MATHEMATICAL MODEL FOR STAFF SCHEDULING PROBLEM IN HOSPITAL MANAGEMENT USING LINGO SOLVER

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Abstract:

Scheduling plays a vital role in todays scenario in all organizations right from allocation of resources, budget estimation, financial planning and demand forecasting. These are the functions in which scheduling plays a essential part in day today activities. The success of organization based on the effectiveness of planning and scheduling operations within the organization. Scheduling has predetermined time interval within which we have to assign all activities as per plan subjected to given constraints. Each schedule event will have a start time and end time within the estimated limit the proposed function or particular activity must be done smoothly without affecting the resources. The resources such as raw material, men, machines and money are the challenging constraints in any private or public organization. In this paper attempt has been made to estimate manpower scheduling requirements in a hospital management system. First the problem is to be solved using mathematical solver such as LINGO solver for various problem sizes then it is to be compared with algorithm in terms of solution accuracy and computational time.

Keywords: Scheduling, LINGO Solver, Computational time, Manpower

1. Introduction:

The success of any organization depends upon efficient scheduling of manpower requirements. The service satisfaction of hospital management system can be defined by in terms of proper scheduling and allocation of manpower to address the patients in hospital environment very day. Nowadays due to increasing demand in health care system hospitals face a challenge in proving the efficiencies in taking care of daily routine operations. The management of workforce in medical hospital is one of the crucial tasks. The allocation of staff under specific time interval is said to be the challenging job in today hectic work environment if any one is not reporting to the duty, we have to look for other alternate sources. So, in every hospital management system there will regular staffs and also contract workers will be working together in order to reduce the burden of non-availability of workforce. Efficient staff scheduling will lead to enormous quality and performance. The main objective of scheduling is to ensure the availability of staffs in the work place in order to serve the patients in the need able time without risking the life of others. Hence in this paper attempt has been made to develop mathematical using LINGO Solver for various test problems by considering the objective of minimizing the staff requirement in critical period or during emergency condition in each day. Linear programming model is considered in this paper with the following constraints such as number of staffs needed in each time interval. Then later the performance of simple efficient algorithm is compared with that of model.

2. Literature review:

Maria .M.Rinder [1] in this article authors have Carried out extensive literature survey in the area of Industrial engineering applications in staff scheduling of hospital systems from the existing literature authors have collected various tools and techniques such as Mathematical Programming , Data Mining ,Genetic Algorithms and local searches for optimum schedules are gathered from literatures. These are the new tools and techniques which helps to solve problems in staff scheduling problems. Key findings obtained from these studies are reduced time of scheduling plan for patients.

Joren Marynissen [2] This article gives the review about fully flexible integrated hospital systems in planning and scheduling. Patients needs to visit several resource types within the hospital setup to receive complete treatment as per given scheduled appointments. The main aim of this problem is to serve each patient completely till end. Integrated hospital scheduling

has given more importance quite nowadays. Integrated scheduling of resources can be augmented with all necessary facilities to under smooth flow of operations.

Ping Shun Chen [3] In order to study the inter hospital resource allocation and scheduling problems author has approached pooling resource concept to assign medical staffs according to the requirement of monthly schedules. In this research three algorithms are preferred such as HRA1 (Human Resource Allocation based on hospital size), HRA2 (Human Resource Allocation based on average allocation) and HRA3 (Human Resource Allocation based on severity). From these heuristic procedures it is clear that hospital managers can make final decisions concerning the allocation and scheduling of staffs in the hospitals.

Wael Rashwan [4] Over a several period of years main concern in hospital management is optimising the staffing and scheduling problems. The comprehensive review of research is presented with three dimensions problem frame work, solving approach, evaluation perspective and uncertainty. By using optimization mathematical model users can provide solution for both staffing and scheduling decisions. In this paper author has considered multiple factors like coordination, environment complexity, underutilization of staffing, variability and lack of decision support. Multi-dimensional approach such as data analytics, Modelling, simulation, Machine learning and optimization has been used in order to deliver adequate staffing and shift scheduling framework.

John .S.Dean [5] In this paper author has defined the role of staff scheduling by assigning staffs as per time slots in order to satisfy the constraints. In this research genetic algorithm was implemented for scheduling nurses in the hospital. In this study two types of chromosomes are considered such as one-bit chromosome traditional in type which is used to represent each schedule and the other one two – dimensional array chromosome to represent each schedule. From the experiment results it is clear that two-dimensional array chromosome outperforms faster than single bit chromosome.

Micheal Morz [6] In this paper work rotation scheduling problem plays an important role for solving work related schedule assignment of staffs. In this paper genetic algorithm is presented is of two types such as mutation operator and three methods for crossover are presented. Finally, the results are compared from benchmark problems.

Kimmo Nurmi [7] Workforce planning considers have for the most part centred around staff rostering, for example allotting representatives to shifts and deciding working days and rest days. In the ongoing years, the age of movements has increased expanding enthusiasm for scholastic network. Move age is the way toward deciding the move structure, alongside the assignments to be completed specifically moves and the capabilities required for various movements. Application regions of staff rostering and move age incorporate medical clinics, retail locations, call focuses, cleaning, home consideration, guarding, assembling and conveyance of products. This paper presents the General Task-based Shift Generation Problem (GTSGP). Apparently, the issue has not been concentrated in the writing. The GTSGP is to make mysterious moves and allot errands to these shifts with the goal that workers can be doled out to the movements. The focused-on errands must be finished inside a given time window. Undertakings may have priority imperatives and progress times between assignments are thought of. The objective is to amplify the quantity of movements workers can execute. We present the first computational aftereffects of unravelling GTSGP occasions. We quickly depict the PEAST calculation, which is utilized to fathom the test occurrences.

Bilgen ayan-koc [8] Among the faculty booking issues, nurture planning issue (NSP) is touchier and more significant since it is explicit and identified with human wellbeing. In this examination, it is planned to make the best work routine for 15 attendants working in 2 movements at an emergency clinic working 24 hours per day by utilizing Simulated Annealing (SA) Algorithm. The strengthening calculation created inside the extent of the exploration was composed without any preparation by keeping up yet building up the essential rationale of the overall tempering calculation. The issue tended to by the calculation which was required to give the best booking to the medical attendants by fulfilling every one of the 16 imperatives were illuminated by the created calculation. (All things considered, was determined as 34 seconds (min.150-max.1,338 preliminaries) on account of 7-15 working medical attendants. The calculation has likewise been tried for the situation of 9 off (for example 6 working) attendants and the best arrangement in 195 seconds (min.456-max.4,864 emphasess) giving all the imperatives. In the investigation, another temperature decrease strategy and another task procedure were produced for the toughening calculation. The new evolved procedure is called as "various recreated toughening with twofold task".

Azurah A.samah [9] In this paper, a structure is introduced to plot the means of robotizing specialist planning measure utilizing a transformative calculation. Molecule Swarm Optimization (PSO) is applied inside the structure to produce ideal work routine for accessible

if the need arises specialists in crisis office at a public clinic in Malaysia. Presently, the specialist plans are set up by a head staff called chief who plays out this monotonous errand physically where a ton of time is spent to play out this assignment. The primary motivation behind this exploration is to create an ideal specialist plan where the quantity of staff working is gotten the job done, singular inclinations is satisfied and all specialists are dealt with reasonably. An orderly structure is set up which can be applied to any mechanized available to come in to work specialist planning arrangement of crisis division in a Malaysian clinic.

From the literature survey it is observed that various researchers have done using mathematical models (Linear programming, Mixed Integer model), algorithms which is of simple in nature and meta heuristics like Simulated Annealing Algorithm, Genetic algorithm etc. Hence in this paper attempt has been made to develop mathematical model using linear programming approach and algorithm can be used to compare the solution accuracy between mathematical model and algorithm.

3. Methodology

In this section attempt has been made to develop mathematical model for staff scheduling by considering linear programming approach. The objective of model is to minimize the staffs to be scheduled per day depending in the requirements. The case study was done by own considering hospital staff scheduling problems in day today working environment. The mathematical model was developed using **LINGO Solver** package for 10 different problems by considering the same objectives as minimizing the staff requirement per day based on the constraints. The general form of mathematical model is given below:

$$\text{Min } Z = \sum_{I=1}^{N} x_i \qquad \text{----------} \qquad 1.$$

Subject to

$$\sum x_i \; >= a_i \text{----------} \quad 2.$$

Equation 1 ---------- Represents the Objective Function

Equation 2 ---------- Availability of resource constraints per day

Model illustration:

```
Min x1+x2+x3+x4+x5+x6
ST
x6+x1>=20
x1+x2>=25
x2+x3>=35
x3+x4>=32
x4+x5>=22
x5+x6>=15
END
```

Model output:

```
Global optimal solution found.
  Objective value:                              77.00000
  Infeasibilities:                              0.000000
  Total solver iterations:                             5
  Elapsed runtime seconds:                          2.29

  Model Class:                                        LP

  Total variables:                     6
  Nonlinear variables:                 0
  Integer variables:                   0

  Total constraints:                   7
  Nonlinear constraints:               0

  Total non-zeros:                    18
  Nonlinear non-zeros:                 0
```

Variable	Value	Reduced Cost
X1	20.00000	0.000000
X2	10.00000	0.000000
X3	25.00000	0.000000
X4	7.000000	0.000000
X5	15.00000	0.000000
X6	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	77.00000	-1.000000
2	0.000000	-1.000000

3	5.000000	0.000000
4	0.000000	-1.000000
5	0.000000	0.000000
6	0.000000	-1.000000
7	0.000000	0.000000

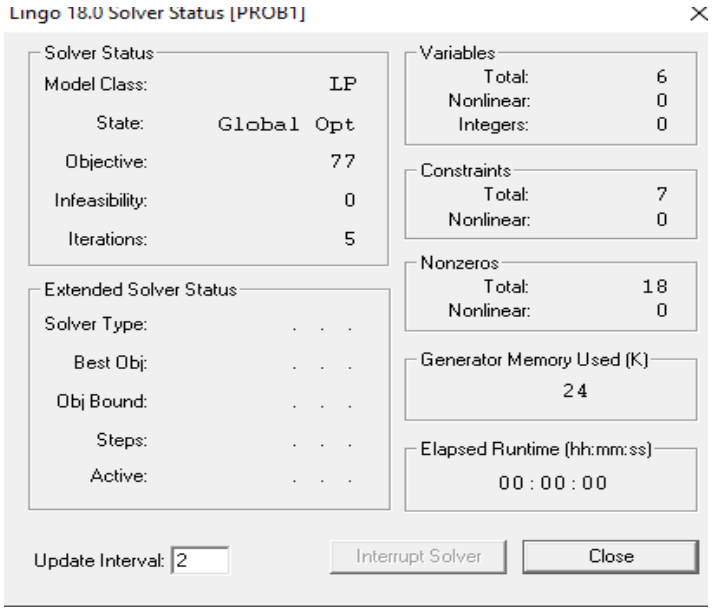


Fig 1. Model Objective Function

From this model the objective function is said to be 77 that is the minimum number of staffs required per day. The number of variables from this model is 6 and total number of constraints is 7. Therefore, the total number of decision variables is 42. The simple new efficient Heuristic was developed to compare the results of model against heuristic algorithm the steps are illustrated as given below:

Step 1: Start

Step 2: Generate a set of time interval(x)

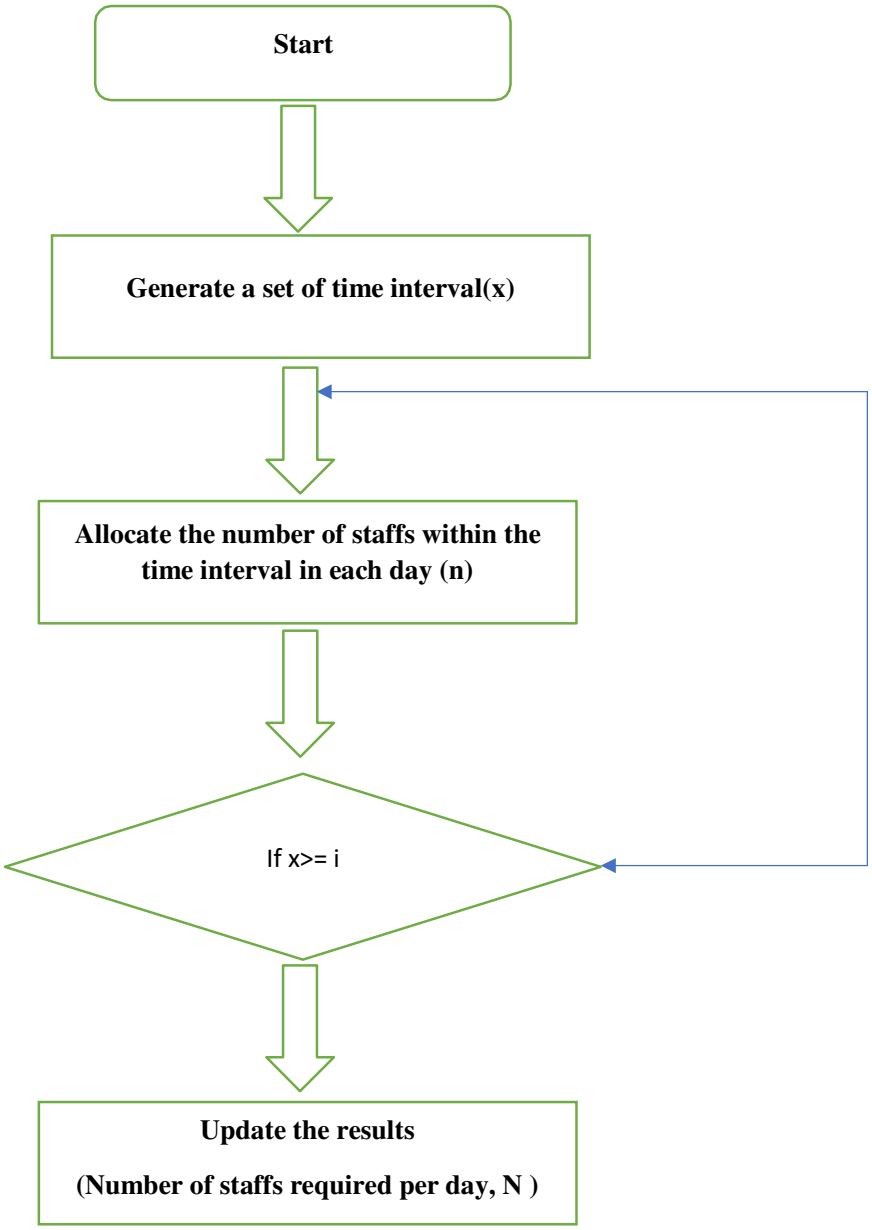
Step 3: Allocate the number of staffs within the time interval in each day (n)

Step 4 : If x>= i

Step 5: Update the results (Number of staffs required per day, N)

Stop

Algorithm steps:



Results and Discussion:

In this section the output given by the mathematical model for various problems is analysed through pictorial representation as shown in fig2. From graph it is clear that computational time is measured along x axis for various problems ranging from 1 to 10 secs. In Y axis objective function value is plotted in the graph that varies from 10 to 90 numbers based on the daily requirement of staffs in the hospital. From the graph it is known that the minimum requirement of staffs to be scheduled every day must be around 22 numbers from Fig2.

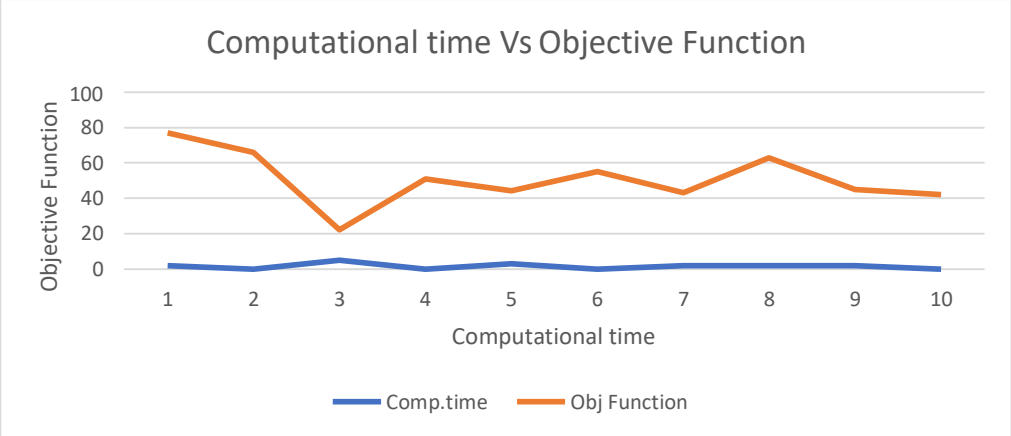


Fig2.

Problem size	Computational time (s)	No of iterations	Objective function (N) Total number of staffs required per day	Algorithm Results
1	2	5	77	77
2	0	5	66	65
3	5	6	22	22
4	0	4	51	51
5	3	4	44	43
6	0	4	55	55
7	2	4	43	43
8	2	4	63	63
9	2	4	45	45
10	0	4	42	42

From the table it clears shows that results given by algorithm and model does not show much difference so the proposed algorithm functions better as compared to model this was the inference from the above table.

Conclusion:

In this paper importance of scheduling in manpower requirement in the hospital is carried out by linear optimization approach. The results of the model are compared with heuristic algorithm based on the results it is clear that model and algorithm does not show any much differences.

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