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Fifth Generation Technology in India

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Abstract: In terms of total internet users, India is the world's second largest market. With the increasing demand for high speed data in India, current 3rd Generation and 4th Generation technology would be unable to fulfill the users' internet demand. This requires the construction of the next network generation called the 5th Generation Network. The upgrade to the 4G network is 5G, which is the 5th Generation of mobile wireless communication technology. 5G promises lower latency, quicker speeds, and more load capacity by utilizing shorter, higher-frequency radio spectrum bands. The methodology used in the paper would be deductive and the problems faced in 5G deployment across various countries where 5G is already deployed and have similar infrastructure as that of India would be studied. The paper will include a thorough examination for the possible obstacles to 5G deployment in India and a discussion of its future scope and implementations as well as solutions to the issues that are preventing 5G deployment.

Keywords: 5th Generation, 5G in India, Barriers to 5G deployment, Future prospects of 5G, Wireless communication.

I. Introduction

A. About 5G Technology

The Fifth Generation of telecom networks that is 5G network is a big development in today's fourth generation long term Evolution networks. The Fifth Generation network is constructed to full fill today's digital society's large growth in data and communication, billions of mobile smartphones, the Internet of Things and tomorrow's technologies. Fifth Generation would first run in combination with existing Fourth Generation networks, until developing as entirely standalone networks in future take-off and service extension.

Fifth Generation technology can be used in these three major areas:

Machine to Machine Communications on a Large Scale: Often Internet of Things (IoT), which includes linking of machines without human interference on a size not seen before which is in billions. This means it has the power to revolutionize current industrial systems and technologies, including business communications, engineering and agricultural practices.

Ultra-Reliable Low Latency Communications (URLLC): Critical missions which include real-time computer management, industrial automation, coordination between vehicles and autonomous vehicles, safety systems, and transport networks that are safe. Low latency networks are now opening up a new setting where medical services, diagnosis and treatments are all achievable.

Improved Mobile Broadband: Provide considerably higher data speeds and greater ability to make the planet a better place to live. New applications would include fixed wireless Internet coverage for households, radio applications without the need of broadcast applications, and improved mobility for people on the move. For communities, Fifth Generation would make it easier to attach billions of devices to our smart cities, smart schools and smart houses, smart and safe cars, boost health care and education, and have a better and more efficient place to live [1].

B. Areas of Implementation

Following are some of the major areas where Fifth Generation can be implemented and can be used as a successful business model:

Intelligent Energy Distribution with Fifth Generation: Traditionally, energy providers have developed one-way networks, starting with electricity generation, followed by direct delivery of power to homes and businesses. Today, they generate electricity from highly diverse sources, including renewables. Renewable electricity often comes from private entities and businesses who feed their self-generated electricity from the edges of the network. In addition, new trends of energy use are evolving as the amount and type of energy-consuming technology, such as electric cars, increase.

*Critical IoT Automation Applications in Smart Factories***:** With modern cellular networking requirements, virtually any asset can be linked and operated in a factory to overcome operational challenges. In order to be competitive, producers are finding consistency in production and the opportunity to produce a wider variety of personalized goods [2]. This ensures that

operating processes and production lines must be integrated and adaptable to allow quick design changes and to minimize lead times, without sacrificing protection or efficiency.

Smart Offices with Fifth Generation and IoT: Enterprises need to connect, track and manageall devices from a transparent, unified and intuitive interface in their local, regional or global Internet of Things ecosystem. Internet of Things Connectivity Management which is a part of the IoT Accelerator, provides enterprises with access to many of suppliers of telecommunications providers while encouraging them to change their operations online.

Increasing Driving Safety: Telematics is about technology and equipment that combine telecoms with vehicle information - in other words, it is the driver, the monitoring centre, or thepublic safety administrator who communicates data from or about the vehicle to a different source. They will be one of the primary benefactors of Fifth Generation technology since it will allow these sensors to communicate more data faster than ever before. These sensors contribute to the development of a C-V2X framework, which allows cars to interact with one another, other drivers, and monitoring stations. This information allows automobiles to be spatially oriented on the road, which is crucial for improving popular safety features like automatic braking, blind spot recognition, and potentially autonomous driving.

Enabling Next-Generation Public Safety Networks: In any emergency situation, immediate, effective and secure contact is essential to facilitating and maintaining efficient emergency operations. Respondents such as emergency medical service staff, fire fighters or police officers need to be able to rely on quick and safe access to save their life. In order to satisfy these demands, national security departments are gradually moving to mobile solutions because of the functionality offered by Fifth Generation - such as safe and speedy sharing of data, images and video [3].

C. Rationale

In order to allow a wide range of applications and services, including driverless vehicles, tele-surgery, and real-time data analytics, the Fifth Generation is expected to be the cornerstone of emerging technologies such as the Internet of Things and computer networking. The ULL that is Ultra-Low Latency given by Fifth Generation technology makes it ideal for these applications. Latency is the amount of time taken to travel between source and destination.

A panel on Fifth Generation claims that innovations will expand the use – for the first time – of cellular devices across entirely new markets, ranging from the manufacturing to the trade, education, health care, and agriculture, social and financial sector.

It also stresses that even after the Fifth Generation connection to the Indian network, mobile technology (2^{nd} generation, 3^{rd} generation and 4^{th} generation) will continue to be used and it may take ten years to phase it out.

Fifth Generation's importance for India is generally agreed, because of the lower rate of physical infrastructure spending, to be much greater than in industrialized countries. Fifth Generation according to the government panel, can offer 'leapfrog' opportunities by providing 'intelligent infrastructure' which offers lower cost and faster infrastructure delivery. Of the many key applications of Fifth Generation one would be the introducing a sensor-incorporated system allowing the actual time delivery of data in areas which include development, market sustainability and agriculture. Fifth Generation will also add to the quality of transport networks by rendering it intelligent. Fifth Generation would allow connectivity between automobiles and vehicles, including the realization of driverless cars.

II. Literature Review

Deployment of Fifth Generation Networks Challenges for Developing Countries [4]: This paper addresses the challenges of the Fifth Generation deployment in India, examines its possible reach, implementations, on-going contrasts of networks and challenges of the Fifth Generation implementation in developed countries. Network transmission has progressed over a span of time, starting with First Generation in the 1980s, the Fourth Generation networks have been developed and work is being undertaken to deploy Fifth Generation infrastructure standards so far, Fourth Generation is yet to be established through the globe. In spite of this, progress on implementation of emerging technology has begun, as Fourth Generation is demonstrating to be inadequate to satisfy the common demand for an extremely dense network.Thus to address such problems, introduction of Fifth Generation technology is taking place as itoffers, high-speed data, reduce delay, save resources, videos can be downloaded without compromising their efficiency. This paper poses the complexities of introducing Fifth Generation in India and discusses its potential reach, implementations, ongoing network comparisons as well as challenges in implementing 5^{th} generation in a developing country.

Towards Frugal Fifth Generation: A Case Study of Palghar Test-Bed in India [5]: The transition from the Fourth Generation network to Fifth Generation Telecommunications Standard continues. Satisfying the connectivity needs of rural areas is only a remote hope in the midst of this transformation. This research elucidates the criteria for networking in rural areas and outlines a network architecture based on these requirements as well. Low mobility, low power and wide cells remain main aspects of the broadband network architecture for rural areas. The frugal Fifth Generation network is referred to as this network in rural areas. The paper discusses 2 test beds that on the basis of the frugal Fifth Generation network architecture, have been deployed in India.

Problems in Implementing Fifth Generation in India [6]: With a rising appetite for fast speed of data in India and an increase in the number of customers over the last 10 years, the new Third and Fourth Generation technologies would not be able to fulfill

the internet needs of users. The creation of the next generation of the network called the 5th generation of the network is also important. This paper provides a detailed report on the issues faced in the deployment of Fifth Generation in India, address its potential reach, its implementations and suggest solutions to the factors causing problems in the implementation of Fifth Generation.

A Review on Activities of Fifth Generation Mobile Communication System [7]: In 2020 the Fifth Generation of mobile connectivity will be introduced in several countries with the goal of providing a true wireless environment free from the existing limitations in the communication infrastructure, which is a big driving force for all researchers, academics and engineers. Work is moving around the world to create a new platform that will play a very significant role in the successful rollout of Fifth Generation. New technologies are being explored that have high speed, power, spectral quality, energy efficiency, pseudo-outdoor communication, etc. that address current problems in the mobile communication system. A detailed research on key technology, barriers, spectrum distribution, projects and existing Fifth Generation scenarios is addressed and outlined in this work. The present thesis offers extensive analysis to resolve the problems and trends relevant to the implementation of Fifth Generation.

Fifth Generation Mobile Services and Scenarios: Challenges and Solutions [8]: It is projected that the Fifth Generation network (Fifth Generation) will support a large number of data traffic and wireless connections. Various traffic data have various requirements for qualityof service (QoS). The Fifth Generation based mobile network is intended to address the limitations of previous cellular standards (i.e. 2G/3G/Fourth Generation). Fifth Generation networks support a wide variety of applications including intelligent homes, self- contained driving, drone operations, critical health and mission applications, Industrial IoT (IIoT), entertainment and multimedia. According to the experience gained by end users, several Fifth Generation services are divided into Fifth Generation immersion, Fifth Generation intelligent, omnipresent, Fifth Generation autonomous and Fifth Generation services. A short overview of Fifth Generation technical scenarios is provided in this paper.

Barricades in Network Transformation from 4G to 5G in India [9]: In the sphere of technology and communications, the next significant development in the world is the 5th generation or 5G technology, which should be operational worldwide by 2020. Although it willlead to numerous changes in the world, it will connect millions of heterogeneous things, provide high speed internet and use real-time data for real-time analytics, such as road and automotive sensor coordination. The nomenclature of these groups was studied through thorough research and secondary sources.

III. Methodology

The Literature Review included a description of the evolution of mobile communications, technologies involved in the Fifth Generation mobile networks, and a discussion of some of the challenges that various countries have faced, as well as potential roadblocks that India may facein successfully implementing 5G networks.

The gap identified after the literature review is that many hindrances have been found regarding the implementation of the Fifth Generation technology in India, but the solutions to those problems have been understudies. Seeing the current need for high speed data, people are willing to have Fifth Generation network in India. But unlike Fourth Generation which is still not implemented all over India, Fifth Generation networks need a better roll out plan.

Investigation needs to be done in this area.

It can be seen from the previous section that there are only a few academic materials on the actual impediments to 5G installation in India. As a result, this study might be viewed as an attempt to close this gap.

During the development of the Research Design, theory development is very significant. It has something to do with how a research study's findings and conclusions are presented. The following are three major techniques to theory development:

Deductive Method: This approach is employed when the research begins with a theory derived from previous academic literatures, and a research strategy is then devised to test the theory.

Inductive Method: This approach is employed when the research begins with data collection in order to investigate a phenomenon, resulting in the development of a theory in the form of a conceptual framework.

Abdicative Method: This system is applied when data is gathered to investigate a find themes, phenomenon, and explain patterns in order to develop a new theory or change an existing one, and then test it with further data.

This research study uses a deductive approach, in which the researcher develops the theory by researching past and recent literatures about the barriers to 5G technology in other countries, and then uses that information to determine the barriers in India. Finally, potential solutions have been presented.

IV. Findings Problems in Implementation of 5G in India

When we look at the current state of mobile networks in India, we can see that serving hotspot areas has always been a

major difficulty for service providers since India first entered the cellular wireless communications market. Because India has such a large population, hotspot zones are tightly packed with both old structures and potential subscribers. This creates an issue in terms of locating an adequate number of suitable installation sites. The main issue emerges when users roam in groups, increasing the capacity demand at each location. It is projected that as technology advances from 2G to 4G and then to 5G, the per subscriber capacity allocation would increase dramatically. The issues that have been identified are as follows:

Absence of Supervisory Bodies in India's Telecom Sector

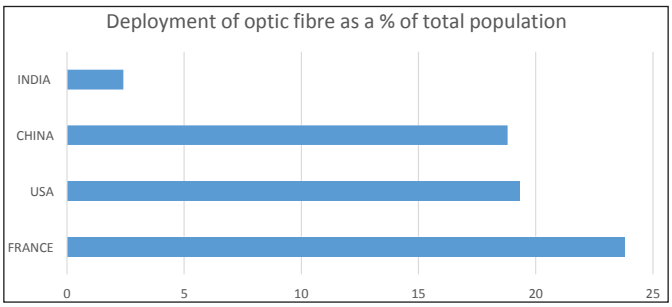
Since the Broadband development in the past ten years, India's telecommunications sector has failed to develop a regular broadband strategy for India. 5G Technology needs an adequate implementation approach and this seems unlikely for India to accomplish in the coming future due to the lack in the regulatory organizations [10]. The approval of 5G Technology in India will boost India's economic development by 13.9 percent, the World Bank reports say. Besides the absence of politicians, proceeding delays and the many problems of India's telecom sector are substantially harmed. Companies facing loss in the 2G spectrum scandal clearly showed that other telecommunications firms cannot invest in India in future projects.

Lack of Fibre Infrastructure in India

Optical fibre has a significant part for building every new network generation. The function of fibre is highly significant for the development of 5G in India. It plays a significant function in increasing data capacity and improving the quality of voice calling. Because the fibre infrastructure is lacking, India suffers poor service quality, and calls for drops are a sign of low fibre investment and backhaul infrastructure investments by the country. The focus is on developing a policy that puts importance to fibre deployments only Twenty percent of towers in India are backhauled compared with Eighty percent in nations such as the U.S., Korea and China. India deploys only 15 million miles of fibre per annum on average, compared with the present requirement of at least 50 km each year, according to a recent report [11].

The lack in fibre is partly owing to the lack of a shared city duct infrastructure across multiple participants. Currently, local governments charge the full cost of road surface restoration every time a current fibre operator either lays new fibre or has to access the fibre in the case of a break. As a result of this condition, it is incredibly difficult for any player to lay in-city fibre.

Furthermore, because multiple companies are digging the roads without the necessary coordination, this causes a great deal of trouble for all city inhabitants.



According to the aforesaid research, one of the main problems that India confronts in its ambition of taking the massive leap from 4G to 5G is the availability or accessibility of the correct spectrum, as well as the cost of it, according to several researchers.

Problems in Last Mile Connectivity

Since Fibre infrastructure in India is not adequate, the last-mile connectivity has also been hindered. NOFN has been launched as a project to increase the final connectivity of 250,000 gram panchayats in rural India. Three telecom companies have been awarded work with a ratio of 70:15:15 however only limited Gram panchayats have been linked after two years.

5G requires both network upgrade as well as speed but is regrettably still a huge dream for India due to the absence of last-mile connectivity in the rural parts has a lack of consistency in 5G networking performance.

India's large population lacks access to inexpensive 5G devices. Consumers would not be able to purchase affordable 5G phones even if 5G network connectivity becomes available. The majority of existing gadgets will be incompatible with 5G, necessitating the purchase of new ones, which will be costly.

High Data Rates and Low Data Speeds

High Data Rates and Low Data Speeds are also a big challenge in India when it comes to 5G implementation. India currently ranks in average internet speed of 6.5 mbp/s at 89th out of 147 nations. The current rate of data given by firms in India, particularly in rural areas, is not steady. High data speed games that are not evenly available in India are necessary to upload huge size files such as HD videos. The data rate requirement is 1 TBPS for 5G, but, because of the lack of fibre infrastructure and last-mile connection, India has 6.5 mbp/s average Internet speed which is not at all good as compared to the global standards [12].

Country	Auction determined price (in Cr/MHz)	Spectrum Price in India is x times the price in other countries		
		In Absolute Terms	Basic Spectrum Price/ Population/ GDP per capita	Basic Spectrum Price/ Population/ ARPU
Italy	182	3	2	1
UK	70	7	6	3
Australia	35	14	6	3
Spain	14	35	16	12
Austria	7	70	10	3
India	492	1	1	1

V. Discussion

A. Possible Solutions

5G Investments Ought to be Ahead of the Curve: Unlike 4G, where cases were developed as the technology was deployed and adopted, 5G requires a large number of use cases to be established well ahead of time before it can be made publicly available. Therefore, 5G networks should not only be constructed to give great speeds, but also the proper amount of experience these applications demand.

Digital push, as a result of a pandemic, has increased the number of critical cases requiring extreme latency, for example remote treatment, remote sales and operations or mobile banking. All cases require high bandwidth access, such as e-classroom service, remote working and telemedicine, all of which exchange high video volumes. Every case of use has a particular network need. Furthermore, 5G would need to have a far larger fibre grid reach than its predecessor. It is even more necessary for networks to provide seamless 5G experience by spending their money where spectrum, equipment and fibre are to be purchased.

More Collaboration is Needed to Eliminate Digital Inequality: To succeed, 5G would need omnipresent coverage. If it were only possible in some urban centres, nothing but hotspots would be created that do not provide real-life 5G usage scenarios outlined above. Imagine a village patient trying to talk to a city doctor about a video call. The network, the app and the content delivery network (CDN) must all function together to ensure that both sides have the correct experience. These efforts are arduous, with the regulators, local authorities, TSOs, OEMs, CDN suppliers and apps having to work closely together.

When 5G was added, edge data centres, which required the high degree of cooperation between operators and CDNs, would become a frequent item. In order to provide content smoothly, appswould need to be ready and cooperate with both operators and CDNs. And regulators need to make sure that regulations are implemented at the proper moment to prevent government approvals from becoming a bottleneck. Digital inequality is removed when everyone collaborates.

Experience-Focused Testing Could Improve Success Rate: In terms of spectrum selections, a lotof success is determined by picking the correct architecture and deployment tactics. And it is a highly suggested and agile method to test their deployment to guarantee that they develop networks. This test should not just be a quality check in 4G, but should be a thorough measurement of the network, app, and device user experience. Operators can benefit from experiential testing in their entire deployment strategy to test the performance of their networks when commercial traffic is opened. If this were to be achieved they would be able to solve problems before consumers are discovered and so enhance the success rate of constructing a 5G network that the industry and the people need.

B. Applications of 5G

The quality and interactivity of 5G technology will improve, which should encourage widespread use. Virtual reality, for example, will be valuable to train and for long distance conferences. Technicians would be able to mediate using augmented reality spectacles all because of the remote aid of engineers who would instruct them through the procedures.

These types of equipment would reduce travel cost and increase workplace protection. OB Services is previously working on these applications through co-innovation stages. One more innovation is the use of digital twins to conduct exams without causing damage to the equipment. When utilised to optimise prototypes, these copies can save you a lot of money [13].

Industry 4.0 and 5G Technology

Industry 4.0, according to the majority of observers, will be one of the 1st major implementations of 5G dedicated services. In this industry, customers already have expressed high prospects. But, the objective isn't just to link a workplace to the internet; it is also about to change the current business prototypes, processes and also the production line, among other things. In

environments where autonomous humans, robots and machines all work together, densification of linked things and real-time data analysis will be critical.

5G will speed up processing, analysis, and decision-making by transferring data at unimaginable speeds to local edge computing centres. Beyond connectivity, it's about facilitating transformation so that businesses can fully use 5G's promise.

5G Technology and Sales

5th Generation Technology would also allow for extremely precise order management. If an issue occurs at the production work, instant feedback would automatically rework and calculate the production schedule. After that it would notify the client of a probable late delivery. It would also be feasible to incorporate networking directly in the device. It would be able to interface with AI and provide analytical maintenance in this way. It will be viable to utilise a hologram to instruct applications remotely, teaching the user precisely to use that product. In all of the above scenarios, 5G actually offers a whole different world of opportunities.

5G and Transport

Another major aspect of 5G is the growing number of connected automobiles. New applications could be created using communication between infrastructure (traffic, roads, signals and traffic lights) and vehicles as well as other road users (cyclists, pedestrians, etc.) and to enhance traffic flow and reduce accident rates. For transportation experts, 5G will improve operational efficiency [14]. When ships, trains, and aircraft dock, land, or arrive at a station, the capacity to transfer a significant quantity of stuff in almost real-time would allow them to swiftly recover predictive maintenance data and navigation information and share refueling.

5G and Important Communications

It would be feasible to allow a wide variety of vital information in the future so as to protect people, processes and goods. Enterprise security applications would benefit from 5G by enabling linked security teams to respond to emergencies in real-time. Until fibre is widely deployed, 5G will increase fixed network performance.

The Tactile Internet and 5G

Tactile Internet is basically having an article in my control, such as tactile gloves, that one maywork on to operate another thing from a different place with real-time feeling, just as the distant thing was in my hand itself. It is all because of the cameras and sensors connected via the 5G Technology, people are able to manage a vehicle in another country from their own location.

Managing remote things is widespread: robotics, drones, working in dangerous environments, homecare and much more. This means that high performance linked objects are available and high-speed, low-latency data transmission from end to end is required. This is essential.

Integrating the Internet tactile into a company could significantly improve workstation and increase employee safety [15].

SECTOR	PROJECTED EMPLOYMENT CHANGE WITHOUT 5G, 2019-2034 (THOUSANDS)	JOBS CREATED BY 5G (THOUSANDS)
Agriculture	61	43
Construction	1,257	228
Utilities	-26	14
Manufacturing	-944	309
Transportation and Warehousing	493	157
Educational Services (public and private)	852	399
Healthcare and social assistance	5,417	706
Government (not including education)	20	290

VI. Conclusion

By conducting this research, I have studied the difficulties, solutions, applications and the extent of the 5G rollout in India. The challenges of 5G technology implementation in India are the subject of this study. After analysing the data, the issues discovered can be divided into three categories: spectrum-related challenges, last mile connectivity challenge, fibre infrastructure-related challenges, and affordable 5G device-related challenges. In the literature review portion, these

categories were examined in further depth. Many research have been undertaken on the 5G network and the Evolution of Mobile Communication over generations, however there are very few academic resources accessible on the Challenges for 5G Implementation in India, which the current paper addresses. Furthermore, the largest obstacle for 5G in India has been identified as the lack of fibre infrastructure. 5G will elevate India's current network infrastructure to new heights, helping it to boost India's level of economic performance and helping it to improve its Internet speed ranking. India will only receive 5G if the government removes the current issues with the rollout of 5G.

VII. Future Scope

The current study can serve as a solid foundation for any future research on this subject. The issues raised here can be studied and analysed in depth on an individual basis and further research work can be carried. In addition, a comparable study might be undertaken for other countries with similar infrastructure to India in order to draw comparisons.

References

[1] J. Thompson, X. Ge, H. C. Wu, R. Irmer, H. Jiang, G. Fettweis, and S. Alamouti, "5G wireless communication systems: Prospects and challenges," *IEEE Commun. Mag.*, vol. 52, no. 2, pp. 62-64, 2014.

[2] S. Patil, V. Patil, and P. Bhat, "A review on 5G technology," *Int. J. Eng. Innovative Technol. (IJEIT),* vol. 1, no. 1, pp. 26-30, 2012.

[3] C. Felita, and M. Suryanegara, "5G key technologies: Identifying innovation opportunity," in *2013 International Conference on QiR (Quality in Research),* 2013, pp. 235-238.

[4] S. Indoria, "Deployment of fifth generation networks challenges for developing countries," 2020, doi: 10.1007/978-981-15-0630-7_25. [Online]. Available: www.scopus.com

[5] M. Khaturia, J. Singh, A. Patil, S. B. Belur, A. Karandikar, P. Chaporkar, and T. Ghadge, "Towards frugal fifth generation: A case study of Palghar test-bed in India," Paper Presented at the *2019 IEEE Wireless Communications and Networking Conference Workshop, WCNCW 2019*, Jan. 2019, doi: 10.1109/WCNCW.2019.8902530. [Online]. Available: www.scopus.com

[6] S. Sharma, "Problems in implementing fifth generation in India and solutions for it," *International Journal of Management and Applied Science*, vol. 4, no. 5, pp. 78-82, 2018.

[7] Y. B. Zikria, S. W. Kim, M. K. Afzal, H. Wang, and M. H. Rehmani, "5G mobile services and scenarios: Challenges and solutions," *Sustainability*, vol. 10, no. 10, p. 3626, 2018, MDPI AG. doi: http://dx.doi.org/10.3390/su10103626.

[8] A. Kumar, and M. Gupta, "A review on activities of fifth generation mobile communication system," *Alexandria Engineering Journal*, vol. 57, no. 2, pp. 1125-1135, 2018, doi: https://doi.org/10.1016/j.aej.2017.01.043.

[9] M. K. Pandey, A. Gaurav, and V. Kumar, "Social, technical and economical challenges of fifth generation technology in Indian prospective: Still fourth generation auction not over, but time to think about fifth generation in India," in *2015 International Conference on Computer and Computational Sciences (ICCCS),* IEEE, Jan. 2015, pp. 157-162.

[10] S. Puri, R. S. Rai, and K. Saxena, "Barricades in network transformation from 4G to 5G in India," *2018 7th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO),* 2018, pp. 695-702, doi: 10.1109/ICRITO.2018.8748303.

[11] O. Nyarko-Boateng, F. Xedagbui, A. Adekoya, and B. Weyori, "Fiber optic deployment challenges and their management in a developing country: A tutorial and case study in Ghana," *Engineering Reports*, vol. 2, e12121, 2020, doi: 10.1002/eng2.12121.

[12] https://economictimes.indiatimes.com/industry/telecom/telecom- news/telcos-to-defer-5g-rollout-for-5-years-as-prices-too- high/articleshow/72233242.cms

[13] A. Y. Ding, and M. Janssen, "Opportunities for applications using 5G networks: Requirements, challenges, and outlook," *Proceedings of the Seventh International Conference on Telecommunications and Remote Sensing (ICTRS'18),* 2018, pp. 27-34, doi: 10.1145/3278161.3278166.

[14] https:// www.thehindu.com/business/how-will-a-Fifth Generation-network-power-the- future/article27698653.ece

[15] https://www.progressivepolicy.org/publication/the-third-wave-how-5g-will-drive-job-growth-over-the-next-fifteen-year

[16] Q. Qiu, S. Liu, S. Xu, and S. Yu, "Study on security and privacy in 5G-enabled applications," *Wireless Communications and Mobile Computing*, vol. 2020, Art. id 8856683, doi: https://doi.org/10.1155/2020/8856683.