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Operations Research in Telecommunication

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ABSTRACT

Operations Research known as the science of better by the science community and by industry provides a set of tools and techniques and uses complex processes to make decisions. In this paper, we analyze the advancement of the telecommunications industry and its link to Operations research. This paper is divided into three sections. The first section talks about the objectives and the methodology of the research. In the next section we talk about the observations, the OR techniques used in the Telecommunication industry and the findings of the paper. Lastly, we talk about the limitations OR faces in the telecommunication sector.

Keywords— *Operations Research, Telecommunications, Network planning, Methods, Optimisation*

1. INTRODUCTION

India is the world's second-largest telecommunications market with massive amount of subscriber base of 1.20 billion and it has also been registered for having strong growth in the past decade and half. The GDP of the Indian economy is majorly going to have a contribution from the telecommunication industry, this can be inferred by the rapid growth in telecommunication. A humungous growth has been seen by India in the past two years, in the app downloads as that has increased by 165 percent. India has 604.21 million internet subscribers and ranks second in terms of Internet usage as well. The base of telephone subscribers in India has increased from 1,186.63 million at the end of June to 1,189.28 million at the end of July marking an increase of 0.2 percent. Urban subscription of telephones increased from 675.58 million to 678.02 million whereas rural subscription increased from 511.05 million to 511.25 million. The telecommunication density increased from 90.11 at the end of June to 90.23. The urban figure marked a rise from 160.78 to 161.12; while the rural teledensity slightly declined from 56.99 to 56.98. Adding to that India holds a place of being the world's second-largest telecommunications market, with total number of subscriber base of 1,183.51 million according to March 19 statistics.

India remains the world's fastest-growing market in terms of the Google Play downloads in the second and third quarter of 2018. India aims that over the next five years with a rise in the mobile-phone penetration and attempts in reducing the data costs, India will add 500 million new internet users in which will definitely create opportunities for new businesses. Apart from the growth, there is also a certain downfall seen in the telecommunication industry Bharti Airtel has reported 2.5 million subscribers exiting its network. Vodafone Idea had 3.4 million exits. A broad study of problem-solving and decision making in human organizations is called Management Science. This helps the businesses to achieve goals using various scientific methods.

It focuses on the qualitative methods rather than quantitative techniques of management; this is in order to increase the organizational effectiveness of the working and make better decisions that help in making the company function well. The main purpose of this research paper is to analyze the problems of the telecommunication sector and to find effective solutions through operational research. This will help the industry flourish better and can contribute towards economic growth and development.

1.1 overview of the industry

In a raw form, the telecommunications industry is the tool that ensures spreading data with words, voices, audios, and videos across the globe for various purposes. It has not been a long time since telecommunications industry has seen a boom increasingly in India after the inception of Jio. There is still ample room for the growth of this industry. Currently, the world market leaders on the basis of market capitalization in telecommunications sector are-

Verizon (VZ), which provides wireless and wireline services, in addition to broadband and information services, has a current market capitalization value of approximately $200 billion.

China Mobile Ltd (CHL), which has only been in business since 1997, has a market cap value of approximately $185 billion due to the growth in the use of cell phones and Internet services in China within the past 15 years.

The trends in the technology as far as telecommunications are concerned to have been towards open and interconnected local and global digital networks for texts, voice, data, and videos, using high-speed fibre optics and satellites. But in 2019, it has far more extensive technologies being used to fulfill the objective of interconnectedness locally and globally. Some of them are 5G, "connecting the IoT", "Cloud Computing", "Carrier-Grade Wi-Fi"," and Integrating with Content". The basic objective fulfillment is ensured along with extension of telecommunications industry with all the new technologies.

To be specific, India stands as the second-largest telecommunications market in the world after China regulated by the Telecom Regulatory Authority of India (TRAI). As and when telecommunications sector is flourishing and Artificial Intelligence being a big part of it needs undivided attention wherein it gives rise to complex mathematical models. The only way to solve such problems is by the use of Operations Research which provides a set of techniques and tools for thinking, analyzing and solving, which leads to making decisions in a structured and focused way towards efficiency and optimality. Currently, with such expansion in Operations Research methodologies, researchers are able to establish strong relationships amongst the variables of the models of telecommunications and give definite conclusions regarding its usage and how better we can improve it to be. Some possible areas where the modeling is used are telecommunications network planning, optimization of invariant network, traffic demand dynamic routing, communication admission control and many more. All in all, Operations Research has proved to be fruitful until now with certain limitations which if kept in mind can fetch amazing results.

1.2 Research objectives

- To understand and analyze the different problems arising in the telecommunications network.
- To find the solutions and models as to how those problems are formulated to ultimately reach the solution.
- To elaborate on the effectiveness of Operations Research in solving these problems.
- To outline the limitations of the modeling of network-related problems solved by Operations Research.
- To describe the importance of Operations Research in the telecommunications sector.

1.3 Research methodology

Qualitative research based on past research papers. The information and data for this study have been collected through secondary resources such as:

- Past Research Papers
- Articles
- Websites and Books
- Reports

(The data sources have been listed among the references at the end of this paper). An analysis of different problems and formulated solutions to tackle these problems in the telecommunications network has been carried out. Through this analysis, we drew inferences in order to understand the importance of Operations Research in Telecommunications and its effectiveness in solving these problems.

2. LITERATURE REVIEW

Telecommunications is a fast-paced industry where the goal post is always changing. Ever since its inception, the industry has gone through several major structural changes – some aided with the use of Operations Research. The following is an assessment of different well-known plans of actions, understanding their basics and bringing up their confinements so as to see how the future of Telecommunications changes.

3. SIMPLE NETWORK MANAGEMENT PROTOCOL (SNMP)

Proposed by Internet Engineering Task Force (IETF) in 1988 for IP network management; The SNMP management protocol assumes simple manager and agent relationships whereby the manager does the data gathering and process while the agent supplies the data. The manager is the brain of network management and it administers and conducts Operations and Management tasks (OandM) for the managed devices Resources are represented as objects containing a set of data variables.(K. Laghari, I. Yahia, N. Crespi, International Journal of Computer science and Information Technology (IJCSIT), Vol 1, No 2, Nov 2009) The definition of objects are standardized across resources of the same type, however proprietary extensions to these objects are also common. The values of variables are typically pre-set by the agent on in place of the manager. Common performance improvement for SNMP is to have the manager perform get operations only at limitedly dispersed time intervals and have the agent send notifications to the manager with any variable value update. They can be very inefficient when operating over managed objects with large variable tables. (R. Boutaba, J. Xiao, TELECOMMUNICATION SYSTEMS AND TECHNOLOGIES - Vol. II - Telecommunication Network Management)

4. TELECOMMUNICATIONS MANAGEMENT NETWORK (TMN)

TMN was developed by the International Telecommunications Union (ITU) as a foundation for the management and deployment of various management services. TMN principles are integrated into telecommunications network to send and receive information and manage resources. It also enables communication with Operation Support System (OSS) (The International Engineering Consortium - Telecommunications Management Network (TMN), 2018-19) Here, a manager process issues commands and receives notifications, and an agent process carries out commands, sends responses, and sends forth events and alarms.TMN provides a framework for networks that are flexible, scalable, reliable, inexpensive to run, and easy to enhance. It accommodates increasingly able and productive systems by standardizing network -management tasks and imparting crosswise communication over systems. TMN enables handling to be conveyed to proper levels for adaptability, ideal execution, and productivity. Today's Industry demands are for low cost, whereas TMN's Management Framework is faced with expensive tools. TMN is based on object-oriented approach but it doesn't have object location transparency because the manager requires knowing complete detail of agent. Its protocol stack brings more complexity and that's why it's also considered as quite heavyweight. (K. Laghari, I. Yahia, N. Crespi, International Journal of Computer science and Information Technology (IJCSIT), Vol 1, No 2, Nov 2009)

5. TELECOMMUNICATIONS INFORMATION NETWORKING ARCHITECTURE (TINA)

The TINA project is currently defining a common information networking architecture that can be applied to a wide variety of networks. It implies the addition of trading services and enables the creation, deployment, exploitation, and management of services worldwide. However, there are specific requirements that need to be satisfied. The following are an example of the objectives, queries, and models that TINA undertakes:

- Subscription information modeling services provided to users via a subscription
- Charging information objects modeling charging mode applied to a subscription and objects acting to realize charging

(J. Fessy, B. Finance, Y. Lepetit, P. Pucheral, Data Management Framework and Telecom Query Service for TINA). TINA's object orientation is to ensure interoperability, software reuse, flexible distribution of software and homogeneity in the design of services and their management. Since the goal is to build a reference model for open telecommunication it engages telecommunication services and management services. The architecture encompasses an integrated IN/TMN domain. Whilst TMN only offered Management services, TINA offers Management and Multimedia services. (J.P. Hubaux, S Znaty, Telecommunication Services Engineering: Definitions, Architectures, and Tools) Currently, TINA-C is inactive. The last TINA deliverable was released in 1999. Despite some research activities on TINA in the past, very little industry realization of TINA has been seen.

6. WEB-BASED ENTERPRISE MANAGEMENT (WBEM)

An initiative was first started in 1996 by Microsoft, Intel, BMC software, Compaq and Cisco systems and later adopted by Desktop Management Task Force (DMTF); WBEM is applicable to resource-constraint environments and allows for transparent and location independent access to managed objects with a simple client-side architecture. The main goal of this initiative has been to provide interoperability among multiple-vendor management solutions. The Common Information Model is primary to WBEM and all object classes and interfaces are specified with CIM schema. The CIM Object Manager (CIMOM) serves as the mediator between management applications and providers by constructing nested CIMOMs between the providers and the managers. The application interacts with a namespace as management application is not directly aware of the CIMOM. There are five types of providers in WBEM. Ordered by increasing levels of implementation complexity, they are property provider, instance provider, class provider, namespace provider, and standard provider. (R. Boutaba, J. Xiao, Telecommunication Systems and Technologies - Vol. II - Telecommunication Network Management) A WBEM server has to deal with several issues such as HTTP and XML coding, CIM schema repository, security features like Secure Shell (SSH) and authentication, and a CIM Object Manager (CIMOM) that is used to handle client requests and server responses. These issues unquestionably need a measure of assets and make incorporation into embedded devices difficult troublesome. (M. Hutter, A. Szekely, J. Wolkerstorfer, Institute for Applied Information Processing and Communications (IAIK), Embedded System Management using WBEM)

7. FINDINGS

To start with, we analyzed the problems that the telecommunications industry is facing for some time and how operations research has been on the rescue to provide optimal solutions to such problems. The main cause of telecommunications industry to face problems in any area of it is technological advancement and improvement in distribution of data on a frequent basis. These are the causes that not only affect the problems and its functioning quantitatively but qualitatively too which alters the overall structure of the network model itself.

a) One such problem that has been prevalent in the industry is the creation of optimal scenario of network development in space and time. This takes into consideration the development of an algorithm that results in an optimal network structure according to minimum cost criteria that includes expenses on installing new commutation systems and the introduction of remote modules.
b) Another problem we came across is to find a model that can locate base stations in a geographical layout area of 20×20 km2 and connect end-users to the base stations. This mainly describes the mathematical model for the base station location problem in Fixed Wireless Access -networks.
c) A new problem that came to the forefront was that traditional schemes are no more efficient management schemes due to continuous growth in the complexity on one hand and technological advancements in network and services on the other hand.
d) Now hot buzz word is autonomics which envisions a paradigm that is autonomous, service-centric, future proof, and technology agnostic. These all promises of autonomic vision could be met as soon as issues related to autonomics could be resolved, making the autonomic vision a reality.
e) The high network availability and toll fraud prevention are the most important management tasks. We have found out that it is very important to make the users aware of the services and service capabilities.

f) In the topological design of wire-based telecommunication networks, the problem corresponds to the design and planning stage. The problem arises when the network has to be extended or positioned. The topological design has been the most traditional problem in the Operations Research network.

These are some of the problems we found while going through the research papers, solutions to which are discussed subsequently. In order to derive solutions, we had to examine the problems that analysts have given solutions to and we were surprised to see how extensive the use of Operations Research in the various problems that are were discussed above.

Problems to reduce the costs and expenses were mainly solved as a **"Transportation Problem"** that we studied in the first module of our course. This provided us with "how in real life transportation problem can be used" and it actually gives effective results to be implemented while optimizing telecommunications network planning. After the formulation and solving it, three software products were built: for setting parameters of space-time system, solving optimization problems and presenting reports for optimal solutions. This guarantee, that all requirements for connection to the network will be satisfied, keeping network cost minimal.

Subsequently, we came across a unique method used to solve the problem that can locate base stations in the geographical layout area, the method was "**Simulated Annealing**" which focussed on minimizing the number of not connected end-users within the given timeframe. It solved the problem using the C programming language. Briefly, using simulated annealing the real-life base station was converted into a model and two test runs were done. First, with 7 base stations, which gave number of non-connected end-users in this solution is 272 and the minimal load on a base station is 64.512 kbps. Second, with 9 base stations, which gave a number of non-connected end-users is 198 and the minimal load on a base station is 40.832 kbps. The solutions in both cases were found within 15 sec.

Apart from the methods of OR many other economic methods were used to address these problems. Some methods taken into consideration were billing policy, SWOT analysis had the potential to reveal the key elements that have to be taken into account for network planning. Migration analysis, technology benefits and cost benefits also form important factors while deciding the one optimal solution from many optimal solutions. Effectiveness of the models and methods used to address the problems had more or less solved the issue but there is always a margin of error that constitutes of the model used currently getting old with the advent of new technology due to which a new problem arises and hence a new model. Considering the effectiveness of the problems discussed and their solutions given, most of them performed fairly well in providing the optimal solutions keeping in mind the constraints, variables and every other minimization and maximization type objective functions.

The importance of OR in most of the sectors not specifically in telecommunications has been significant. All in all, it provides a model to experiment just like the real system where all the models of it can be tested and finally after finding the most optimal one can be implemented. As far as we know, researchers are still trying to be well versed with most of the approaches, operations research as a technique has still not flourished up to the brim. Operations Research (OR) in telecommunications as a thriving field is promising, in the future. Operations Research will find wide gaps to make successful contributions since the extreme complexity that telecommunications problems usually show is enormous. On the other hand, due to the constant changes in telecommunications, the OR researchers will have to adapt quickly to the ongoing changes in the industry and cooperate more efficiently with the technical aspects.

Limitations concerning operations research are not less as we find in the research papers of the researchers, variables concerning a problem are more in number which sometimes gets tedious to deal with. The same is the case with constraints. The gap is significant between the real systems and the formulated one so the researchers will also have to make the necessary effort to reduce the gap between real life and academic problems, listening to the feedback from practitioners and real-life successful experiences. Therefore, we can conclude that Operations Research provides a set of techniques for analyzing, thinking and solving problems in the telecommunications sector towards efficiency and optimality.

8. CONCLUSIONS

Operations research and management science approaches can lead to a better, healthy system in terms of 4A's i.e. accessibility, affordability, availability, and acceptability. The telecommunications industry is on a boom and is a profit-making industry with the constant progress seen especially after the introduction of Jio and the increase in the number of people attracted to the usage of mobile phones, data, and landline connections. But that is not enough for every mobile network to sustain in the telecommunication industry, after liberalization, privatization, it is seen that the prices are falling as a result of competition in the segment. The beneficiaries of this competition are none but the consumers, who are given a wide variety of services. In the future years to come, India is predicted to witness a communication revolution, which would, as a result, increase the subscriber base to match that of the developed world. The service providers should work extremely hard to meet the need of the hour i.e. a new revolution in the industry by adopting proper operational research and management strategies. Apart from that an important contribution of this study is how marketing strategy should be developed and sustained over different target markets in the telecommunication sector. The future commitment from a customer to an organization depends on perceived marketing element. The issue and challenges faced is that of increasing recognized as well as a critical success factor in the emerging scenario.

9. LIMITATIONS

- **Lack of Research Papers**: As students who are new to writing research papers, we did not have access to and knowledge of all the websites related to Research Papers. As a result, we were unable to find sufficient research papers and information regarding our topic.

- **Time Constraints**: This research paper was part of our college project and hence, we had to meet certain deadlines. This may have affected the quality of our work.
- **Lack of Technical knowledge:** Since we were new to writing research papers we did not have the required technical knowhow.

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