Scientific Journal of Impact Factor (SJIF): 5.71

E-ISSN (O): 2348-4470
P-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 8,Issue 10,Octoberr2021

OPERATIONS RESEARCH IN TELECOMMUNICATION

Aadarsh Kataria[1], Aadit Pillai[2], Aagam Chokshi[3], Aahana Albert[4], Aarnav Mundra[5]

[1,2,3,4,5]*SYBBA, NMIMS, ASMSOC, Mumbai Campus*

ABSTRACT: Telecommunications is essentially the exchange of information over distances via various technologies. It refers to all types of data, including text, voice, and video transmissions. In an industry teeming with potential and over 5 billion people having access to the network, competition is rife, and it becomes necessary to ensure that every customer has their needs catered to in an efficient and optimized manner. For such massive amounts of data to be transmitted instantly with no logistical issues is no mean feat, and this paper discusses the role of OR in streamlining the process. A considerable amount of research papers, articles, journals, and case studies were analyzed and discussed to properly understand and explain the usage of OR in this field. Essentially, this paper aims to bring to light how big of a role Operations Research has played in shaping the telecommunications industry and how it will continue to do so for the foreseeable future.

I. INTRODUCTION

Telecommunication is the transmission of information by different types of technologies like wire, radio, and other such electromagnetic means. The telecom sector includes companies that provide services and infrastructure required to transmit signals, messages, and data. Telecommunication systems have advanced majorly from the earlier times, it is an extremely volatile, competitive, and ever-growing industry. (What is the Telecommunications Industry?, n.d.) the telecommunication industry is a truly global one, it is present on every continent on earth, including remote corners like Antarctica. The global spending on telecom services is expected to reach 1.595 trillion US dollars by 2024. (O'Dea, 2021). The shift in customer inclination towards new-generation technologies and smartphones, increasing number of mobile subscribers and demand for high-speed data connectivity are the main drivers fueling the growth of this industry. (Global Telecom Services Market Size Report, 2021-2028, 2021)

Operations research is a specialized branch of mathematics and statistics and is closely related to computer sciences. It is an analytical method to solve problems and arrive at decisions. OR is very useful in the management of organizations (Lewis, n.d.). Telecommunications plays a very important role in today's world and global communication network is without doubt one of the most prominent areas for technological advancement. With innovation and growth comes a scope for improvement and several hurdles to be overcome. Just like any industry the telecom industry also has several problems some of which can be solved with the help of operations research.

There are several research studies which focus on the application of various OR techniques in the field of telecommunication, some of the popular ones include linear and integer programming, optimization of routing and scheduling, queuing and many more (Košir & Trnkoczy, 2010). In (Machado & Gassenferth, 2014) there is proof of linear programming being used to increase profitability of telecom service providers in the midst of hyper-competition in said industry in brazil. There are many other such research papers which address the application of

OR in the telecommunication industry. Though a couple of issues presented by the telecom industry has been solved with the help of OR techniques, it was identified that there was still scope for more solutions to be found. With this paper we identify two more major issues faced by the telecom industry which must be solved at the earliest i.e., the Urban-Rural divide and problems in Complex Operational Services like billing, remote working, etc.

As undergraduate students studying a subject like operation research in an era of ever-advancing telecom services we felt that this topic would be ideal to research on. We wished to add further knowledge to the existing sea of information on the said topic. We also wanted to focus on the implications of the same and hope to throw light on certain problems which would make it easier for industry experts to identify and solve at the earliest.

II. LITERATURE REVIEW

"OPERATIONS RESEARCH IN TELECOMMUNICATIONS – WHY AND HOW?"

The telecommunication industry is rapidly growing in size and scope. Now telecommunications is crucial for its basic purpose and is an essential part of everyday life. In the era of digitalization, an appropriate telecommunication network is a key to economic development (Gomez-Barroso & Marben-Flores, 2020).

It is telecom related problems that came to be the motivation factor behind the study of various operation research methodologies in the initial stages. For example, routing and dimensioning problems led to the research of OR methods like shortest path, network flows, linear and non-linear optimization, etc. The need to improve performance of telephone systems contributed to extensive research towards the queueing systems. And there are many more such telecom related problems that contributed to the development of OR methodologies. (Gavish, 1995)

In (Samarakkody, 2019) we can identify some issues faced by the telecommunication industry. They can mainly be classified as competition from OTT messaging platforms such as WhatsApp, Twitter, etc; Decrease in Voice revenue; Cost incurred to upgrade to new technology; Development of 5G; increase in costs as the services being provided are increasing in complexity.

The structure of the telecommunication industry has been compared to a road traffic system where communication channels represent roads and network devices represent the vehicles. Therefore it seems very obvious to use operations research methods to solve problems that arise in the telecom sector. There are a variety of methodologies used for optimizing the telecommunication systems, the choice depends on the goal to be attained. The most common and widely accepted techniques are the mathematical programming techniques like linear and integer programming. Optimization of routing and scheduling, queuing and other such techniques are also used. After the solution is implemented in the real world, the "feasibility test" is conducted which involves using simulators that provide a significant improvement in the optimization cycle, thus we deduce that OR methods are appropriate to solve large scale telecommunication issues. (Košir & Trnkoczy, 2010)

The literature in the field of operations research is replete with its contribution to the telecommunications industry. Operations research techniques have helped organizations in the important area of cost reduction and location optimization (Shetty, Shah, Banka, Mehta, & Shah, 2019). Widespread adoption of OR techniques in finance, manufacturing, energy, and telecommunications has facilitated the fast pace of technology advancement (Košir & Trnkoczy, 2010).

(Košir & Trnkoczy, 2010) also argued that other than optimizing cost and location, OR techniques successfully maximize customer satisfaction with minimum resources. The present literature on the topic has mainly emphasized the following impacts of OR in telecommunications. First, the OR techniques provide detailed analysis of the system

and, thus, deal with the system's complexity. Not only this, it makes the system more predictable. Second, it helps in solving typical process problems. For instance, encryption protocol (Cortés, 2012), real-time network operations and wireless and mobile communications (Cortés & Muñuzuri, 2008). Lastly, it helps discover new techniques that can help expand the scope of telecommunications (Dye, Stougie, & Tomasgard, 2003).

Model building is an important tool for analysing, built, implement and improvise the telecommunications system (Košir & Trnkoczy, 2010). For model building, OR methodologies have supported telecommunications for a long time by providing numerous theories, such as probability and statistics, optimization, simulations, etc. The most relevant issue faced by telecommunications companies is effective data management (Cortés, 2012).

An operations research approach to solve communication system problems is ideal as it helps to prevent unwanted ambiguities from entering the main issue and moving the focus from the same. It enables engineers working on such communication systems to focus their attention on the problem, solution and application of solution to the system in the real world as well. (Harris, Hauptschein, & Schwartz, 1958)

The telecommunication industry is going through major changes and is evolving rapidly. Telecommunications is a vast field that shows continuous changes and has ample opportunities to explore. Over the last couple of years the growth of this industry has increased rapidly, and with the changing and evolving needs of the customers of this industry, which seems to be majority of the population there are constant updates being made to the current telecom systems. As we know, with constant changes come new hurdles that need to be overcome. Therefore it is imperative to use operations research to solve some of these problems that arise and, that OR as a field adapt to the changing industry's needs quickly.

III. METHODOLOGY

In the analysis, we have taken up two problems regarding telecommunications which we all face in our daily life. The first problem is "The Urban-Rural Divide" which exists till date, and the second problem was related to "Complex Operational Services". The data used in both the problems was secondary. The first problem is based on quantitative data while the second problem is based on qualitative data. After in-depth research from various sources, the data in the first problem was taken from a press release from a very trusted source, which is Telecom Regulatory Authority of India (TRAI). We compared the data of urban users with the rural users and how much it has progressed from 2014 to 2019. The numbers have improved over the years but still not enough. Even now India is very far from getting rid of this urban-rural divide. The second problem was stated after doing a thorough research from a number of research papers, articles, journals, sites etc. We read about all the operational services and chose the ones which were creating the problems. Subsequently, we stated the solutions that we found useful and that would help solve the problem in the best possible way. A lot of ideas for these solutions was taken from research done by group members.

IV. ANALYSIS AND FINDING

THE URBAN-RURAL DIVIDE

The evolution of the telecommunications industry has started with the rise of mobile telephony (Gupta, 2015). However, the growth rate has slowed down and the transition to data has now begun. The telecommunications industry in India has gone through various phases of change as mobile service providers realize that the revenues from voice services will not be sufficient to meet the increasing demands for data. This is evidenced by the rapid rise of data revenues.

There were several problems faced by the telecommunications industry since the beginning and most of them were resolved. This problem (The urban rural divide) is one of the most prominent problem which has been going on from quite a considerable amount of time. The following table consists data as per June 2020.

Table 1 : Telecom Subscribers

Telecom Subscribers (Wireless + Wireline)	
Total Subscribers	1,160.52 Million
% change over the previous quarter	-1.48%
Urban Subscribers	636.83 Million
Rural Subscribers	523.69 Million
Market share of Private Operators	88.55%
Market share of PSU Operators	11.45%
Tele-density	85.85
Urban Tele-density	137.35
Rural Tele-density	58.96
Wireless Subscribers	

Source: ("Indian Telecom Services Performance Indicator Report" for the Quarter ending July-September, 2019, 2020)

This table shows us the current situation of telecommunication in India. The total population of India as of 2020 is 1379 million out of which there are 1160.52 million subscribers. If we look at these numbers, they are quite good for a developing country like India but if we go in detail, you will be shocked. Out of 1379 million people only 481 million people live in urban households and 898 million people live in rural households. That's almost 70% of the total population. As we can see that only 524 million subscribers are there in rural areas out of 898 million which is only 58% of the total while in urban it is oversubscribed by 35%. We can conclude that urban people have more than one or two connections in their house while in rural people are struggling for even one telecom connection. This divide has now existed for a long time and still the solution is yet to be found.

Tele-density is number of telephone connections per hundred people in an area. In 2014 the tele-density in India was 77.58 and in 2020 as the table suggests, tele-density is 85.85. We can see the overall improvement but again the rural tele-density is very low compared to urban. Rural tele-density in 2014 was 46.09 and in 2020 it is 58.96. though it has increased in the past 6 years but still is very less compared to urban. Whereas in urban, tele-density has decreased from 148.06 in 2014 to 137.35 in 2020.

Now we will look at the data of internet subscribers

Table 2 : Internet Subscribers

Internet/Broadband Subscribers	
Total Internet Subscribers	749.07 Million
% change over previous quarter	0.79%
Narrowband Subscribers	50.84 Million
Broadband Subscribers	698.23 Million
Wired Internet Subscribers	23.05 Million
Wireless Internet Subscribers	726.01 Million
Urban Internet Subscribers	455.98 Million

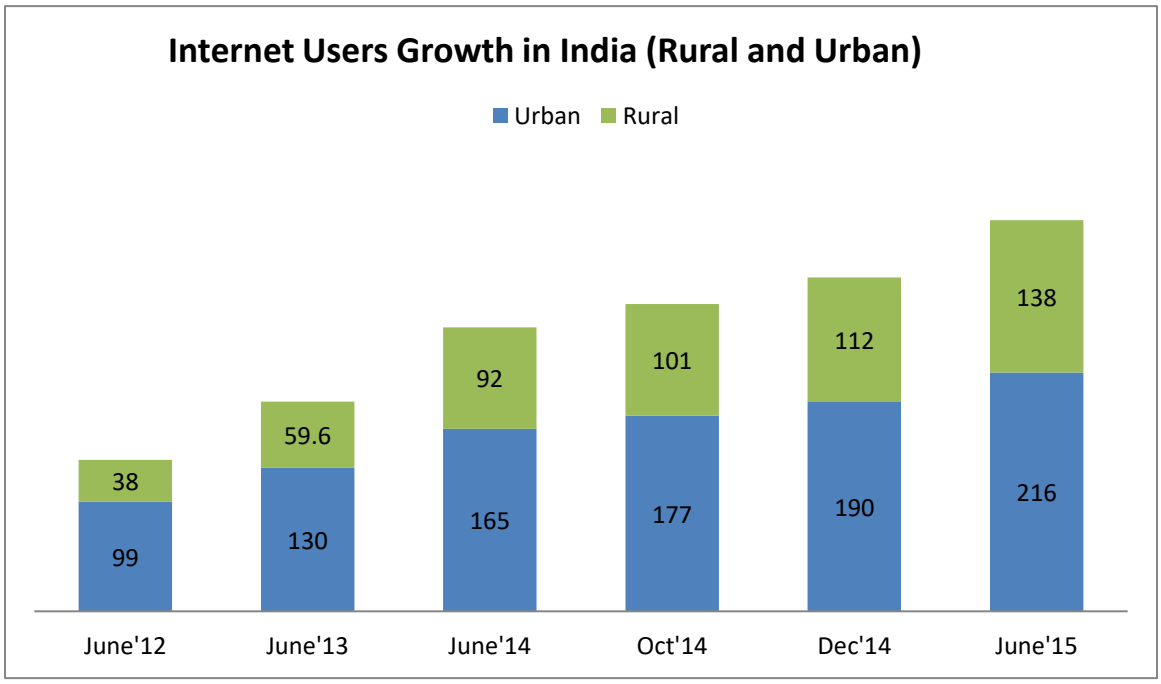
Rural Internet Subscribers	8293.09 Million
Total Internet Subscribers per 100 population	55.41
Urban Internet Subscribers per 100 population	98.35
Rural Internet Subscribers per 100 population	33

Source: ("Indian Telecom Services Performance Indicator Report" for the Quarter ending July-September, 2019, 2020)

Total internet subscribers in India as of 2020 are 749.07 million which is approximately half of the total population. Out of these 749 million subscribers 293 million are rural subscribers and 456 million are urban subscribers. Again, we can clearly see the difference between urban internet subscribers and rural internet subscribers.

The graph below shows the increase in rural internet subscribers over years from 2012 to 2015.

Table 3 **(Figures in Millions)**



Source : (PRABHUDESAI, 2018)

So to conclude, this urban-rural divide needs to be resolved. Though it has improved over years but the rural area is still very far behind. The government as well as private companies like Airtel, Vodafone etc. should take remarkable measures to overcome this problem.

V. COMPLEX OPERATIONAL SERVICES

Telecom operators often have hundreds of thousands, if not millions of subscribers, and along with an ever-evolving catalogue of products and other operational services like service configuration, order fulfilment, customer care, and billing which are becoming increasingly complicated (Preshani, Sachith, Samaradeera, & Samarakkody, 2019). Also

with customers getting more and more demanding in terms of the quickness of service, any organization cannot afford to be tardy. And due to the on-going pandemic, problem of quick customer service and contact centres is also rising.

Problems of few of the operational services are briefly mentioned below:

- **Need for Quick and Personalized Customer Support**- With telecom providers often having millions of paying subscribers, quick resolution of consumer issues is of utmost importance, as any delay in doing so will resulting in long wait times and agitated/dissatisfied customers.
- **Remote Working**- With the spread of covid-19, operating through a contact center with hundreds of employees is not possible as it is both a threat to their health and, in some countries, even illegal. So, due to this, companies are migrating to remote working. It is a huge challenge to continue operating and provide support while working from home.
- **Billing**- Above average billing errors consistently haunt customers of telecom carriers and this leads to poor customer service reputation. Few of the errors are Inaccurate or deceitful rates, Inaccurate or deceitful rates, missing renewal or new-service discounts, continued billings after the stop-bill date, Obscure third-party add-on fees, Charges for services you don't receive at all etc.

Solution

This is where operations research comes into the picture, providing a set of techniques and tools for thinking, analysing and solving, which leads to a structured and focused decision-making process, which also focuses towards efficiency and optimality. OR methodologies have long been fruitful in the telecommunications sector, with various tools such as mathematical modelling, optimization theory, graph theory and the artificial intelligence methodologies among others providing a massive impetus to status that modern telecommunication industry enjoys.

One of the more prominent figures to aid with the performance of telephone systems is A.K Erlang. In a 1917 paper he proposed a formula to model telephone traffic showing that the Poisson distribution could be used to characterize incoming calls. Since then, Erlang's formula has been sued to estimate the necessities of lines in circuit switched telecommunication networks.

Telecom providers need to upgrade their connectivity and IT infrastructure and they should focus on providing data and voice services that are affordable, having high quality and reliable.

Few of the ways in which they can solve these problems are as follows:

- **Migrate to digital channels**: To continue operating, it is essential to migrate face-to-face and phone assistance to digital channels like Twitter, WhatsApp or Facebook. These apps and social media will become more relevant. This is because phone conversations are slow and bureaucratic whereas these apps will allow companies to develop immediate, digital and one to one communications between the agent and the customer.
- **Automating Customer service:** Simple customer conversations can be automated using AI-powered chatbots. This will ensure that customers don't have to wait in line to get their questions answered. Also, the executives won't have to spend time solving repetitive issues.
- **Using live chats:** Once the repetitive questions are answered by the chatbox, executives will have more time to solve complex issues which chatbox cannot solve. This can be done easily through a live chat which will eliminate waiting time and complicated processes.
- **Technology from the cloud:** Now, due to the pandemic, employees are working from home. So to work effectively, they will need a software solution that can be easily used and managed from anywhere. Clouds provide end-to-end solutions and with this, allow customers and agents live chat where they can see the chat history and even connect to different social media channels. These platforms also help monitor chatbot's performance, conversations and analyse metrics to improve the service. This technology will help define a work from home strategy where their employees are safe and operating effectively.

The importance of OR in the telecommunication industry cannot be understated, as it provides a model to experiment with various models and find out the most optimal one to be implemented. In fact, it gave birth to the telephony call routing efficiency, and all most of the routing algorithms used to define operation routing table are based on the shortest path and minimum spanning tree algorithms. However, due to the dynamic nature of the industry, researchers will have to quickly adapt and keep up with the rapidly advancing technological aspects.

VI. RECOMMENDATIONS

- Tele-density in rural areas needs to be improved in comparison to urban areas.
- Everyone should have access to broadband with a minimum download speed of 2 Mbps.
- Boost domestic manufacturing and turn India into a global powerhouse.
- Enable network services and devices to be combined.
- Work on spectrum liberalisation and licencing regime simplification.
- Improve service quality and achieve "one nation, one number" by implementing "complete mobile number portability" and "one nation—free roaming".
- Cloud computing and Voice over Internet Protocol (VoIP).
- Telecom providers should upgrade their IT and connectivity infrastructure. They should provide data and voice services that are of high quality, affordable and reliable.
- They should also look at the level of ICT innovation and adapt to digital transformation by creating cross-functional interfaces and by seeking tools to maintain organisational flexibility.

VII. CONCLUSION

Operations Research provides a set of techniques and tools for analyzing and solving. It helps decision-making in a structured and focused towards efficiency and optimality. As discussed previously, it has been used extensively in the telecom industry with great success. However, this does not mean that the work is done. OR researchers will have to adapt to the ongoing changes in the telecommunications brought upon by the rather dynamic nature of the industry and the rapid technological advancements being made. Researchers also need to work upon reducing the gap between real life and academic estimations which can only be done by being attentive to the remarks real-life studies. With the ‘5G Revolution’ on the horizon, the usage of operations research will be essential drawing out a plan to ensuring a seamless infrastructure overhaul, and the subsequent mass-migration of customers to the new network.

This paper looks to drawn attention to the linkages/usage of Operations Research in the field of telecommunications. It also discusses several issues faced by the industry and how concepts like OR have been used effectively to alleviate some of the issues. The paper also has some suggestions that we feel would be effective in solving some issues that companies still struggle with. The Telecommunications industry plays a significant role in keeping the society functioning, keeping people connected. hereby facilitating growth and development and is hence an integral part of our day-to-day lives that needs to be managed as effectively and efficiently as possible. To ensure the smooth function of the industry as a whole, the proper implementation of operations research is paramount.

VIII. LIMITATIONS

- As of December 2014, India's tele-density was 77.58, with an urban density of 148.06 and a rural tele-density of 46.09. The overall number of subscribers is 970.97 million, with 85.74 million having broadband connections. There is clearly a distinction between rural and urban subscribers. The latter have several connections whereas more than half the rural population does not have a phone subscription. It's important

not to read too much into this distinction, as it's conceivable for families to share a single connection and for customers to have many connections that aren't being used. Being connected is not the same as having a subscription.

- The statistics on broadband access are quite disappointing. With a minimum speed of 2 mbps and 100 mbps on demand, the National Telecom Policy of 2012 (NTP 2012) aimed to have broadband on demand by 2015 and 175 million broadband subscribers by 2017. By the end of 2014, we had reached 85.74 million users at a minimum speed of 512 kbps. At this rate, it appears highly doubtful that the goal will be met. In the case of Internet connectivity, one may expect the urban–rural disparity to be more evident. While there is no credible data on tele-density, the fact that Delhi and Mumbai are two of the top five states in terms of broadband penetration strongly suggests that this is the case.

- Sometimes the chatbot is very frustrating. Customers get irrelevant questions from misguided chatbots and they tend to have a bad image about the business.

- The use of live chat doesn’t work well with older demographics. People above the age of 55 are unlikely to use the live chat efficiently.

- Cloud services are basically public and the customers usually rely on the cloud provider to ensure that they are taking proper care of the data. But the security of data is not guaranteed and the data might get leaked.

REFERENCES

"Indian Telecom Services Performance Indicator Report" for the Quarter ending July-September, 2019. (2020, January 8). New Delhi, India : TELECOM REGULATORY AUTHORITYOF INDIA.

(2021). *Global Telecom Services Market Size Report, 2021-2028.* Grand View Research.

(2021). *Telecom Services Market Size, Share & Trends Analysis Report By Service Type (Mobile Data Services, Machine-To-Machine Services), By Transmission (Wireline, Wireless), By End-use, By Region, And Segment Forecasts, 2021 - 2028.* Grand View Research.

Cortés, P. (2012). Operations Research and Telecommunication Systems Management: A Successful Alliance. *Journal of Telecommunications System & Management*.

[1]. Cortés, P., & Muñuzuri, J. (2008). A brief review of the state of the art in Operational Research in Telecommunications. *OR Insight*, 25-34.

Dye, S., Stougie, L., & Tomasgard, A. (2003). Approximation algorithms and relaxations for a service provision problem on a telecommunication network. *Discrete Applied Mathematics*, 63-81.

Gavish, B. (1995). Telecommunications—A Revolution in Progress. *Institute for Operations Research and the Management Sciences*, 29-32.

Gomez-Barroso, J. L., & Marben-Flores, R. (2020). Tecommunications and economic development - The 21st century: Making the evidence stronger. *Telecommunications Policy*, 1-13.

Gupta, S. (2015). Telecommunications at the crossroads in India.

Harris, B., Hauptschein, A., & Schwartz, L. S. (1958). Operations research in communications. *Transactions of the American Institute of Electrical Engineers, Part I: Communication and Electronics* , 633-638.

Košir, A., & Trnkoczy, J. (2010). OPERATIONS RESEARCH IN TELECOMMUNICATIONS – WHY AND HOW?

Lewis, S. (n.d.). *operations research (OR)*. Retrieved from WhatIs.com: https://whatis.techtarget.com/definition/operations-research-OR

Machado, M. A., & Gassenferth, W. (2014). *AN APPLICATION FOR EFFICIENT TELECOMMUNICATION NETWORKS PROVISIONING USING LINEAR PROGRAMMING*. Brazil.

O'Dea, S. (2021, June 5). *Forecast of worldwide telecom services spending from 2018 to 2024, by region*. Retrieved from Statista: https://www.statista.com/statistics/864709/telecom-services-spending-worldwide/

PRABHUDESAI, A. (2018, May 21). *India Crosses 300M Internet Users Milestone: IAMAI*. Retrieved from trak.in: https://trak.in/tags/business/2014/11/19/india-300m-internet-users-2014/

Preshani, Sachith, Samaradeera, & Samarakkody. (2019). *Challenges and Opportunities in Telecommunication Sector*. ENGINEERING UNIVERSITY OF RUHUNA, ELECTRICAL AND INFORMATION ENGINEERING.

Samarakkody, P. (2019). *Challenges and Opportunities in Telecommunication Sector*.

Shetty, S., Shah, S., Banka, T., Mehta, T., & Shah, T. (2019). Operations Research in Telecommunication. *International Journal of Advance Research*, 340-344.

What is the Telecommunications Industry? (n.d.). Retrieved from CFI: https://corporatefinanceinstitute.com/resources/careers/companies/telecommunications-industry/

