

A Survey on Planning and Optimization of Telecommunication Networks: Aspects and Challenges

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ABSTRACT: Telecommunication networks and its usage are the most important technological tools which are playing an important role in today's scenario. Internet has become the need of every individual right from students to housewives and businessman to researchers. Hence reliability of these networks is required to be improved for proper usage and better user experience. But planning telecommunication network is not a task of restructuring again and again as it involves huge investment. Therefore optimization of these networks becomes important. This paper discusses about various parameters of networks for its planning. Basics of mathematical programming is also discussed at elementary level. Some network design and algorithms are also introduced. Some light is also thrown on routing and reliability aspects of the same.

KEYWORDS: Planning of networks, optimization, mathematical programming, algorithms, topological design, routing.

I. INTRODUCTION

Planning of communication networks means providing a solution to organization to meet future needs of connectivity by using the existing networks as the starting point. Looking into today's scenario of networks, it becomes essential to provide the optimized solution to this problem of network planning.

Professionally, optimization of networks means minimizing the cost of outlays for equipment and operations and maximize the revenue out of it. But this has to be done over specific span of time as technology, user requirements and the economic environment factors keep on changing from time to time.

The main problem with optimization of networks is, there are variety of parameters we are required to work on, viz. Cost of implementation, reliability of network, public image for accepting the technology, capacity of the network and potential for growth for future expansions.

Looking at these parameters it is preferable to have this network problem divided into smaller subproblems and then work on each of them individually.

II. PLANNING OF NETWORKS

Broadly, communication networks are divided in telephone networks and computer/data networks. This paper describes mainly about the planning of data networks here. The planning can depend upon various factors like Technology, business, environmental, etc. Even the time span for which we design a network is also an important factor because the hardware and software selection is different for networks being planned for either 2 years or 20 years. Network features of major concern here are statistical load on the network, number of subnetworks, number of services, standards and resources. Planning of network also includes many administrative points like financial policies,

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forecasting, goals and long range plans. Technical aspects for consideration under planning are vast which includes switching and routing, addressing, signalling, maintenance, etc. There has to be a detailed and immediate engineering plans for the above mentioned points.

There are various network features to be concentrated on while planning like statistical load, number of subnetworks, hardware, software and other resources.

Mathematical Programming for planning:

Mathematical formulations for communication networks consists of two major parts:

- i) Objective Function
- ii) Set of constraints

An objective function is an important parameter for finding the cost of implementation whereas set of constraints are nothing but the set of mathematical equations which describes the planning. For objective function, another quantity which may be related to performance or reliability. A set of constraints put a restriction on range of possible solutions. In other words, constraints define the feasible solution space. An objective function and associated set of constraints are called as a mathematical program.

The optimization term in general means the minimization but in some cases leads to maximization of the objective function. The better definition of the optimization can be the process which tries to make the best possible utilization of the input resources and tries to get the maximum out of it as an output in the desired form. The only thing that matters is that the optimized solution should satisfy the set of constraints. A mathematical program can have a single and unique globally optimum solution as well as many locally optimal solutions. Here, a globally optimal solution refers to the entire feasible solution whereas locally optimal solution refers to limited portion of the feasible solution space.

Linear programming is used in network planning to optimize the telecommunications network design.

If all the decision variables are having integer solution then such a program is known as an integer linear program. If only some of the decision variables have integer solutions then the term mixed integer linear program is applied.

A popular approach to solving integer linear programs is the family of branch and bound algorithms. Understanding concepts of decision trees is important for solving such cases. Dynamic programming is used for a large family of optimization problems which can be transformed into the problem of finding the shortest path through an appropriate graph.

Network Algorithms for planning:

Algorithms were introduced originally for the generation of large scale network topologies. It is required to determine link locations and certain node locations in a way that serves to minimize cost.

Generally, algorithms are useful for determining concentrator locations, terminal assignments and minimum weight spanning trees. Queuing delays can also be considered as a performance measure because this delay increases exponentially as links become loaded.

The result in terms of topological design, is to produce sparse topologies, with a limited number of high capacity links.

i) The terminal assignment problem: each generic terminal has to be interconnected to the outside world through a generic "concentrator". Depending upon the type of networking being carried out, this connection is achieved by means of devices such as front end processors, multiplexers or ATM switches.

ii) The concentrator location problem: in the terminal assignment problem, the locations of the concentrator were fixed and known. In the concentrator location problem one seeks to select the best locations for concentrators from a list of candidates sites, as well make the terminal assignments for m sites and n terminals.

iii) Minimum weight spanning trees: it is a graph that serves to connect N nodes. Each node is connected to one or more links (edges). The overall graph, being a tree, has no cycles (loops). A little thought will show that spanning tree connecting n nodes consists of exactly $N-1$ edges. One can assign "weights" (costs) to each possible link. Then the MWST problem is to find a spanning tree that minimizes the sum of the weights of the links chosen. For instance, if the weights represented the distance between the different nodes, one would be calculating the spanning tree of

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minimum total length. If the weights represented the cost of each link, one would be calculating the minimum cost network.

III. DISTRIBUTED NETWORK TOPOLOGICAL DESIGN

Previously, communication networks used star-type pattern or tree networks for interconnection and hence there was no routing problem as there was a single path from each terminal to its mainframe. This scenario changed when packet switching networks came into existence in 1960. This system had data in the form of packets which in turn had header and information payload.

These network became very popular as it was best suitable for resource sharing. Looking into the traffic demands of this network, it gave rise to the concept of distributed network in place of centralized ones. This made many users to have their asynchronous communication share the same link. It is also referred as statistical multiplexing which makes cost effective communications. But such networks did not use tree or star topology. The graph used to represent the network topology of packet switching networks have multiple paths between any pair of nodes. So, arises the new dimension of a routing problem. This is even more challenging because the determination of the optimal routes depends on the capacity assigned to each link and the optimal allocation of capacity to the links depends on the routes chosen.

Main points of consideration here are:

- i. Queuing delay as a penalty.
- ii. The capacity assignment problem.
- iii. A routing problem.
- iv. Combined capacity and flow assignment.
- v. The branch exchange algorithm.
- vi. The cut saturation algorithm.

IV. ROUTING

Routing with economies of scale

A larger system serving many users is more cost effective than a smaller system serving few users. The cost per user is referred as "Marginal cost". In particular, this will consider long haul transmission systems.

Shortest path routing

This is most commonly used type of routing. Such routings are called for in several algorithms. The basic idea is to represent the network of interest as a graph. The nodes of the graph represent computers, hosts or switches. The edges of the graph represent communication links. Associated with each edge is a scalar cost value. Typically, this may represent physical distance, delay or some security, QoS or performance metric.

"A shortest path is not necessarily unique"

Some network like Ethernet or token ring LAN do not have a routing problem as there is a single path between any pair of nodes.

Routing can be implemented either in a centralized fashion or in a distributed fashion. Most routing algorithms in a single run can generate the shortest paths between a given node and all other nodes.

V. RELIABILITY

Reliability is the study of how systems composed of hundreds or thousands of computers can function and communicate with each other even if some link fails in between, for extended periods of time. The networks are made up of various components. Therefore reliability of a network also depends majorly on these components. There are various ways in which we can connect these components for enhancing reliability of that network. These connections

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can be achieved by various serial, parallel, combination of serial and parallel connection, some complex configurations or by exact calculation of large systems. The aim is that the entire system does not fail even after failure of some of the components. For increasing reliability and lifetime of networks various functions are required to be considered like survivor function, probability density function and hazard function. Probabilistic risk assessment is also required which deals with the negative consequences of system or component failure.

VI. CONCLUSION

We have studied various network components and parameters. Various factors affecting the networks are also studied which include many non-technical factors. These factors are important from implementation point of view. These complex networks can be well planned with the help of mathematical models using tools like linear algebra and other such mathematical programming tools. Various network algorithms are discussed along with the design considerations. This paper has also given information about all basic parameters related to reliability. As reliability is most important factor for which this entire optimization process is carried out so that the user experience becomes smooth.

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