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HUB & SPOKE Model for Health Care-Simulation & Results

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Abstract: In this paper, we present HUB & Spoke Model to a general class of healthcare systems. The HUB & SPOKE Model is applied on real time data collected for east district of Delhi and the results are shown in this paper. In addition, the model is optimized to determine the optimum number of doctors required during the service session. In order to do this, the dispensary name, present load, capacities are the key data to be collected for the east district.

Keywords: Decision Support Systems, HUB & Spoke Model, Excess load, Decision Process.

I. INTRODUCTION

Decision Support Systems are computer-based information systems that aid decision-makers with semi structured and unstructured tasks [1][2][3]. Decision support systems have a wide range of application areas like manufacturing, finance, marketing, human resources management, and strategic planning [1]. And health care systems are one of application in which DSS found its role. It is observed that in health care systems there is a regular mismatch between the demand for a treatment service and the available provisioning. Due to less availability and poor access of health care, patients suffer long delays. Due to these delays the patients sometimes may lead to loss of life.

Therefore this is the necessity that the resources like doctors must be properly utilized, so that the patients get proper medication and there is no loss of life [5]. HUB & SPOKE model is used and applied in this paper to facilitate load balancing and decentralization and thus helpful in providing collaboration with other health care centers. More specifically, an optimization model is also developed that enables us to understand theoretically the optimal number of patients to be treated , thus effective use of resources in health care systems.

II. DESCRIPTION OF HUB & SPOKE MODEL

Hub and Spoke Model is a DSS model that can be used in Load Balancing, Manpower Planning and Equipment Planning etc. In conventional terms it can be used in manufacturing and logistics sector but here this model is redesigned to facilitate decentralization and load balancing. The input to this model consists of name of dispensary, no. of doctors, present load/day, and capacity of dispensary that the system (hospital) can handle. The output computed by this model is Excess load for a dispensary and Excess load= Present load- Capacity.

Prolog is used here for optimizing the HUBs and Spokes network. Once a hub and spoke model is created, further requests for patient servicing can be satisfied by: The present hub or its spokes (if they have free capacity). However if the present network is full, the requests for patient servicing must be redirected to the nearest hub and spoke network, thus facilitate collaboration that is not shown in this paper. Again search is performed in the collaborative network to determine if the request can be satisfied by the hub or by its spokes. Collaboration between different organizations can be achieved by the openness of the systems [6]. Spatial health care systems are the systems that directly supports patients in managing their everyday life as the name "SPATIAL" [7].How load balancing can be achieved is shown in Table 1 &2.

An OPD slot of 6 hours per day and 5 minutes per patient per doctor is assumed in this paper. Therefore a dispensary with 1 doctor has a capacity of 12 patients per hour or 72 patients per day for a slot of 6 hours. The Hub is selected to absorb all excess load (total excess load=+42 as shown in table 1), transferred from the spokes while by design the spokes are constrained to their capacity. The Hub is selected according to load (volume). So the center with the highest load i.e. dispensary e is the hub. This results in a hub and spoke model (fig 1). The corresponding information is entered in the M-data table (fig 2) that can be used for future use.

The number of Doctors needed in Hub (e) is therefore 12.The hubs can also be chosen according to the distances between the dispensaries. Once a hub and spoke model is created, further requests for patient servicing can be satisfied by: The present hub or its spokes (if they have free capacity). However if the present network is full, the requests for patient servicing must be redirected to the nearest hub and spoke network in a collaborative network. Again search is performed in that network to determine if the request can be satisfied by the hub or by its spokes. DSS can be combined with AI techniques to make (DSS+AI=IDSS) to solve the semi structured problems [8,9].

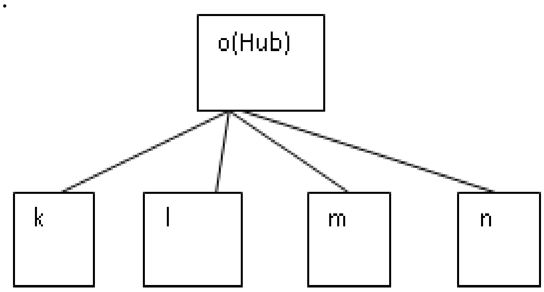

Figure 1: HUB & Spoke Network

Name of HUB-"o"	Name of Spokes- "k, l, m, n"	Free capacity at hub—"o" under loaded=30	Free capacity at spokes—" k=41 & l=36".

Figure 2: Metadata table for the network

Table 1: Hub & Spoke Model Input for the network

Name Of dispensary	**No. Of doctors**	**Present load / day**	**Capacity of dispensary**	**Excess load**
K	3	175	216	-41
L	3	180	216	-36
M	2	195	144	+51
N	1	200	72	+128
O	5	300	360	-60
Total excess load in the network				+42

Table 2: New load distribution for the network

Name of centre	**New loads on centre**	**No. Of Doctors**
K	175	3
L	180	3
M	144	2
N	72	1
O	360+42=402	6

III. DATA COLLECTION & ANALYSIS

The development of decision support model consists of 3 layers:

a. Statistical layer: This layer uses regression analysis to generate the conclusions. The input data is time series data and the format for this analysis is given in Table 3. The collected data is entered into spreadsheets and Excel functions are the basis for performing the regression analysis. Regression analysis is a mathematical measure of the average relationships between 2 or more variables in terms of original unit of data. Regression equations are constructed between the patient load(X) and available resources(Y). The equations are of the form y=a+ bx.

Where x and y are the variables, b is the slope of the regression line, a is the intercept point of the regression line and the y axis.

Slope(b) = $(N\Sigma XY - (\Sigma X)(\Sigma Y)) / (N\Sigma X^2 - (\Sigma X)^2)$

Intercept(a)=$(\Sigma Y - b(\Sigma X)) / N$ …… ……………(1)

The regression analysis of 25 primary health care centers in east district of Delhi is shown in table 4.

Table 3: Data format for the analysis of Regression Model

S.No.	Dispensary Name	Year	Annual OPD attendance	No of doctors

b. Queuing layer: This layer uses queuing theory of operations Research to derive the conclusions. The data collection format for queuing layer is shown in table 4. The analysis is done using Queuing model. In the case of a single service channel or single layer the m/m/1 formulae is used for making the predictions and in case of multiple service channels m/m/s queuing model formulae is used for making the predictions[4].

Table 4: Data format for the analysis of Queuing Model

Hospital Name:

Serial Number	Hours	OPD Name	Service Rate	Arrival Rate	No. Of Doctors

c. Prolog layer: This layer consists of 2 components:

a) Query driven: Uses the production rules and a knowledge base to answer the questions.
b) Model Simulation: Enables the decision makers to simulate various aspects of queries.

For this layer the input data and new load distribution is shown in the above section.

IV. MODEL ANALYSIS

Implemented in Prolog and two types of data i.e. static data and dynamic data is described.

A. Static Data: -

pload (cname, patient load), /here pload has 2 arguments cname and patient load/
disp (cname, no.of doctors),
Hub=load(centre) with maximum patient load.
Hub is selected by max patient load on a center.
If pload (a, l1), pload (b,l2), ………pload(n,ln) then max (l1,l2……..ln)=M.
pload (H, M)=H is obtained as the hub with maximum patient load.
Excess load of a center= patient load-capacity of the dispensary.
If Excess load is positive then it is called overloaded center and if excess load is negative , then it is called under loaded center.
T_{free}=freecap $_{HUB}$+freecap $_{SPOKES}$. / where T_{free} is total free capacity in the network, freecap $_{HUB}$ is the free capacity in hub and freecap $_{SPOKES}$ is the free capacity in spokes. This information is stored in tables as shown in fig 2.

B. Dynamic Calculation of capacity:

Capacity of a centre & excess load of a center asserted dynamically in the database.

```
:-dynamic calculatecapacity / 0
calculatecapacity:- disp(X,Y),
                    pload(X,Z),
                    getcap(X,Y,C),
assert(capacity(X,Y,C)),
E is Z-C.
assert ( excess (X,E)),
fail.
calculatecapacity:-!
getcap(X,2,C):- C is 144.
getcap(X,1,C):-C is 72.
```

New load distribution constraints (in the network):-

a) N_{SPOKE} <= C_{SPOKE} where N_{SPOKE} is new load on a spoke and C_{SPOKE} is capacity of a spoke.

b) $N_{HUB} = C_{HUB} + T_{EXCESS\ LOAD}$ where N_{HUB} is new load for a Hub, C_{HUB} is capacity of Hub and $T_{EXCESS\ LOAD}$ is total excess load in the network.

Table 5: Data collected for 25 Health care centers in east district of Delhi

S.No.	Disp Name	Present Load	Capacity	Excess load
1.	Bholanathnagar	132	72	60
2.	Chandernagar	162	144	18
3.	Ferozegandhi	131	72	59
4.	Geeta Colony	226	144	82
5.	Himmatpuri	234	144	90
6.	IP Extension	95	144	-49
7.	Jagatpuri	84	72	12
8.	Kalyanpuri	219	144	75
9.	Kalyan Vas	191	144	47
10.	Kanti nagar	152	144	08
11.	Karkardooma	190	144	46
12.	Karkardooma Court	121	144	-23
13.	Krishna nagar	144	144	0
14.	Laxmi nagar	189	144	45
15.	Mandawali	303	144	159
16.	Mayur Vihar	118	144	-26
17.	Mukesh nagar	130	144	-14
18.	Raghubir pura	126	144	-18
19.	Shashi garden	180	72	108
20.	Suraj mal vihar	195	144	51
21.	Thokar	105	72	33
22.	Trilokpuri	389	144	245
23.	Vasundhra Enclave	229	144	85
24.	Vishwas nagar	154	144	10
25.	Vivek vihar	207	144	63

Table 6: New load Distribution for 25 Health care centers in east district of Delhi

S.No.	Disp Name	New Load
1.	Bholanathnagar	72
2.	Chandernagar	144
3.	Ferozegandhi	72
4.	Geeta Colony	144
5.	Himmatpuri	144
6.	IP Extension	95
7.	Jagatpuri	72
8.	Kalyanpuri	144
9.	Kalyan Vas	144
10.	Kanti nagar	144
11.	Karkardooma	144
12.	Karkardooma court	144
13.	Krishna nagar	144
14.	Laxmi nagar	144
15.	Mandawali	144
16.	Mayur Vihar	118
17.	Mukesh nagar	130
18.	Raghubir pura	126
19.	Shashi garden	72
20.	Suraj mal vihar	144
21.	Thokar	72
22.	Trilokpuri	144+1096=1240
23.	Vasundhra Enclave	144
24.	Vishwas nagar	144
25.	Vivek vihar	144

The center with the highest volume is the hub and that is "TRILOKPURI (389)". Now, total excess load in network=1094

The total excess load is transferred to the hub TRILOKPURI and its new load = 144+1096=1240 (shown in the table 6).The remaining health centers are all spokes and their new loads are the capacities or less if present load is less than their capacity. Here we can see that the HUB selected has absorbed the total excess load, while the spokes are constrained to their capacity. This is reflected in the new load distribution ass seen in the table above.

Using Prolog Queries the DATA OUTPUT for East District are.

?-getnodal(D).
389
Nodal dispensary
D=Trilokpuri
?-calculate excessload(T).
T=1096
Yes
?-getloadonhub.
T=1240
Yes
?-freeloadinhub.
NO.
Hub is full.
Yes.
?-freeloadinspokes.
5 spokes are free.
Yes

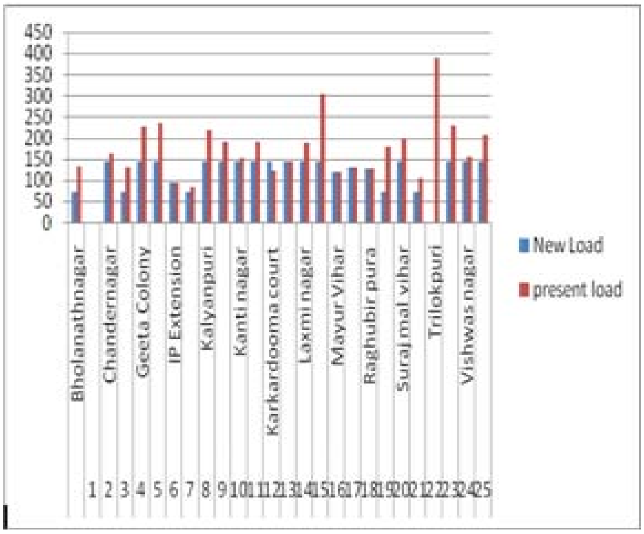

Figure 3: Graph showing the new load and present load for the health care centers in delhi.

The successful delivery of medical care is a complex outcome that depends on multiple factors like structural factors and related infrastructure. These factors are also highly dependent on valid, accurate, complete and reliable data collection and the use of that data to build models and systems to support the decision making processes involved [10]

V. CONCLUSIONS

The primary health care data of 25 health centers in east district of Delhi is taken for analysis of HUB & SPOKE network. One of the hospitals is chosen as HUB and remaining are the spokes. The free capacity in the network is defined in the metadata table, defined for the network that can be used further for facilitating the collaboration.

This model can be combined with ANN/Expert systems to facilitate collaboration and thus helpful in better utilization of resources. There is a great need of better utilization of resources especially in India to save lives of poor people.

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