crippled by margin pressure:- Although the investment in 5G will increase gradually as improvements to current 4G/LTE technol- ogy.It is estimated that the industry may need an additional investment of USD 60 to 70 billion to successfully develop 5G networks due to the demandfor 5G spectrum and network densification. In the face of such rising debt levels and sector consolidation activity, it is thought that the telecommuni- cations are constrained in their capacity to undertake capital investments.[6].

H. The modernization and densification of networks will be challenging:-Dueto the relatively shorter and more fragile mid frequency band (under 6 GHz band), a more densely packed small cell network architecture would be re- quired for better throughput and performance across 5G networks. In this regard, it will be necessary to strengthen ”inbuilding” solutions using fixed wireless solutions, as well as to disperse and deploy small radio cells in big numbers onto street furniture like bus shelters, posts, lamp, traffic signals, etc. Small cell-based network densification using 4G network backhaul is yetnot done on a significant scale. Given the current 4G network coverage, it might be challenging to develop commercial 5G use cases over 4G networksin the near future.[6].

I. Enhancing the security apparatus through the use of emerging technologies:- Security and privacy protection are likely to face new issues as a result of the emergence of new business architecture which is evolving over 5G networks.As industries are predicted to prosper thanks to 5G and the cloud environ- ment, this is predicted to result in the promotion of a vast array of networked devices. One of the important factors in enabling linked industries will be the development of a new trust model that is protected by business continuity. Cyber attacks are becoming more frequent and sophisticated all around the world as internet usage and digital connectivity rise. According to estimates, such attacks might cost the world economy up to US$ 575 billion annually, or 1% of yearly GDP.The Global Cyber Security Index, a report releasedin 2017 by the UN’s International Telecommunication Union (ITU), also re- vealed that only around half of all nations had cybersecurity plans or were in the process of building one.. India was ranked 23rd on the index, which was headed by Singapore with 0.925. In order to define and direct actions connected to cyber security, National Cyber Security Policy of India for 2013 was developed. Proposed measures include building an assurance framework, improving legislation, and advancing research and education. Although the policy was warmly accepted, an effective implementation structure would encourage industry adoption.Currently, as India attempts to achieve com- mercial viability across 5G-based networks and is on the verge of undergoinga digital revolution, regulatory framework must be put in place well in ad- vance to protect and propel the linked ecosystem that would emerge in placeof 5G[6].

J.Cons[4]:-
Massive capital expenditure required for new installations.
Larger scale of infrastructure deployment due to small cells.
Greater operational and maintenance costs.
Limited coverage area due to shorter reach of the signal.
Susceptible to atmospheric absorption and blocking through material.
Need new 5G capable devices.
Interference with more applications in the same frequency.
New security and privacy issues.

K.Given that small cell operations in India would necessitate the construc-tion of numerous additional new towers, this problem will become even more critical. In India, telecom providers are required to install mobile towers on private property in densely populated regions, particularly in cities. Due to objections from the locals, it had been challenging for them to construct towers near hospitals, schools, and residential areas during 3G and 4G in-stallations. State governments have provided standards for the installations, while local municipal organisations do not grant authorization or delay them severely. To reduce opposition, the DoT at the Central Government level has been raising information about the primary fear factor associated with EMF radiation through an online portal, publications, and seminars.[4]

L.Revenue modelling:- Maximizing a RAN operator's revenue, which includesboth long-term and short-term revenue, is the goal of request admission. The parameters in the slice request indicate the long-term revenue, which remains constant over a wide time window. The beamformers in each short time slotspan influence the short-term revenue, which may vary from slot to slot due to variations in wireless channels.[2].As per the suggestion of author of[2; 3; 7; 8; 9] recent research has begun to examine how URLLC and eMBB can coexist in the same physical network. which propose using multiple eMBB and URLLC slices in C-RAN to maximise operator revenue, which includes both short-term revenue and long-term revenue, and to meet both inter-slice constraints (such as total system bandwidth) and intra-slice con- straints (such as quality of service (QoS) to each user) requirements. These studies fail to address the problem of revenue maximisation that a RAN op- erator encounters when dealing with numerous network slice requests.

M.Network slicing:- The main idea behind network slicing is to conceptually isolate network services and resources that are designed to meet particu- lar requirements of a shared infrastructure [3]. This article investigates the cost-effectiveness of splitting the shared RAN for eMBB and URLLC service multiplexing.[10].
RAN slicing is anticipated to be completed in a timescale of minutes to hoursin order to keep up with the rate of slicing surface layers. However, compared to the length of a slice operation, wireless channel changes happen far more quickly, on the order of milliseconds. As a result, solving the problem of the two timescales is challenging. Inter-slice interference isolation: Finding away to isolate inter-slice interference is difficult since different types of slices(eMBB slices and URLLC slices in this research) share the same physical channel in a RAN slicing system. Total utility maximisation is challenging because different types of slices in a RAN slicing system use the same radio resources. As a result, it is challenging to effectively coordinate resources for different types of slices in order to maximise the utility of the entire system.. To address the aforementioned difficult issues, a C-RAN slicing architecture for eMBB and URLLC service multiplexing was developed. To address the two timescales issue, it first used an alternating direction method of mul- tipliers (ADMM) [11] in conjunction with a sample average approximation (SAA) technique[12] to simplify the two timescales problem into multiple single timescale problems. Then, to orthogonalize diverse slices to isolated interslices, a flexible frequency division duplex (FDD) technique was used.

Finally, it created a generic utility framework that maximised the total utility of eMBB and URLLC service multiplexing by admitting eMBB and URLLC slice requests efficiently[13].

VII. CONCLUSION

This paper gives a rough idea about what and how 5G technology worksits requirement as well as specification includes eMBB, mMTC, and UR- LLC Implementation is one of the aspects on which this paper is focused and all the possible challenges coming up with it such as lack of regulatory bodies, insufficient fiber infrastructure, poor last-mile connectivity, and com- plicated Right of Way regulations. To overcome these challenges, India must invest in fiber infrastructure and streamline its regulatory framework. Withthe proper implementation, 5G has the potential to revolutionize communi- cation services in India and bring about new opportunities for growth andinnovation.

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