CATOR

Computational Approach to Operations Research

PROJECT REPORT

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING IN COMPUTER SCIENCE AND ENGINEERING OF THE BHARATHIAR UNIVERSITY, COIMBATORE-641 046

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1991 - 92

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CERTIFICATE

Register No. ...

This is to Certify that the Report Entitled

CATOR COMPUTATIONAL APPROACH TO OPERATIONS RESEARCH

has been submitted by

Mr...

in partial fulfilment of the award of Bachelor of Engineering in the Computer Science and Engineering Branch of the Bharathiar University Coimbatore-641 046 during the academic year 1991 - 1992

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Submitted for the Viva-voce Examination held on : ....

Internal Examiner   External Examiner

ACKNOWLEDGEMENT

We are deeply indebted to **Prof. P. Shanmugam M.Sc.(Engg.), M.S., M.I.E.E.E., M.I.S.T.E.,** Head of the Department of Computer Science and Engineering, whose encouragement lead us in accomplishing this project.

We take this opportunity to thank our Principal **Major T.S. Ramamurthy B.E., M.I.S.T.E.,** for his encouragement during the project work.

We wish to express deep sense of gratitude to our guide **Mr. K. Manikandan B.E., M.I.S.T.E.,** for having encouraged and guided us throughout the course of the work.

A special word of thanks is due to Miss R. Pavai for her constant support and **Mr. G. Balasubramanian** for his able advise.

Finally we wish to thank all our patrons for providing us with all the requisite data.

TEAM MEMBERS.

SYNOPSIS

The project CATOR - Computational Approach to Operations Research is the application of scientific methods, techniques and tools to problems involving the operations of a system so as to provide those in control of the system with optimum solutions to the problem.

CATOR seeks the determination of the best course of action of a decision problem under the restriction of limited resources. This project implements the six OR techniques namely linear programming, transportation, assignment, job - sequencing, travelling - salesman problem and PERT.

Linear programming technique is concerned with the allocation of limited resources among the competing activities in the best possible way to optimize an objective function.

Transportation model deals with the transportation of available goods from various sources or supply centres to different destinations so that the total transportation cost is kept as minimum as possible .

Assignment model is applied to efficiently allocate m jobs to n machines so that the total time or cost of performing jobs will be kept to a minimum or the profit attained will be a maximum.

Job - sequencing is concerned with the situation where the effectiveness measure is a function of the order or sequence in which a series of tasks or jobs are performed.

Travelling - salesman problem deals with the selection of a route by a salesman that will minimize the total distance travelled in visiting n cities and returning to the starting point.

PERT - Program Evaluation and Review Technique is network model used to determine an optimum sequence of performing certain operations concerning jobs in a project in order to minimize the overall time and cost.

The above techniques used in CATOR helps in solving the problems arising in an industrial evironment.

A project in its real sense is meaningless without having an application. We have taken note of this fact and has included real time applications for the different tools in CATOR. This infact, shows the importants of the subject Operations Research in our daily life.

A bus - scheduling problem is speficied as a linear programming model and is shown that money, materials and time can be saved by its application. Transportation model finds its usage for a car distribution agency for which Transportaion costs are minimized. Another application is for a Tea Factory for minimizing the Transportaion cost in transporting tea from the factories to the warehouses. Real time datas are taken from an industry to show the importance of both assignment and job-sequencing tools and the optimal assignment and the correct sequence in which jobs are to be processed so as to maximize the profit by reducing the cost and time. Selection of the shortest distance for a salesman in visiting many cities is the area where the travelling salesman tool is applied.

We have given the areas of application of our project CATOR. But CATOR even finds its use in many other diverse fields also.

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INTRODUCTION

1.1. CATOR

CATOR is a software package applicable to problems arising from operations involving integrated systems of men, machines and materials. It is also an aid for the executive in making his decisions by providing him with the needed information based on the scientific methods of analysis.

The project provides a scientific and logical approach to the problem and helps in obtaining the best possible solution. Thus difficulties arising in every department of a business organization can be solved using the various tools provided by CATOR.

The six modules are applicable in definite fields so as to obtain best possible solutions. For example, transportation problem is applied to a business environment when factories are located at some places and ware-houses at some other places. The ultimate aim is to minimize the transportation cost. This is achieved by the use of scientific techniques and mathematical tools.

The project also finds its application in many diverse fields as engineering, defence, town-planning etc.

1.2. SCOPE OF O.R

In any business organization, the executive is interested in maximizing the profit or minimizing the cost or expenses. The term involved is optimization signifying the maximization or minimization of the effectiveness function. The three entities which control any business are money, men and machines. The capital is required to start and carry on the business. Man-power is needed to handle the machineries involved in an industry to produce goods. These three parameters have to be co-ordinated in the best possible way to get the maximum benefit to any business concerned.

Operations Research aims at a scientific and logical approach to the problem and derives the best solution to the problem.

In business organizations, revulutionary changes have brought considerable increase in the division of labour and compartmentalisation of management responsibilities. Now-a-days, there are separate departments for purchase, production, sales, finance and personnel. This gives rise to various problems to all the departments while funcitoning together as a single unit.

CHAPTER II

TECHNIQUES OF O.R

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TECHNIQUES OF O.R

2.1. LINEAR PROGRAMMING

2.1.1. Introduction

Linear programming is used to find a solution for optimizing a given objective such as profit maximization or cost minimization under the given restictions. The technique effectively distributes the availabel resources to all the related fields in the best possible way.

The name Linear programing is because of the fact that the model in such cases consists of linear relationship between the different variables involved in the system. There are many situations to which linear programming technique can be applied. A few of them are stated below:

1. Product - mix problems in industries.
2. Allocation of available man-power, machine - hours to different activities.
3. Production scheduling problems.

In all the above situations the one common feature is the necessity for allocation of resources to activities.

2.1.2. Linear Programming Model

A linear programming model consists of a set of constraints eqations and an objective function. The constrainsts equations restricts the values of the variables involved in the problem. The objective function may be either maximization or minimization.

The construction of the mathematical model involves three main steps.

1. To define the variables which are the unknowns in the problem.
2. To determine the constraints that must be imposed as the variables to satisfy the limitation of the modeled system.
3. To study the objective or the goal that needs to be acheived in order to determine the best solution from among all the feasible solutions of the variables.

The LP model is formulated as follows:

For n decision variables, the objective function is to maximize or minimize.

$$Z = C_1 x_1 + C_2 x_2 + \dots + C_n x_N$$

Where,

C_i = Profit or cost co-efficient of the ith variable and

Z = function to be maximized or minimized.

Let

a_{ij} = co-efficient of the jth constraint and ith variable.

b_i = resource limitation for ith constraint. Then the restrictions may be expressed in the general form.

$$a_{11}\, x_1 + a_{12}\, x_2 \;\cdots\; + a_{1n}\, x_n \qquad b_1$$

$$a_{21}\, x_1 + a_{22}\, x_2 \;\cdots\; + a_{2n}\, x_n \qquad b_2$$

$$a_{m1}\, x_1 + a_{m2}\, x_2 \;\cdots\; + a_{mn}\, x_n \qquad b_m$$

and x_i 0 for all values of i from 1 to n. The inequalities may be lesser than or equal to also as the case may be. The properties of the standard LP form are

1. All the constraints are equations with non negative right hand side.
2. All the variables are non-negative.
3. The objective function may be maximization or minimization.

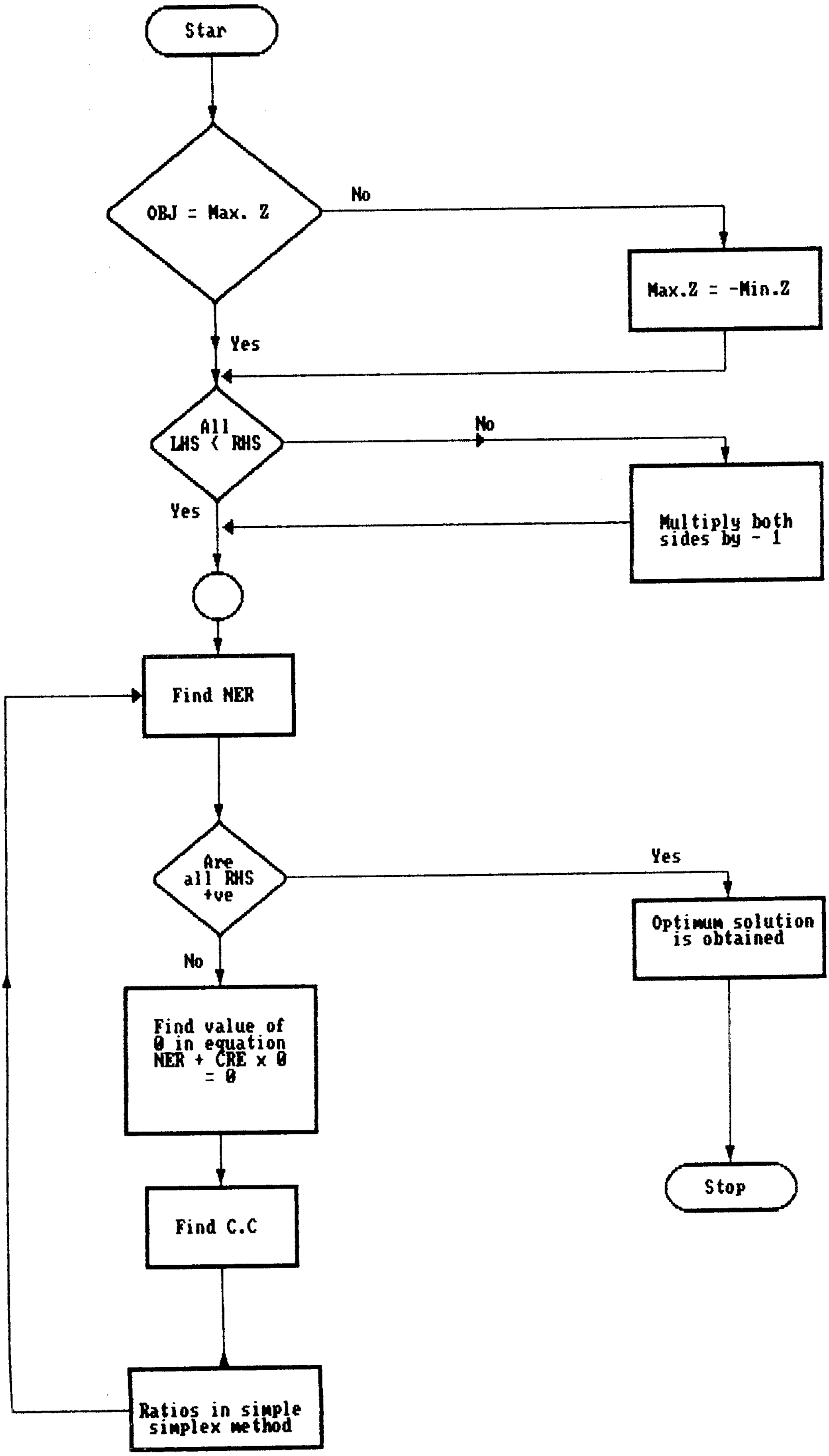
2.1.3. Algorithm

The method used to solve the linear programming technique is the two - phase simplex technique which supports the induction of artificial variables. The idea of using artificial variables is quite simple. It calls for adding a non-negative variable to the left side of each constraints equation that has no obvious starting basic variables. As the name suggests, the two-phase technique consist of two phases.

Phase I. Augment the artificial variables as necessary to secure a starting solution. From a new objective function which seeks the minimization of the sum of the artificial variables subject to the constraints of the original problem modified by the artificial variables. If the minmum value of the new objective function is zero (meaning that all artificials are zero), the problem has a feasible solution space. Go to phase II. Otherwise, if the minimum is positive the problem has no feasible solution. Stop.

Phase II. Use the optimum basic solution of phase as a starting solution for the original problem. It is also noted that in phase II, the artificial variables or removed only when they are non basic at the end of phase I.

2.1.4. TWO PHASE SIMPLEX



2.1.5. Application

Linear programming finds its application in many fields ranging from business management to planning. Thus an optimum solution can be obtained using the module to any problem involving various factors.

Mostly the technique is applied in industries and the module helps in the economic use of production factors thus helping industries to efficiently select and distribute the available resources. The module also provides different optimum solutions so that the management can choose the one which suits to them in the most practical way. It also provides the executives with a better quality of decision.

To prove the enormous areas of its application, the project has worked on real time datas from the Cheran Transport Corporation and also from the Kerala State Road Transport Corporation in efficiently formulating a bus - scheduling problem.

2.2. TRANSPORTATION

2.2.1. Introduction

Transportation model is concerned with the transportation of available goods from various sources or supply centres to different destinations, so that the total transportation costs are kept as minimum as possible. The transportation model is basically a linear program that can be solved by the regular simplex method. However, its special structure allows the development of a solution procedure, called the transportation technique, that is computationally more efficient.

In the direct sense, the transportation model seedk the determination of a tranportation plan of a single commodity from a number of sources to a number of destinations. The data of the model include:

1. Level of supply at each source and amount of demand of each destination.
2. The unit transportation cost of the commodity from each source to each destinations.

2.2.2. Transportation Model

The basic assumption of the model is that the transportation cost an a given route is directly proportional to the number of units transported. In this module, we deal only with systems in which the total supply equals the total demand. In real life, it is not necessarily true that supply equals demand or, for that matter exceed it. However, a transportation model can always be balanced. The balancing, in addition to its usefullness in modelling certain practical situations, is important for the development of a solution method that fully exploits the special structure of the transportation model.

To illustrate a typical transportation model, suppose m factories supply certain items to n warehouses. Let factory i ($i = 1,2, .., m$) produce a_i units and the warehouse j ($j = 1, 2, ..., n$) requires b_j units. Suppose the cost of transportation from factory i to warehouse j is c_{ij}. The decision variables x_{ij} are the amount transported from the factory i to the warehouse j. The objective is to find the transportation pattern that will minimize the total transportation cost.

The model of a transportation problem can be represented in a concise tabular form with all the relevant parameters as follows.

Origins (Factories)	Destinations (Warehouses) 1	2	.....	n	Available
1	C_{11}	C_{12}		C_{1N}	A_1
2	C_{21}	C_{22}		C_{2N}	A_2
...	...			...	...
m	C_{m1}	C_{m2}		C_{mn}	A_M
Required	b_1	b_2		b_m	

The pattern of distribution of items in the form of a transportation matrix is given in the following table.

Origins (Factories)	Destinations (Warehouses) 1	2	.....	n	Available
1	X_{11}	X_{12}		X_{1N}	A_1
2	X_{21}	X_{22}		X_{2N}	A_2
...	...			...	...
m	X_{m1}	X_{m2}		X_{mn}	A_M
Required	b_1	b_2		b_m	

The transportation problem can be represented mathematically as a linear programming model. The objective function in this problem is to minimize the total transportation cost given by

$$Z = C_{11}X_{11} + C_{12}X_{12} + \dots + C_{mn}X_{mn}$$

subject to the restrictions.

Row restrictions

$$X_{11} + X_{12} + \dots + X_{1n} = A_1$$
$$X_{21} + X_{22} + \dots + X_{2n} = A_2$$
$$\dots$$
$$\dots$$
$$\dots$$
$$X_{m1} + X_{m2} + \dots + X_{mn} = A_m$$

Column restrictions

$$X_{11} + X_{12} + \dots + X_{m1} = B_1$$
$$X_{21} + X_{22} + \dots + Xm2 = B_2$$
$$\dots$$
$$\dots$$
$$\dots$$
$$X_{m1} + X_{m2} + \dots + X_{mn} = Bn$$

and $X_{11}, X_{12}, \dots, X_{mn} \quad 0$

It should be noted that the model has feasible solutions only if

$A_1 + A_2 + \dots + A_m = B_1 + B_2 + \dots + B_n$

The above is a mathematical formulation of the transportation problem and the linear programming technique with equality constraints is used.

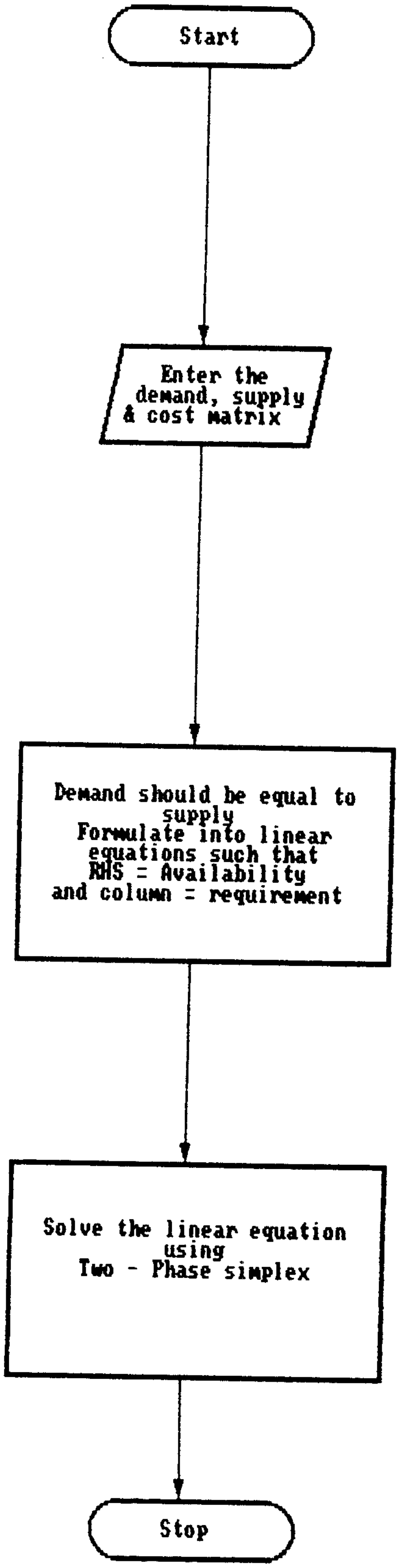
2.2.3 Algorithm

The transportation model employs the Vogel's Approximation Method (VAM) to solve the technique. The method is a heuristic and provides a starting solution, which is close to optimum. The method is based on the difference associated with each row and column in the matrix giving unit cost of trnsportation C_{ij}. The difference is defined as the arithmetic difference between the smallest and next tothe smallest element in that row or column.

The algorithm is as follows:

1. Represent the transportation problem in the standard tabular form.
2. Select the smallest element in each row and the next to the smallest element in that row. Find the difference. This is the penalty written on the right hand side of each row. Repeat the same for each column. The penalty is written below each column.
3. Select the row or column with largest penalty. If there is a tie, the same can be broken arbitrarily.
4. Allocate the maximum feasibly amount to the smallest cost cell in that row or column.

2.2.4. TRANSPORTATION



5. Allocate zero elsewhere in the row or column where the supply or demand is exhausted.
6. Remove all fully allocated rows or columns from further consideration. Then proceed with the remaining reduced matrix till no rows or columns remain.

2.2.5. Application

The transportation model is of very much use to industries where factories are located at some places and warehouses are located at some other places. The aim is to transport the commodities from the factories which are the sources to the warehouses which are the destinations. The ultimate aim is to minimize the total transportation cost.

The module can be applied very efficiently to various industries ranging from oil -refineries to heavy industries. The technique can also be applied in electricity distribution, milk marketing, water supply systems etc. which happen to play an important role in our daily life.

To show the effectiveness of the model, the project uses real time datas from M/S Peria Karamalai Tea & Produce

Co. in the transportation of quality dust tea from the factories to warehouses thus minimizing the total transportation cost.

2.3. JOB - SEQUENCING

2.3.1. Introduction

Job sequencing is an approximate order for a series of jobs to be done on a finite number of service facilities, in some pre assigned order so as to optimize the total involved cost. A practical situation may correspond to an industry producing a number of products, each of which are to be processed through different machines. Sequencing problems are concerned with a situation where the effectiveness measure is a function or sequence in which a series of tasks or jobs are performed.

2.3.2. Job Sequencing Model

Let there be n jobs each of which has to be processed one at a time, on each of the m different machines. The order in which these machines are to be used for processing each job as well as the expected or actual processing time of each job on each of the machines is known as the sequencing problem, then the aim is to slelct from the theoretical feasible alternatives the one that is both technologically feasible and minimizes the total elapsed time.

Terminology and notations used in sequencing

Number of Machines

A job must pass through service facilities before it is completed.

Processing Order

The order in which various machines are required for completing the job.

Processing Time

Processing time is the time, each job requires at each machine.

Idle Time

This is the time a machine remains idle during the total elapsed time.

Total Elapsed Time

The time between starting the first job and completing the last one. If there is any idle time it is included.

No Passing Rule

The rule is that the same order of jobs is maintained over each machine.

Problems Concerning N Jobs and Two Machines

If there are n jobs, each of which is to be processed through two machines each of these jobs will go to machine 1 and then to machine 2.

2.3.3. Algorithm

1. Examine the M_{i1} and M_{i2} for $i = 1,2, \ldots n$ and find out min (M_{i1}, M_{i2}).
2. If this minimum be M_{ki} for some $i = k$ process the k^{th} job first. If this minimum be M_{ri} for some $i = r$, process the r^{th} job last.
3. If there is a tie for minima $M_{ki} = M_{ri}$ process the k^{th} job first of all and the r^{th} job last. If the tie for minimum occurs among the M_{i1}'s select the job corresponding to M_{i2}'s and process it first of all.

While dealing with sequencing problem certain assumptions are made.

1. Only one operation is carried out on a machine at a time.
2. The processing times are known.
3. Processing times are independent of order of processing the job.
4. The time involved in moving the job from one machine to another is negligible.
5. An operation must be completed, once started.
6. Only one machine of ech type is available
7. A job is processed in the order to be specified.

Problem with N Jobs and M Machines

Let there be n jobs each of which is to be processed through m machines say M_1, M_2, ... M_n in the order M_1, M_2, .. M_N.

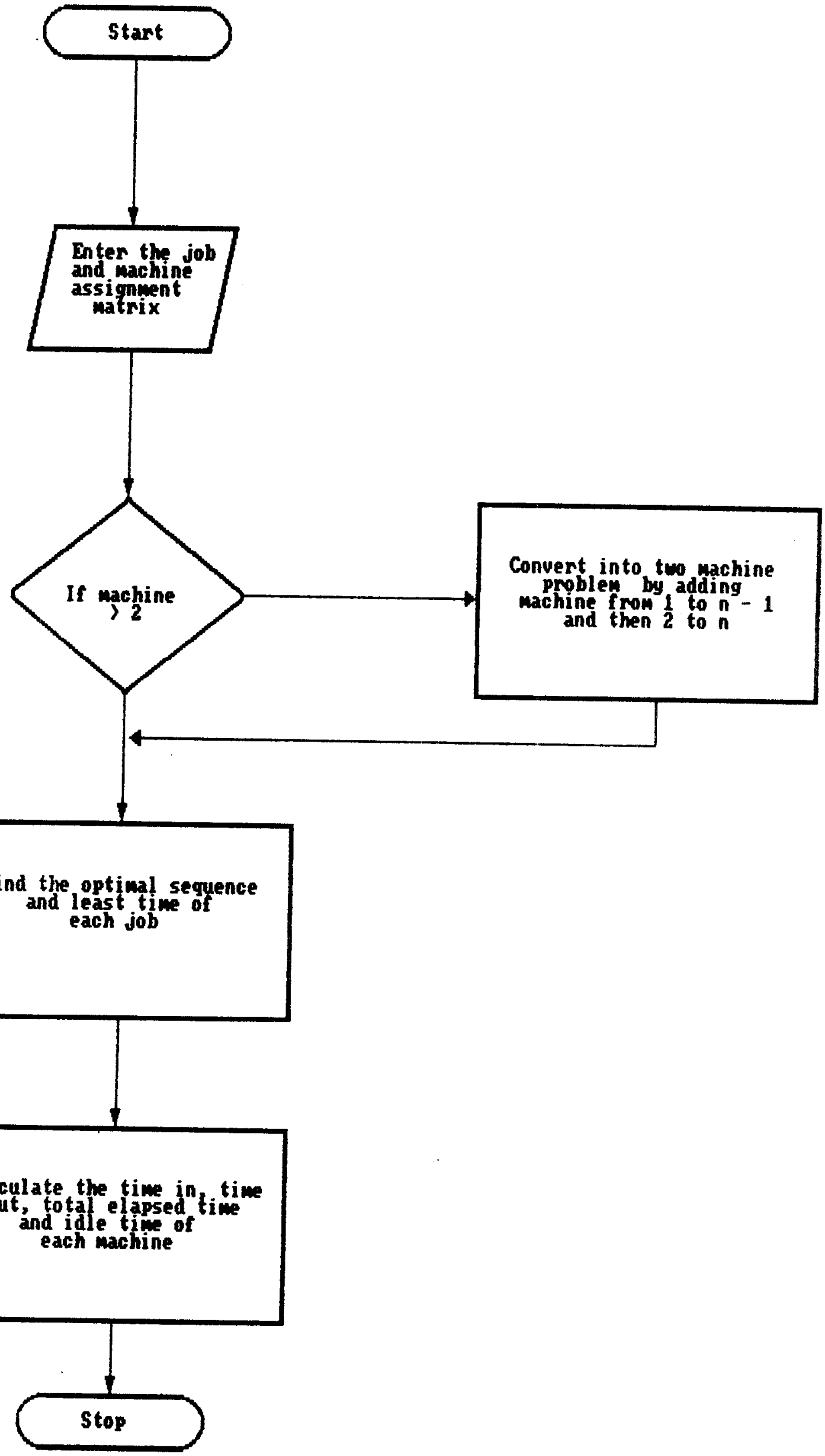
Algorithm

1. Find minimum and maximum of each M_{i2}, M_{i3}, .. M_{im-1} for i = 1, 2, 3, ..., n.
2. Find minimum of M_{i1} Maximum of M_{ij} for j = 2, 3, .. m-1

or

Find minimum of M_i Mim Maximum of M_{ij} forj = 2, 3, ..m-1

2.3.4 JOB-SEQUENCING



3. If the inequations of step 2 are not satisfied, method fails otherwise go to next step.

4. Convert the m machine problem into two machine problem by introducing two fictious machines G and H.

$$Mig = M_{i1} + M_{i2} + \ldots\ldots + M_{im} - 1$$

$$Mih = M_{i1} + M_{i2} + \ldots\ldots + M_{im}$$

Determine the optimal sequence of m jobs through 2 machines by using optimal sequence algorithm.

5. In addition to conditions given in step 4

If $M_{i2} + M_{i3} + \ldots\ldots M_{im-1} = C$

is a fixed positive constant for all

$i = 1, 2, ..n$ then, determine the optimal sequence for n jobs and two machines M_1 and M_m in the order M_2 M_m

2.3.5 Application

Job sequencing is applied to find the best order of placement of jobs to various machines so as to utilise the available resources to the maximum.

The module uses the advantages of the digital computer in solving problem so as to find the optimal sequence to process n jobs on m machines. The tool finds its application in fields as business management, industries and agricultural product units.

ASSIGNMENT

2.4.1 Introduction

The assignment model is applied to efficiently allocate m jobs to n machines. It is interesting to find the assignment of these jobs to different tasks so that the total time or cost of performing jobs will be kept to a minimum or the profit attained will be a maximum. Then the objective function in assigning the different jobs to different machines is to find the optimal assignment that will minimize the total time taken to finish all the jobs by the machines.

2.4.2 The Assignment model

The assignment problem is a special case of the transportation problem in which the objective is to assign a number of origin to the equal number of destinations at a minimum cost or maximum profit. The assignment is made on a one-to-one basis given an n x n array of real numbers representing the individual return associated with assignment one item to one machine. The best assignment is to be found so that the total return is optimal. The solution to an assigment problem is based on the following theorem

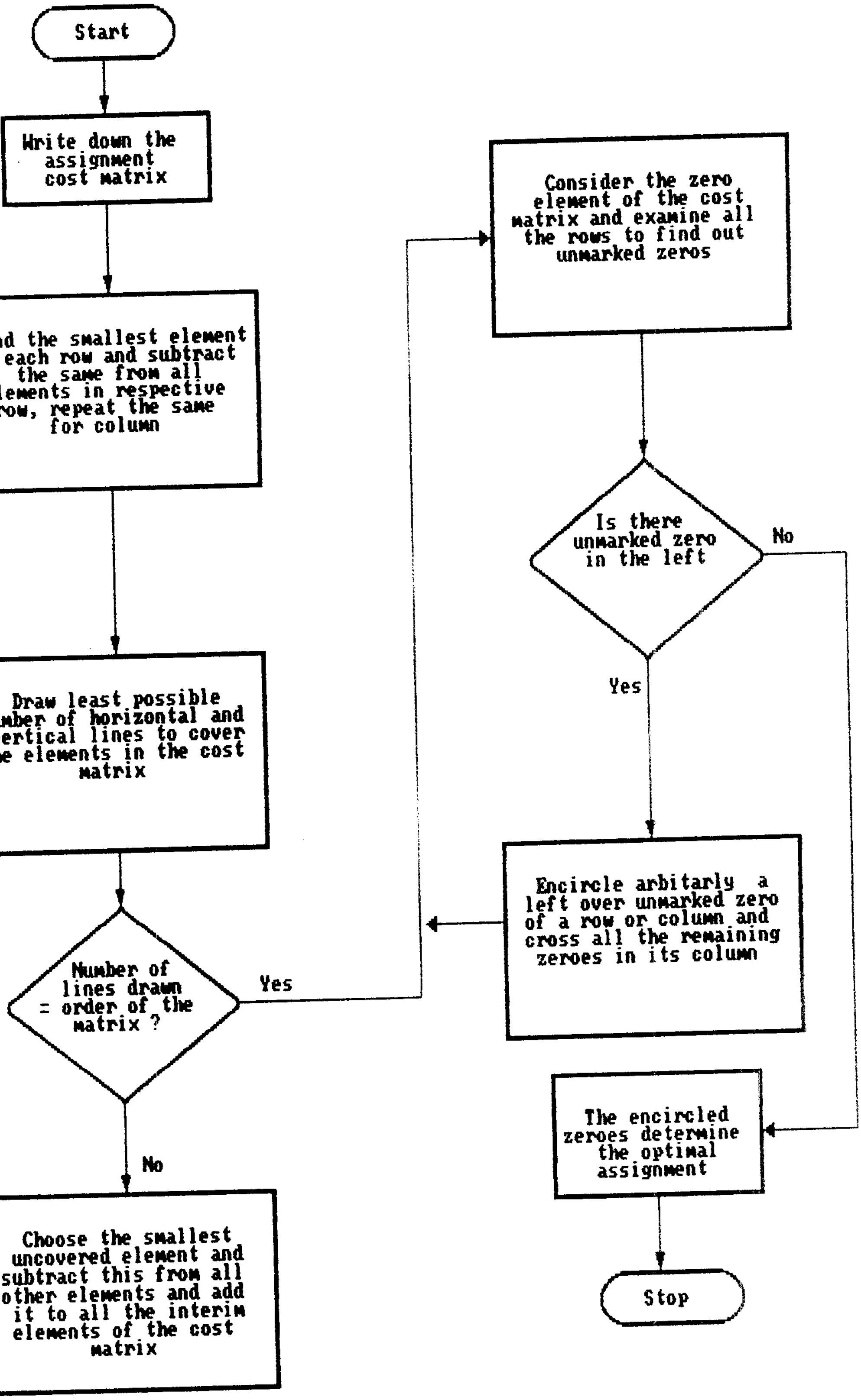
If in any assignment problem, we add a constant to every element of a row or column in the effective matrix, then an assignment that minimizes the total effectiveness in one matrix also minimizes the total effectiveness in the other matrix.

Hungarian Assignment Method

2.4.3 Algorithm

1. Write down the assignment cost matrix of the cost matrix of the problem.
2. Find the smallest element in each row and substract the same from all elements of respective rows.
3. Find the smallest element in each column and substract the same from all elements of respective colmns.
4. Draw lease possible number of horizontal and vertical lines to cover the zero elements in the cost matrix.
5. Check if the number of lines drawn equals the order of the matrix.

2.4.4. ASSIGNMENT



6. If it is not equal, choose the smallest elements of the cost matrix subtract this element from all the uncovered elements and add the same at all the intersection elements of lines.
7. Repeat step 4 and check.
8. If it is equal, an optimum solution is obtained.
9. Consider only the zero element of the cost matrix. Examine all the rows and columns successfully to find out one with exactly one unmarked zero. Encirclethis zero and cross all the remaining zeros in the column.
10. Check if there is any unmarked zero left.
10. (a) If there is then encircle arbitarily a left over unmarked zero of a row (column) and cross all the remaining zeros in its column (row). Then an optimal solution is obtained.
10. (b) Repeat step 6 and check.
11. If there are no unmarked zero left then the encircled zeros determine the optimal assignment.

2.4.5 Application

The assignment model can be applied sc as to efficiently distribute n jobs to m machines thus minimizing the time and cost. The module is very helpful in situations arising in industries where a final product is obtained after processing through many machines. For example in a tool manufacturing unit, the final product which is a tool is made only after doing various process as shaping, grinding, boring etc. in the respective machines.

The aim of the executive is to minimize the time and cost using the assignment algorithm.

A real time application of the module is given using datas from m/s Prasad Engineering Works, Coimbatore.

TRAVELLING - SALESMAN

2.5.1 Introduction

The travelling salesman technique deals with the selection of route by a salesman, that will minimize the total distance travelled in visiting n cities and returning to the starting point without returning to the city already visited. The salesman can save very much money and time with proper planning using the travelling - salesman model.

2.5.2 Travelling - Salesman Problem

Suppose a salesman has to visit n cities. He wishes to start from a particular city once, and then return to his starting point. The objective is to select the sequence in which the cities are visited in such a way that is total travelling time is reduced. Starting from a given city, the salesman will have a total of (n - 1) ! different possible round trips. Further since the salesman has to visit all the n cities the optimal solution remains indipendent of selection of starting point.

The problem can be represented as a network where the nodes and arcs represent the cities, and the cities and the distance between then respectively. Let in a five city problem, a round trip of the salesman be given by the following arcs.

(3,1), (1,2), (2,4),(4,5), (5,3),

These arcs taken in order are called the first, second, third, fourth and fifth directed arcs for the trip. In general the Kth directed arc represent the Kth leg of the trip. that is on leg k the salesman travels from city i to j.

To formulate the problem whose solution will yeild the minimum travelling time.

X_{ijk} = 1 if the Kth directed arc is from city i to city j.

= 0 otherwise

Where i, j and k are integers that vary between 1 and n.

Following are the constraints of the problem.

1. Only one directed arc may be assigned to a specific k.
2. Only one other city may be reached from a specific city i.
3. Only one other city can intiate a direct arc to a specified city j.
4. Given the Kth directed arc ends at some specific city j the $(K + 1)^n$ directed arc must start at the same city j.

These constraints ensure that the round trip will consist of connected directed arcs. The objective function is to minimize the total distance.

2.5.3 Algorithm : Eastman algorithm

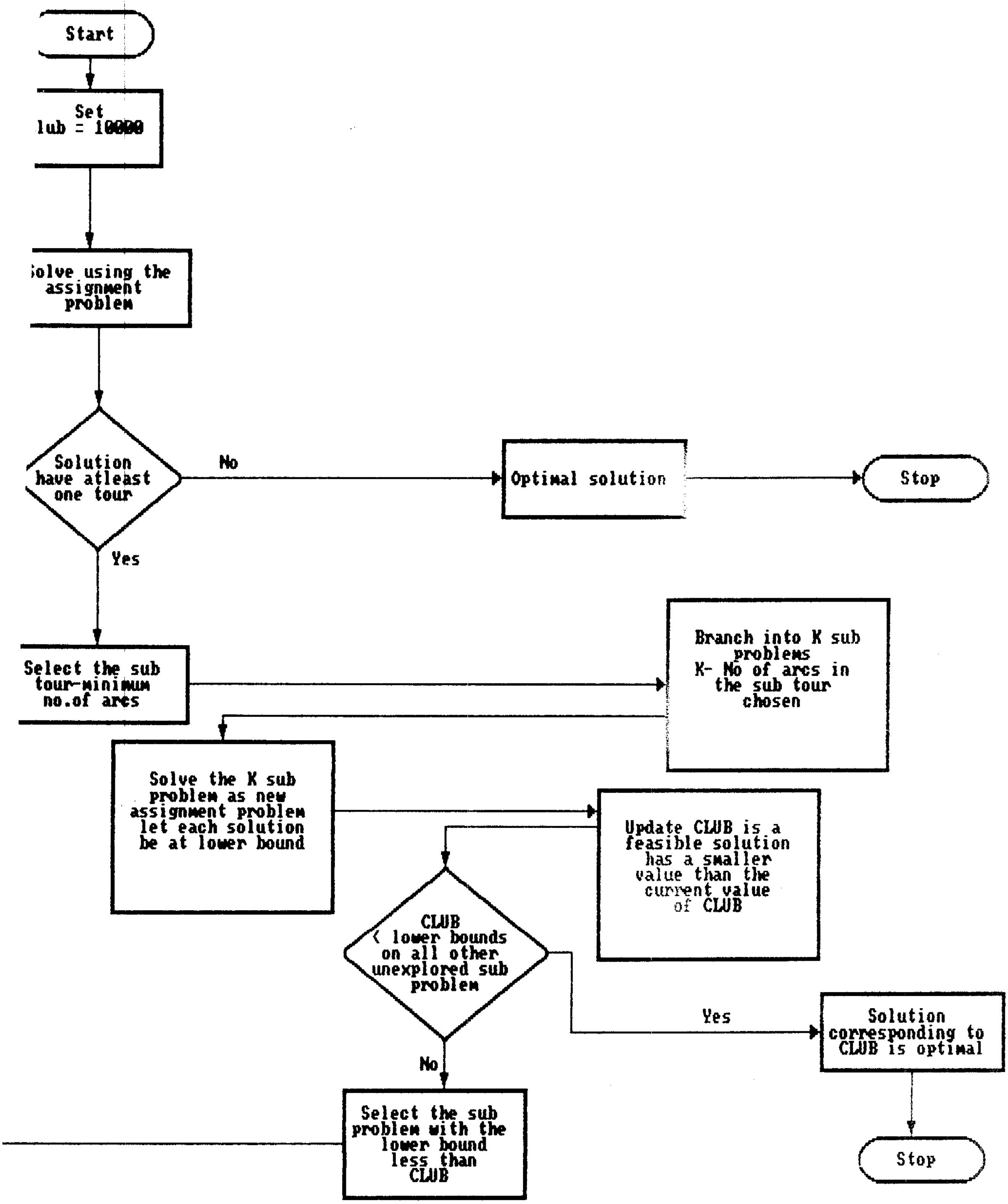
1. Let CLUB represent the current lower bound on the optimal solution of the travelling - salesman problem.
2. Solve the associated assignment problem wherethe distance D (I,J) are the elements of effectiveness matrix. If atleast one subtour exist in the solution go to step 3, otherwise the optimal solution of the assignment problem is also an optimum solution of the travelling - salesman hence terminate the process.
3. Select a subtour and let K be the number of arcs in the selected subtour Eastman selects the subtout with the smallest number of arcs.
4. Branch into K sub problem. If the subtour is

   $I_1 \rightarrow I_2 \rightarrow \ldots\ldots\ldots\ldots I_k \rightarrow I_1$

   let $D(I_1, I_2) = 2$, for sub problem 2

   $D(I_2, I_3) = 2$
5. Solve the k new assignment problems. Each solution distance is a lower bound for the corresponding sub problems.

2.5.4. TRAVELLING SALES-MAN



6. If there are one or more feasible solutions from step 5 and if the smallest total distance for these feasible solutions say small then set CLUB = small.
7. If CLUB is less than the lower bounds on all other unexplained subproblems, then the solution corresponding to CLUB is an optimal solution of the travelling - salesman problem. Go to step 8.
8. From the set of all unexplored non feasible sub problems with a bound less than CLUB, select the sub problem with the smallest lower bound further branching.

2.5.5. Application

The module is applied to find the best route to be traced by salesmem so that he can come to the starting point after visiting all the places thus the minimizing the distance travelled.

The tool finds its used for customers service department and sales department of all industries. The executive is concerned with having a good distribution and serving facility with minimum time and cost.

To demonstrate the efficient use of the module real time datas are worked upon from 'English Electric Company', Madras.

PERT

2.6.1 Introduction

PERT -Programme Evaluation and Review Technique is a planning and scheduling technique in which the overall time and cost are kept to a minimum. Every job is reprsented by an arrow, the precedence and successor relationship of all jobs are listed and a network is prepared. The chief aim of drawing the network is to find the critical activities constituting the critical path.

The technique is proved to be useful in planning and scheduling large projects consisting of numerous activities whose completion times are uncertain and are independent of one another. 'Event' means reaching a certain stage of completion of the project.

A 'network' is defined as a graphic representation with a flow of some type in its branches. It represents nodes and branches. A node is the intersection of two branch lines. It is denoted by a circle. Each node represent an event which is a specific definable accomplishment recognizable at a particular instant of time. The arrow - heads indicate the sequence in which evnts must be achieved.

2.6.2 Pert Model

In 'PERT' an arrow diagram represent a project graph. Each activity is represented by an arrow connecting two nodes, representing two events. The start of an activity is identified by the tail of the arrow and the completion of the acitivity is identified by the head of the arrow.

```
  (1)---------------------------- (2)
 node           branch            node
```

In case of project, since large number of activities are involved, it is very difficult to establish the exact time for completion of each and every activity. Hence it is only possible to find out the probabilistic times of completion of the project.

t_0 - optimistic time.This is the time below which an activity cannot be performed if everything goes well.

t_p = pessimistic time. This is the greatest time that will be consumed to complete an activity if everything goes wrong.

t_m = most likely time.

t_e = expected time

$= (t_0 + 4t_m + t_p)/6$

standard deviation can be given by the formula

$s_t = (t_p - t_0)/6$

the varience V_t of expected time is calculated as the squence of the deviation.

$V_t = [(t_p - t_0)/6]^2$

2.6.3 Algorithm

1. Find the optimistic time.
2. Find the pessimistic time.
3. Find the expected time for the activity from the formula below

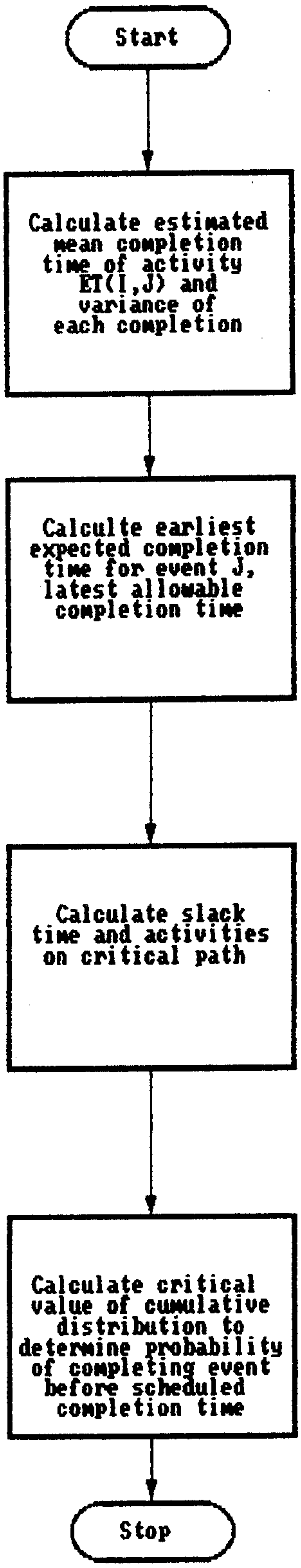
   $t_e = (t_0 + 4t_m + t_p)/6$ where,

   t_0 = optimistic time.

   t_p = pessimistic time.

   t_m = most likely time.
4. Find the standard deviation of the probability distribution to notethe measure of variability of possible activity times.

2.6.4. PERT


Start
Calculate estimated mean completion time of activity ET(I,J) and variance of each completion
Calcululte earliest expected completion time for event J, latest allowable completion time
Calculate slack time and activities on critical path
Calculate critical value of cumulative distribution to determine probability of completing event before scheduled completion time
Stop

Standard deviation can be given by

$$S_t = (t_p - t_0)/6$$

5. Find the varience V_t of expected time from the formula

$$V_t = [(t_p - t_0)/6]^2$$

6. Find the expected length of the entire project after calculating the expected length (t_e) of every activity with the weights attached to the three time estimates.
7. Finally, final the critical path and length of the critical path is the sum of the t_e's of all activities along the critical path.

2.6.5 Application

PERT is useful in research and development projects in order to minimize the overall time and cost.

The following are the suggested application when PERT is found useful.

1. The construction of a building or of a highway.
2. Planning and launching a new product.
3. Scheduling maintenance for a project.
4. The manufacture and assembly of a large machine tool.

5. To conduct a music or drama festival.

6. Preparation of budget for a company.

The project uses real time datas from M/s. Pioneer Constructions to demonstrate the usage of the module in minimzing the time and cost involved in a project.

CHAPTER III

DEVELOPMENT OF SOFTWARE

3.1 The software concept

The various tools available to solve the problem will be displayed based on the type of the problem, the user has to choose a tool. For a same problem different tools will be available. It is left to the user to decide the tool.

3.2 System flowchart

The entire software comprises of several modules. Each module is classified as one of the tool of operations research. The flow of control through the entire software is basedon the choice of the system used at every stage. The flow chart in fig.1.1 depicts the various flow paths.

3.3. Description of modules

The main program consists of several modules. Each module is written and executed separately. When a

CHAPTER IU

CONCLUSION & FUTURE DEVELOPMENT

CHAPTER V

APPENDICES

CHAPTER – VI

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