TRAVELLING SALESMAN PROBLEM AND CALL ROUTING

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

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DECLARATION

I, Tanya Gahlot, 2K20/MSCMAT/41 student of M.Sc. Mathematics, hereby declare that the project Dissertation titled "Travelling Salesman Problem and Call Routing" which is submitted by me to the Department of Applied Mathematics Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Science, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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I hereby certify that the Project Dissertation titled " Travelling Salesman Problem and Call Routing" which is submitted by Tanya Gahlot, Roll No. 2K20/MSCMAT/41 [Department ofApplied Mathematics], Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Science, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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I would like to acknowledge that this project was completed entirely by me and not by someone else.

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ABSTRACT

In this paper we have briefed the minimum cost or to maximum profit of the routing network calls using travelling salesman problem. Our problem is somehow related to least cost routing, we will use heuristics method for travelling salesman problem to solve our formulated problem. All the network calls are transported via different routes between base stations. Service providers lay down their networks or sign an agreement with other provider services to customer while establish a connection, selecting the route associated with minimum cost is the ultimate solution. Telecommunication carriers regularly enter into whole scale contractual agreements with other carriers to access all or part of the other carrier's telecommunication networks and/or telecommunication services. The provider aims at maximizing its profit and minimizing its cost while providing services. It also aims at maintaining a good quality of service and customer count and to protect itself from competitors. Here we are going to minimize the cost or maximize the profit of call routing by different methods for example nearest neighbors, sub tour heuristic and branch and bound which may help the company to achieve its goals. As by having a good network connection with minimum cost incurred will help company to provide good quality, maintain customer base, and thus reducing its competition. The costs that we obtain in all three methods are almost same but at the same time we find alternative paths too. So the company can decide which path they can choose. We take the total cost of call routing including establishment call, renting, marketing, purchasing etc and the link connection cost also. A coding is also done in order to obtain the optimal result. This paper relate the telecommunication costing with mathematical methods and in the end apply the mathematical code in python is given for finding optimal.

TABLE OF CONTENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS USED

SYMBOLS USED

1. CHAPTER 1: INTRODUCTION

1.1. (1)**TRAVELLING SALESMAN PROBLEM**

Merrill M. Flood first proposed the Travelling Salesman Problem in 1930, in order to address a school bus routing issue. It is one of the most studied computational problems in optimization, and it serves as a baseline for many other optimization techniques.

The Travelling Salesman Problem (TSP) is the task of discovering the quickest and most efficient route for a travelling salesman to visit a list of specific destinations. The purpose is to determine the shortest route from a list of options in order to reduce total travel distance and expense. The TSP falls under the category of "NP-complete" combinatorial optimization problems. Because of two factors, it is characterised as "NP-hard."

There aren't any quick solutions.

When you add more destinations to the TSP, the complexity of computing the best route grows. The TSP may be solved by studying each round-trip route and determining the shortest one. The number of routes multiplies exponentially as the number of destinations increases. Even the most powerful computers are unable to keep up with this exponential increase.

Travelling salesman problem deals with finding the shortest (closed) tour in an n-city situation where each city is visited exactly once and return to the origin city. Travelling salesman problem is a type of routing problem. Suppose a salesman has to visit n cities, he decides a route where he starts with a city and visit each city once and only once and return back to the same original city, minimising his time/distance travelled. Starting from any city the salesman can have (n-1)! sequences. A travelling salesman problem is represented with the help of the graph with nodes as cities and arcs made with respect to the routes available between the cities with time/distance taken to travel as the corresponding weights. The distance/time between two cities which are not connected directly is considered as infinity.

(1)Mathematical Expression: The problem, in essence, is an assignment model that excludes sub tours.

Specifically, in an n-city situation, define

$$x_{ij}= \begin{cases} 1 & if\ city\ is\ reached\ from\ city\ i \\ 0 & otherwise \end{cases} \quad (1)$$

Given that d_{ij} is the distance from the city i to city j, the TSP model ig given as

Minimize $$z = \sum_{1=1}^{\infty} \sum_{j=1}^{\infty} dij\ xij, dij = \infty$$

for all i = j

subject to

$$\sum_{j=1}^{n} xij = 1 \text{ for all i = 1,2,3,4,........n} \quad (2)$$

$$\sum_{i=1}^{n} xij = 1 \text{ for all j = 1,2,3,4,........n} \quad (3)$$

$$x_{ij} = (0,1)$$

Solutions forms an n city tour

1.2. **HEURISTIC ALGORITHMS** (2)

This section represents three heuristics i.e. nearest neighbour, sub tour reversal, branch and bound algorithms. A Heuristic algorithm is a procedure that determines near-optimal solutions to an optimization problem. However, this is achieved by trading optimality, completeness, accuracy, or precision for speed. Nevertheless, heuristics is a widely used technique for a variety of reasons: Problems that do not have an exact solution or for which the formulation is unknown. The computation of a problem is computationally intensive. Calculation of bounds on the optimal solution in branch and bound solution processes.

1.2.1. **The Nearest-Neighbour Heuristic**

As the name of the Heuristics suggest , a ”good” solution of the TSP problem can be found by starting with any city (node) and then connecting it with the closest one. The just added city is then linked to its nearest unlinked city. The process continues until a tour is formed. Here we form a network system and then we see how TSP can be applied in solving this network problem. Using

TSP we find the minimum distance so that our cost can be minimized. The idea behind nearest neighbour approach is to locate a certain number of training samples that are closest in distance to the new point and use them to forecast the label. In general, any metric measure can be used, but the conventional Euclidean distance is the most used.

1.2.2. Sub-Tour Reversal Heuristic

In an n-city situation, the sub tour reversal heuristics starts with feasible tour and then tries to improve on it by reversing 2-city sub tours followed by 3-city sub tours and it continues till n-1.

1.2.3. Branch and Bound Method

Branch and Bound method is an algorithm that is used to solve the minimization and optimization problem. Also known as divide and conquer method. Under this problem we are given with a large/ big problem and we divide the problem into smaller problems which is known as the branching part. The other part that is to conquer the problems is done by estimation how good a solution can we get from each smaller problem. We have to divide the problem further until we get a problem that can be handled. This portion of the problem is called as bound part.

1.2.3.1. General Strategy of the problem

The solution strategy in branch and bound method is described by 4 major keyword: Relax, Branch, Prune and Search.

Before designing the problem it is important that these words should be well understood. These definitions are as important as the structure of the mode and will vary depending on the application and here we are dealing with Travelling Salesman Problem as the application.

- Relax: This version is generally solved in each problem. The optimal solution which we get gives an optimistic bound of the optimal objective function. In standard problems the structure of the problem is used to find the suitable relaxation. For e.g.: in Travelling Salesman Problem we use constraint relaxation. While solving the Travelling Salesman problem using the branch and bound method the main approach is to relax sub tour elimination constraint. Then the remaining problem gets converted to an assignment problem.

- Branch: The feasible region which we obtain in sub problems can be divided further into new sub-problems and the process is known as branching. Most important thing in branching is that no feasible solution is cut away i.e. any feasible solution must belong to one or several new sub problem. For branching we should have an approach i.e. to make distinct partition
  so that each feasible solution only exists in only one sub-problem.
- Prune: With the given optimal solution from the sub-problem it may be possible to conclude that we do not need to search further. Now we prune the sub-problem and stop the search. If any one of the following cases appear we assume we have a minimization problem.

  1. Case 1: If relaxed problem has no solution then there is no solution to sub-problem. Hence problem has no feasible solution

  2. Case 2: If z = objective function, z = incumbent best feasible solution . if z ≥ z then problem has optimal solution.

  3. Case 3: The problem has a solution i.e. feasible solution. If the objective function value z < z. In general we don't search alternative solution. This implies we prune that can't provide strictly both solution. If none of the case happens then the branching of feasible region into new sub problem is done.

- Search Select: Once we solve the problem then we will go to search strategy, which is used for determining which problem to solve next. Some standard strategies of searching are:

  1. Depth First: Here we have to choose the sub-problem which has been branched most times. The main advantage of this strategy is that a feasible solution is found relatively quickly, also if there is limited time then it is more likely to find at least one feasible solution before

search is terminated.

2. Best First: In this strategy we investigate the tree then we investigate the branches and find the node which is providing the optimistic bound. The advantage of this strategy is in solving linear programming problems we have to move locally in search tree.

3. Breadth First: In this strategy we deal with the sub-problem at a given level in the search tree diagram before going to next level. This strategy basically helps us to solve problems where we do not wish to add more constraints. It works well in those cases where there is no need to add more constraints.

1.3. **LEAST COST ROUTING**

Least Cost Routing, or LCR, is a process to find the most inexpensive way to route phone calls. It is the process of analyzing, selecting and directing the path of outbound and inbound communications traffic depending on which path delivers the best rates. When a call is connected, telecommunications providers employ least cost routing (LCR) to select the lowest cost carrier for bandwidth provision. LCR is most commonly used in interstate or international communications, when the provider selects a carrier to complete a call originating in a different state or country than the exchange where the call is received. Even if a customer dials an out-of-state number, the call must still be routed and finished. LCR can also be used to guarantee that callers connecting within a state or country have a good connection.

2. CHAPTER 2: LITERATURE REVIEW

2.1. TELECOMMUNICATION: (2)

Telecommunication carriers regularly enter into whole scale contractual agreements with other carriers to access all or part of the other carrier's telecommunication networks and/or telecommunication services. For example, a first telecommunication carrier may contract to use another carrier's network to complete toll-free telephone calls in geographical areas that the first telecommunication carrier does not in service, or provide additional capacity on routes for which the first carrier may have limited capacity. The telecommunication service provider may also think of laying down its own network to be able to save itself from competitors and any case of blackout scenario which he might encounter due to shortage of connectivity. Traditionally, a carrier will charge a negotiated fee to route calls using the carrier's network and the rates are valid for some period of time. It is possible, however, for a telecommunication carrier to practice "least cost routing to reduce telecommunication costs. Least cost routing involves using routing tables and making call routing decisions based on which carrier provides the lowest fee to use its network. Often, least cost routing occurs without notifying any of the carriers with higher rates. As a result, such carriers unknowingly lose net work traffic and business to carriers with lower rates.

2.2. QOS- QUALITY OF SERVICE IN TELECOMMUNICATION

(3) 2.2.1. MEANING OF QOS: Quality of service is the measurement of all the performance specially from the user end. In telecommunication it can be defined as the specific requirements provided by the network to the users. Telecommunication is transfer of data or voice. If a packet is sent it does not guarantee any specifies delivery time, speed even if it faces traffic. So there are many problems in telecommunication services that degrade the quality of service. This sorting between user and network is done in such a way that the users describe the performance in the

form of quality of service both positive and negative and the network commits it by making change in quality of service.

2.2.2. SITUATIONS THAT DEGRADE QUALITY OF SERVICE

a) Traffic Overflow
b) Delays: That can cause loss/damage of packets or low performance on large routes.
c) Poor Management [Limited Bandwidth]

2.2.3. PARAMETERS OF QUALITY OF SERVICE

1) Delay: It arises when the end points are distant and the information takes a lot time to reach on the other side. This delay time is increased if the route opted is indirect or have traffic.

   This delay can be measured in two ways.

   a) One Way: Total time from source to destination.
   b) Round Trip: One way form source to destination plus one way from destination to source back.

More commonly round trip is used as it can be measured with a single "Ping" command. This command does no processing and directly sends the response.

This delay can even be seen in best situations like 260 ms in one way. As the distance increases, processing increases that increases the chance of delay. "In telephone call using satellite if the delay is greater than 250 ms the probability of talk is overlap i.e. the speaker repeats its sentence even when other party is responding."

2) Jitter: It is delay variation and occurs due to trafficking, routing changes e.t.c. This affects the quality of audio and video. This can be seen in surfing YouTube i.e. suffering.
3) Packet Loss: It happens when one or more packets of data being transported and failed to reach their destination. This packet loss is due to buffering, signal degradation, high loads on network, defect in network. In Wireless network there is more chance of packet loss.
4) ThroughPut: It is the amount of data transferred in a given time space. The unit in which it is measured is bits/s (bps). It is basically used for measuring the capacity of the link. For e.g. in case of bandwidth meter this tool is used for measuring the speed at which the user is downloading practical information from internet on other

factors also affect the downloading e.g. distance, speed of computer, number of programs running on computer, loading e.t.c.

2.2.4. What are the advantages of Quality of Service?

The main advantage of QoS is that it ensures the availability of a company's network and the applications that run on it. It ensures the secure and efficient transmission of data throughout the network. Instead than updating network infrastructure to increase bandwidth, QoS helps enterprises to make better use of their existing bandwidth.

Additional advantages include:

- Applications that are mission-critical have access to the resources they require.
- Administrators can better manage traffic.
- Organizations can save money by not having to invest in new network infrastructure.
- The user experience has been enhanced.

2.3. HOW CALL IS ROUTED (4) (5)

(6)When a call is made it first reaches the nearest tower/ antenna known as cell towers. Each geographical area is divided into cell and each cell has its own cell tower. Towers are connected with the help of optical fibres.

Our voice is converted to a digital signal with help of MEMS (7) sensor and IC. This digital signal is converted into an EMW signal and further sent to the nearest tower. The tower then routes the call to the base transceiver box at the base station. The call being made contains all the information including from where it was made and to where it is directed. The base station on receiving the call fetch the destination information and then routes and transmit the call to the nearest tower/antenna of the destination device. The device on receiving the signal from its antenna follows the same procedure for decoding.

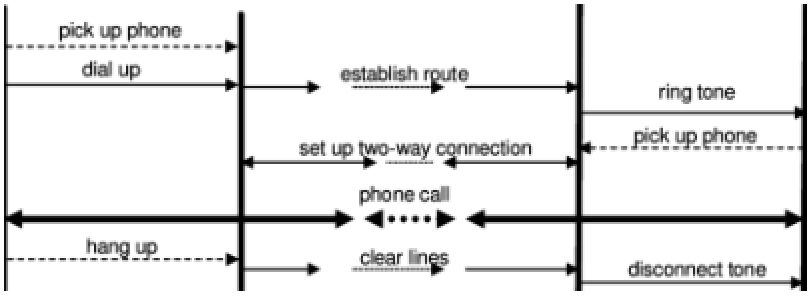

Figure1: How call is routed and connections are made. (8)

We can depict the system as a network, with switching offices serving as nodes and trunks serving as links. In actuality, a call can be routed through any of a number of different channels, saving money by maximising capacity use. Equipment are not dedicated to a particular route but is utilized by different routes at different time. Because demand for calls is a stochastic function at any given time, the definition of capacity must be expanded. The channel can accommodate one hour-long call, 360 calls of 10 seconds each, and so on. However, it is uncommon for a call to begin and end at the same time. In practise, a channel may be idle for long periods of time before becoming busy when a second call is attempted. It's possible that the word "effective capacity" will be used. The number of channels available (two channels can manage more than twice as much traffic as one channel) and the stochastic nature of the traffic (the more unpredictable the traffic, the lower the mean number of ccs a channel can handle) determine effective capacity. Effective capacity is defined as the probability of having a free channel at any given time for a particular quality of service.

2.4. COST FOR SERVICE PROVIDERS (9)

Routing and transferring of calls is done in the form of signals which requires frequency bandwidths. A service provider has to incur a lot of spending to maintain its services and provide us with the facilities. The company has to undergo an agreement with the state and other service providers for the bandwidth distribution, access and rights. The large costs for any telecommunication company are as follows:

1. CAPITAL COSTS

- Spectrum and Government Licensing.(Capital)
- Hardware and Software Expenditure. (Capital)
- Permissions and operation fees required for creating and laying relevant infrastructure to carry out its services.(Capital)

2. OPERATIONS COSTS

- Rents (offices/infrastructure)(Operations(fixed))
- Salaries(Operations(fixed))
- Advertisements and Marketing(Operations(variable))
- Diesel/Petrol (Operations(variable))
- Hardware Contracts(Operations(fixed))
- Costs for interacting with international ISPs (Operations(fixed))
- Rents for infrastructure/services from other service providers(Operations(fixed))
- Electricity Bills (Operations(variable))

The company has to spend a humongous amount on these. In return to cover the cost spend on providing services they charge their customers with the tariffs. But due to high competition in the market a company has to maintain a minimal tariff charge to maintain its customer base and to attract more customers (a perfect example being how the Jio Reliance Communications change the course of telecommunication industry with its attractively low services) therefore the service provider aims to minimize its cost to maximize its profit. Given the costs incurred for different items the most efficient way to serve the cause is to minimize the routing costs. Here we try to formulate a solution to the problem.

2.5. PRICE CALCULATION

When it comes to telecom services, price is a major consideration. It conveys the worth of your offer and sets a number of expectations for it. Pricing can make or break a new product's or service's success. Slow penetration and poor market share are usually invariably the result of an overpriced service. Overpricing can be damaging to services that require a critical mass level to perform correctly and achieve profitability. Many telecommunications services require this critical mass; having a phone with no one to contact is useless. Under pricing an offer, on the other side, might make an otherwise profitable value proposition unprofitable. Because of the lack of profit, a corporation may decide to stop providing the service: destroying customer value and loyalty.

Price of a call in any period is set equal to the sum of the marginal opportunity cost, in that period, of the items of capacity utilized.

Tariff should equal marginal costs, a fixed charge per unit of time should equal the marginal cost of adding a subscriber to the system and of maintaining him there, while a call charge should equal the marginal cost of making that call.

For e.g. a customer pays Rs. x for initial connection, a fixed charge of Rs. y per month for basic service and then a price per call that depends upon distance, duration and time of day.

However local calls are free therefore part of basic charges is substitute for call charges. The cost of maintaining of a subscriber in the system denoted by customer cost are the cost containing capital cost converted to an annual basis of the subscribers telephone, the line connecting him to the exchange and the terminating equipment at the exchange together with the cost of meter and of rendering regular accounts. It is independent of the calls made by the customer.

There are two sorts of charges associated with making a phone call: "traffic costs" and "capacity costs." The costs associated with a call, regardless of when it is made—primarily, the cost of operators and ticket processing—are known as traffic costs. The costs of delivering enough amounts of equipment in and between exchanges to meet peak system demands are known as capacity costs. Finally, there are certain "overhead costs," which include research and development costs as well as some administrative charges.

3. CHAPTER 3: METHODOLOGY

A service provider lay down its network spread across from states state. Install service stations and antennas from place to place to maintain a proper communication, quality of service, customer count and to maximize its profit.

A service provider aims to have multiple routes for the same two locations so as to prevent the cut off or isolation in case of any fault or failure. If the traffic is too high between any two locations that the service provider does not have enough means or not able to handle such traffic it tries to divert the traffic to some alternative route.

Peak-load pricing issues develop when capacity is shared across all periods of the day and demand is not uniform throughout the day. If the service provider does not have a proper set up for establishing a communication between any two locations.

1. The service provider deals with such situations by forming an agreement with another service provider to have access to its routes or bandwidths(It can be better understood with the help of example like if an entity owns a highway and if you want to use that highway for travelling you have to pay each time you use it for the amount of time you use it or at a fixed rate)
2. Install more equipment
3. By varying prices according to the time, a service provider can reduce or manage the traffic intensity during any time of the day, resulting in lower cost incurred on the services provided to meet the peak demand, which results in an increase in long-term revenue and profits on the same route.

In our problem we try to go by the lines of least cost routing and wish to track new routes for the calls to be routed. Assessing the calling rates for a selection of telecommunication companies and then choosing the provider/route that offers the cheapest rate.

3.1.FORMULATING

We try to formulate the problem that relates the branch scheme of telecommunication network wherein we consider 5 locations connected to each other representing a Hamiltonian graph. Weights of each node would be the cost incurred by the service provider while routing calls through that route. The cost includes all the above mentioned costs while establishing a route. Each and every route will be given cases as to how its costs are determined Then using heuristics method we try to find out the best possible route between the two locations which minimizes the cost.

While calculating the weights following things should be considered:

- Traffic between these two locations
- Routes and bandwidth owned by the respective service providers
- Cost of routing calls via other provider and all the cost discussed are in crores.

4. CHAPTER 4: RESULTS AND DISCUSSIONS

There are 5 cities, where each city is connected with one another not all routes are to be owned by a single service providers. To route call between any 2 states a service provider may go through his owned path or shortest path with any other service provider and paying appropriately. All the costs are in accordance to the bandwidth and distance. Let us consider a case when we take company XYZ.

Our aim is to find the path with least cost incurred so as to connect cities and route calls with minimum cost.

$$A_{5x5} = \begin{bmatrix} \infty & 1.2 & 2.2 & 1.5 & 2.1 \\ 1.2 & \infty & 1.0 & 1.1 & 1.3 \\ 2.2 & 1.0 & \infty & 1.8 & 1.6 \\ 1.5 & 1.1 & 1.8 & \infty & 1.9 \\ 2.1 & 1.3 & 1.6 & 1.9 & \infty \end{bmatrix}$$

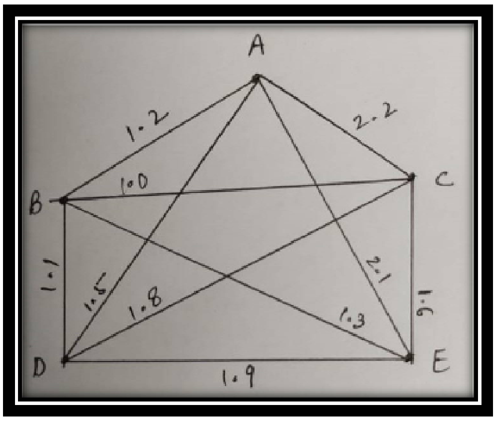

Figure2: Graphical Representation of cities and distances between them.

The routes that can be owned by the XYZ between cities are given as follows

- 1 → 4 = 1.1
- 1→2→4 = 1.2+1.5= 2.7
- 1 → 3 → 4 = 1.3+1.9=3.2
- 1 → 5→ 4 =1.0+1.6 =2.6
- 1→2→3 →4 =1.2+2.1+1.9=5.2
- 1→ 3 →2 →4 = 1.3+2.1+1.5= 4.9
- 1→ 2 →5 →4 = 1.2+2.2+1.6 = 5.0
- 1→5 →2 →4 = 1.0+2.2+1.5 = 4.7

- 1→3 →5 →4= 1.3+1.8+1.6 = 4.7
- 1 →5 →3 →4= 1.0+1.8+1.9 = 4.7
- 1→2 →3 →5 →4 = 1.2+2.1+1.8+1.6 = 6.7
- 1→3 →2 →5 →4 = 1.3+2.1+2.2+1.6 = 7.2
- 1 →2 →5 →3 →4 = 1.2+2.2+1.8+1.9 = 7.1
- 1→3 →5 →2 →4 = 1.3+1.8+2.2+1.5 = 6.8
- 1→5 →2 →3 →4 = 1.0+2.2+2.1+1.9 =7.2
- 1→5 →3 →2 →4 = 1.0+1.8+2.1+1.5 = 6.4

In the route associated with minimum cost to subscriber can be calculated as follows

$$A_{5x5} = \begin{bmatrix} \infty & 1.2 & 2.2 & 1.5 & 2.1 \\ 1.2 & \infty & 1.0 & 1.1 & 1.3 \\ 2.2 & 1.0 & \infty & 1.8 & 1.6 \\ 1.5 & 1.1 & 1.8 & \infty & 1.9 \\ 2.1 & 1.3 & 1.6 & 1.9 & \infty \end{bmatrix}$$

By nearest neighbour heuristic: The nearest neighbour heuristic method can start from any of the five cities. Each starting city may lead to different tour.

1. 1 → 2 = 1.2

   1 → 3 = 2.2

   1 → 5 = 2.1

   1 → 4 = 1.5

2. Now we take the minimum of (1.2, 2.2, 2.1, 1.5) i.e. 1.2

3. 2 → 3 = 1.0

   2 → 5 = 1.3

   2 → 4 = 1.1

4. Now we take the minimum of (1.0, 1.3, 1.1) i.e. 1.0

5. 3 → 4 = 1.8

   3 → 5 = 1.6

6. Now we take the minimum of (1.8, 1.6) i.e. 1.6

7. So the tour of the call become 1 → 2 → 3 → 5 → 4 → 1

8. Here the final tour cost is 7.2

By sub-tour heuristic: In an n-city situation, the sub tour reversal heuristics starts with feasible tour and then tries to improve on it by reversing 2-city sub tours followed by 3-city sub tours and it continues till n-1.

$$A_{5x5} = \begin{bmatrix} \infty & 1.2 & 2.2 & 1.5 & 2.1 \\ 1.2 & \infty & 1.0 & 1.1 & 1.3 \\ 2.2 & 1.0 & \infty & 1.8 & 1.6 \\ 1.5 & 1.1 & 1.8 & \infty & 1.9 \\ 2.1 & 1.3 & 1.6 & 1.9 & \infty \end{bmatrix}$$

Type	Reversal	Tour	Cost
Start	-	(1-2-3-5-4-1)	**7.2**
Two at a time reversal	2-3	1-3-2-5-4-1	**7.9**
	3-5	1-2-5-3-4-1	**7.4**
	5-4	1-2-3-4-5-1	8
Three at a time reversal	2-3-5	1-5-3-2-4-1	7.3
	3-5-4	1-2-4-5-3-1	8
Four at a time reversal	2-3-5-4	1-4-5-3-2-1	7.2

Table1: Sub Tour reversal representation (Own Work)

Thus 1-4-5-3-2-1 (with length 7.2 miles) provides the best solution of heuristic.

By the Branch and Bound:

$$A_{5x5} = \begin{bmatrix} \infty & 1.2 & 2.2 & 1.5 & 2.1 \\ 1.2 & \infty & 1.0 & 1.1 & 1.3 \\ 2.2 & 1.0 & \infty & 1.8 & 1.6 \\ 1.5 & 1.1 & 1.8 & \infty & 1.9 \\ 2.1 & 1.3 & 1.6 & 1.9 & \infty \end{bmatrix}$$

Row Reduction

$$A_{5x5} = \begin{bmatrix} \infty & 0 & 1.0 & 3 & 0.9 \\ 0.2 & \infty & 0 & 0.1 & 0.3 \\ 1.2 & 0 & \infty & 0.8 & 0.6 \\ 0.4 & 0 & 0.7 & \infty & 0.8 \\ 0.8 & 0 & 0.3 & 0.6 & \infty \end{bmatrix}$$

Column Reduction

$$A_{5x5} = \begin{bmatrix} \infty & 0 & 1.0 & 2 & 0.6 \\ 0 & \infty & 0 & 0 & 0 \\ 1 & 0 & \infty & 0.7 & 0.3 \\ 0.2 & 0 & 0.7 & \infty & 0.5 \\ 0.6 & 0 & 0.3 & 0.5 & \infty \end{bmatrix}$$

Total Reduction = 5.6+0.6 = 6.2

Path is 1-3-5-4-2-1 or 1-3-4-5-2-1

For the route

1-3

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & \infty & 0 & 0 \\ 1 & 0 & \infty & 0.7 & 0.3 \\ 0.2 & 0 & \infty & \infty & 0.5 \\ 0.6 & 0 & \infty & 0.5 & \infty \end{bmatrix} \text{TR} = 6.2$$

1-4

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & \infty & 0 \\ 1 & 0 & \infty & \infty & 0.3 \\ 0.2 & 0 & 0.7 & \infty & 0.5 \\ 0.6 & 0 & 0.3 & \infty & \infty \end{bmatrix} TR = 6.2$$

1-5

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & \infty \\ 1 & 0 & \infty & 0.7 & \infty \\ 0.2 & 0 & 0.7 & \infty & \infty \\ 0.6 & 0 & 0.3 & 0.5 & \infty \end{bmatrix} TR = 6.2$$

CASE 1: FOR 1-3

1-3-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0.5 & \infty & 0.3 \\ 0.3 & \infty & 0 & 0.2 & \infty \end{bmatrix} TR = 6.7$$

1-3-4

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & \infty & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0.2 & 0 & 0.7 & \infty & 0.5 \\ 0.6 & 0 & 0.3 & \infty & \infty \end{bmatrix} TR = 6.2$$

1-3-5

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & \infty \\ \infty & \infty & \infty & \infty & \infty \\ 0.2 & 0 & 0.7 & \infty & \infty \\ 0.6 & 0 & 0.3 & 0.5 & \infty \end{bmatrix} TR = 6.2$$

CASE 2: FOR 1-4

1-4-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ 0.7 & \infty & \infty & 0.4 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0.3 & \infty & 0 & 0.2 & \infty \end{bmatrix} TR = 6.8$$

1-4-3

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & \infty & 0 & 0 \\ 1 & 0 & \infty & 0.7 & 0.3 \\ \infty & \infty & \infty & \infty & \infty \\ 0.6 & 0 & \infty & 0.5 & \infty \end{bmatrix} \text{TR} = 6.2$$

1-4-5

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ 0.7 & \infty & \infty & 0.4 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0.3 & \infty & 0 & 0.2 & \infty \end{bmatrix} \text{TR} = 6.8$$

CASE 3: FOR 1-5

1-5-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ 0.7 & \infty & \infty & 0.4 & 0 \\ 0 & \infty & 0.5 & \infty & 0.3 \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} \text{TR} = 6.7$$

1-5-3

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & \infty & 0 & 0 \\ 0.7 & 0 & \infty & 0.4 & 0 \\ 0.2 & 0 & \infty & \infty & 0.5 \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} \text{TR} = 6.5$$

1-5-4

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & \infty & 0 \\ 1 & 0 & \infty & \infty & 0.3 \\ 0.2 & 0 & 0.7 & \infty & 0.5 \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} \text{TR} = 6.2$$

WE CHOOSE THE ROUTE 1-5-4, 1-4-3, 1-3-5, 1-3-4.

FOR 1-5-4

1-5-4-3

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & \infty & 0 & 0 \\ 0.7 & 0 & \infty & 0.4 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} \text{TR} = 6.5$$

1-5-4-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ 0.7 & \infty & \infty & 0.4 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} TR = 6.5$$

FOR 1-4-3

1-4-3-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ 0.6 & \infty & 0.3 & 0.3 & \infty \end{bmatrix} TR = 6.5$$

1-4-3-5

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & \infty \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ 0.6 & \infty & 0.3 & 0.5 & \infty \end{bmatrix} TR = 6.5$$

FOR 1-3-5

1-3-5-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0.5 & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} TR = 6.4$$

1-3-5-4

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & \infty & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0.2 & \infty & 0.7 & \infty & 0.5 \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} TR = 6.2$$

FOR 1-3-4

1-3-4-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ 0.3 & \infty & 0 & 0.2 & \infty \end{bmatrix} TR = 6.5$$

1-3-4-5

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & \infty \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ 0.6 & 0 & 0.3 & 0.5 & \infty \end{bmatrix} TR = 6.2$$

SO THE LEAST PATH WOULD BE

1-3-5-4 or 1-3-4-5

FOR 1-3-5-4

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & \infty & 0 \\ \infty & \infty & \infty & \infty & \infty \\ 0.2 & 0 & 0.7 & \infty & 0.5 \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix}$$

1-3-5-4-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} TR = 6.2$$

Or

1-3-4-5

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & \infty \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ 0.6 & 0 & 0.3 & 0.5 & \infty \end{bmatrix}$$

1-3-4-5-2

$$A_{5x5} = \begin{bmatrix} \infty & \infty & \infty & \infty & \infty \\ 0 & \infty & 0 & 0 & 0 \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \\ \infty & \infty & \infty & \infty & \infty \end{bmatrix} TR\ 6.2$$

The above formulated problems show how a company XYZ can decide its route to reach one city to another given its expenses and covering all the cities in a single route. The result given by the three methods can be given as:

Nearest Neighbour 1-2-3-5-4-1 with cost 7.2

Sub Tour Heuristic 1-4-5-3-2-1 with cost 7.2

Branch and Bound 1-3-5-4-2-1 or 1-3-4-5-2-1 with cost 8 and 8.4 respectively.

The final routes here connect all the cities and form a complete tour while keeping the cost incurred the least. Maximizing providers reach with minimum expenditure.

(10)We have so far discussed the cost incurred while establishing a connection/path from one city to another and tried to find the path with minimum cost. Now we will discuss the cost incurred while establishing a connection or a link for a call to connect and choosing the minimum cost route. We have taken the reference from the paper published on the similar topic. As quoted in the reference paper itself "The paper discusses, 'The nodes of the network are switches with storage capacity, and the connections are lines with flexible bandwidth capacity that transfers the routed packets according to the demands of the nearby storage nodes or destination stations," according to the report. As a result, in a subscribed line-node network, packet routing is associated with expenses. In this study, we developed a mathematical programme to optimise routing costs by evaluating all desired routes with known bandwidth capacity and different link line costs, comparable to the problem described in Ref [1]. The software for the computing algorithm is developed in Python, and a numerical example is used to check the codes.' ". The code discussed in the paper. Ref (10)

```
In [ ]:
from pulp import *
import pandas as pd
import numpy as np

#set of demands, i = (1,2,......,n)
n_demands = int(input("Enter the value of demands = "))

#set of links, j = (1,2,.....,m)
n_links = int(input("Enter the values of links = "))

#p = np.random.random(1,1)
p =int(input("Enter the value of p:"))
print(p)
u = int(input("Enter the value of u:"))
print(u)
# Routing cost for demand i on link 1
row = int(input("Enter the number of rows:"))
column = int(input("Enter the number of columns:"))

# Initialize empty matrix
matrix = []
print("Enter the entries row wise:")

# For user input
for i in range(row):        # A outer for loop for row entries
   a =[]
   for j in range(column):      # A inner for loop for column entries
      a.append(int(input()))
   matrix.append(a)

# For printing the matrix
for i in range(row):
   for j in range(column):
      print(matrix[i][j], end = " ")
   print()
A_row = int(input("Enter the value of row of a :"))
A_column = int(input("Enter the value of column of a :"))
#a = np.arange(2).reshape(2,1)
a =np.random.random((A_row,A_column))
a
print(a)


model = LpProblem("Problem", LpMinimize)
variable_names = [str(i)+str(j) for j in range(1, n_links+1) for i in range(1, n_demands+1)]
variable_names.sort()
print("Variable Indices:", variable_names)



DV_variables = LpVariable.matrix("X", variable_names, cat = "Integer", lowBound= 0 )
allocation = np.array(DV_variables).reshape(n_demands,n_links)
print("Decision Variable/Allocation Matrix: ")
print(allocation)

#objective Function

obj_func = lpSum((p+1)*allocation*matrix)
print(obj_func)
model +=  obj_func
print(model)

# First constraints:

for i in range (n_demands):
    print(lpSum(allocation[i][j] for j in range(n_links)) == 1)
    model += lpSum(allocation[i][j] for j in range(n_links)) == 1

# Second Constraints:

for j in range(n_links):
    print(lpSum(a[j]*allocation[i][j] for i in range(n_demands)) <= u)
```

Figure3: Code discussed in the paper referred. Reference number 10

```
    model += lpSum(a[j]*allocation[i][j] for i in range(n_demands)) <= u


#model.solve()
model.solve(PULP_CBC_CMD())

status =  LpStatus[model.status]

print(status)


print("Total Cost:", model.objective.value())

# Decision Variables

for v in model.variables():
    try:
        print(v.name,"=", v.value())
    except:
        print("error couldnt find value")
```

Figure4: Continuation of Code discussed in the paper referred. Reference number 10

```
Enter the value of demands = 2
Enter the values of links = 2
Enter the number of rows:2
Enter the number of columns:2
Enter the entries row wise:
1
2
3
4
1 2
3 4
[6 8]
[60 80]
Variable Indices: ['11', '12', '21', '22']
Decision Variable/Allocation Matrix:
[[X_11 X_12]
 [X_21 X_22]]
3*X_11 + 6*X_12 + 9*X_21 + 12*X_22
Problem:
MINIMIZE
3*X_11 + 6*X_12 + 9*X_21 + 12*X_22 + 0
VARIABLES
0 <= X_11 Integer
0 <= X_12 Integer
0 <= X_21 Integer
0 <= X_22 Integer

X_11 + X_12 = 1
X_21 + X_22 = 1
6*X_11 + 8*X_21 <= 80
6*X_12 + 8*X_22 <= 80
Optimal
Total Cost: 12.0
X_11 = 1.0
X_12 = 0.0
X_21 = 1.0
X_22 = 0.0
```

Figure5: Result of Code discussed in the paper referred. Reference number 10

4.1.CONCLUSION

Telecommunication carriers regularly enter into whole scale contractual agreements with other carriers to access all or part of the other carrier's telecommunication networks and/or telecommunication services. The provider aims at maximizing its profit and minimizing its cost while providing services. Spending the least amount and raising the highest revenue from it. It also aims at maintaining a good quality of service and customer count and to protect itself from competitors. We tried to find the route with minimum cost spent on establishing a route, minimizing the cost of call routing by different methods, nearest neighbours, sub tour heuristic and branch and bound which may help the company to achieve its goals by having a good network layout and connection with minimum cost incurred on it will help company to provide good quality of service, maintain customer base, and reducing its competition. The costs that we obtain in all three methods are almost same but at the same time we find alternative paths too. So the company can decide which path they can choose. We take the total cost of call routing including establishment call, renting, marketing, purchasing etc and the link connection cost also. A python code is also done in order to obtain the optimal result. This paper relates the telecommunication costing with mathematical methods. Service provider can now look mathematically by taking the help of optimization techniques used as to how they can lay down its network to optimise its functioning.

5. CHAPTER 5: REFERENCES

1. Taha., Hamdy A. ***Operations Research an Introduction. Dorley Kindersley.* isbn: 9789332518223. 13.**
2. **Hongle Xu, Song Wang, Soon-Yi Wu.** *Optimization Methods, Theory and Applications.* s.l. : Springer.

3. *"A Review of energy Efficincy in Telecommunication Networks."*. **Naing., Aung.** s.l. : In: Telfor 2.1 , (2010).

4. *"{QUALITY OF SERVICE IN TELECOMMUNICATION NETWORKS}.".* **Magedanz", "Fabricio Carvalho de Gouveia and Thomas.** s.l. : "TELECOMMUNICATION SYSTEMS AND TECHNOLOGIES", Vol. 2.

5. Understanding Routing. *Youtube.* [Online] https://www.youtube.com/watch?v=gQtgtKtvRdo.

6. Introduction to Telephone Systems. *Youtube.* [Online] https://www.youtube.com/watch?v=Tahfluke6cU.

7. *Peak Load Pricing of Telephone Calls.* **Littlechild, S.C.** s.l. : The Bell JOurnal of Economics and Management Services http://www.jstor.org/stable/3003180, 1970, Vol. 1.

8. Microelectromechanical systems. *wikipedia.* [Online] https://en.wikipedia.org/wiki/Microelectromechanical_systems.

9. *Privacy in (mobile) Telecommunications Services 10.1007/s10676-005-5605-9.* **Penders, Jacques.** s.l. : https://www.researchgate.net/publication/226060464_Privacy_in_mobile_Telecommunications_Services, 2004.

10. What are telecom companies 10 biggest expenses? [Online] https://www.quora.com/What-are-telecom-companies-10-biggest-expenses.

11. *Optimal Packet Routing with Multiple Demands and Link Lines.* **Monu, L.N Das.** https://doi.org/10.1007/978-981-16-5987-4_19, s.l. : Tuba, M., Akashe, S., Joshi, A. (eds) ICT Systems and Sustainability. Lecture Notes in Networks and Systems,Springer, Singapore., Vol. 321.

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----------------------- REVIEW 1 ---------------------
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AUTHORS: Tanya Gahlot, Anjali Singh and Laxminarayan Das

----------- Overall evaluation -----------
SCORE: 1 (weak accept)
----- TEXT:
1. The paper looks more like a report then a technical research article kindly check the writing format for technical research article and update your paper accordingly.
2. The author has not cited any reference in the text however all the references must be cited in the text in the chronological order starting from [1].
3. The author need to add recent research articles in the references section and must be cited in the text explaining their literature work and comparing it to the proposed scheme.
4. Section 1 introduction, has various sub-sections which must be removed and it should be written as a single paragraph.
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----- TEXT:
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2. All the references mentioned in the paper should be cited in the text or vice-versa.
3. The table and figures heading should be incorporated and discussed in the text.
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