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A Conceptual Framework for Collaborative Decision Support Systems for Primary Health Care Managers

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Abstract– **In this paper, a collaborative architecture for intelligent decision support system (DSS) for health care systems is proposed. The framework embeds expert knowledge within the DSS to provide intelligent decision support, and implements the intelligent DSS using collaboration technologies. A problem space contains several Hub and Spoke networks. Information about such networks is dynamically captured and represented in a Meta-data table. This master table enables collaboration between any two networks in the problem space, through load transfer between them.**

Keyword: Decision Support Systems, Decision Process, Collaboration, Collaborative DSS, HUB and Spoke Model, Meta Data.

1. Introduction

Decision Support Systems (DSS) are a specific class of computerized information system that supports business and organizational decision-making activities. As established traditional decision support systems are not giving sufficient possibilities for intervention to the users. So that, it becomes imperative to design intelligent and collaborative systems in complex situations, where decision making is unorganized, allowing a joint resolution of problems and dynamic sharing of the tasks related to user, system and an appropriate collaboration mode.

Due to the complexity of the hospital environment, there are lots of medical information systems for health care collaboration projects from different vendors with incompatible structures. Therefore the heterogeneity towards the data integration, function integration and workflow integration must be considered. However most of the previous design of architecture did not accomplish such a complete integration.

1.1. Objective

In this paper, we are using Hub & Spoke model and meta-data information concept to facilitate decentralization and Load balancing which facilitates collaboration. Collaboration is implemented through transfer of patient load. Its advantages in providing more flexibility to system design and implementation, simplifying the decision-making process, and empowering decision makers at the operational level.

The concept of Meta-data is used to represent information about Hub and Spoke networks, in a Meta data table. This Meta-data table is searched to facilitate collaboration between two different networks. Thus the main objective of this research work is to show the composition of Meta-data for a Hub and Spoke network, obtaining this information dynamically and then providing a conceptual framework for collaborative decision support, where in collaboration means load transfer between two networks in given problem space.

1.2. The Problem Statement

To illustrate the working of the proposed intelligent collaborative decision support system algorithm. This includes a brief discussion of the model analysis for a single Hub and Spoke network.

1.3. Current DSS Frameworks

An expanded DSS framework that helps categorize the most common DSS systems currently in use has been proposed by Power [1]. Accordingly, common DSS types are as follows:-

- Communication Driven DSS
- Data Driven DSS
- Document Driven DSS
- Knowledge Driven
- Model Driven DSS

The proposed conceptual frame work for the DSS is basically a model driven DSS. This framework uses principles of artificial intelligence (AI), to construct a master Meta-data table, that contains Meta-data about each Hub and Spoke network in the given problem space. The Meta-data about each individual network is obtained dynamically by communicating through the network. The master Meta-date table is searched to facilitate collaboration through load transfer between any two given networks.

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Table 1. Types of DSS.

Dominant Component	User Group	Purpose	Enabling Technology
1.Communication Driven DSS	Intra & Inter Organizational users	Conduct a meeting on a bulletin board	Web based or LAN
2. Data Driven DSS	Managers, Staff, Intra & Inter Organizational users	Query a data warehouse, Adhoc Analysis	Mainframe, LAN, Web Based
3. Document Driven DSS	Specialists, Managers	Search web pages, find documents	Web based
4. Knowledge base Driven DSS	Internal users, Customers	Management Advice, Choose products	LAN or Web Based
5. Model Driven DSS	Managers, Staff, Customers	Crew scheduling, Decision Analysis	Stand-alone PC, Web based

In general, DSS can serve multiple purposes and can be implemented using different architectures and enabling technologies. Also the design of new decision support models that use different mathematical and statistical techniques can result in the design of new model driven DSS. The use of Data mining techniques is a fast emerging area in this domain.

1.4. Advantages and Disadvantages of the Proposed Collaborative DSS

The advantages and disadvantages of the proposed intelligent collaborative decision support system can now be described as follows:-

1.4.1. Advantages

(i). Load balancing, through transfer of patient load.
(ii). Decentralization of health care services.
(iii). Bottom up planning, in terms of services and man power to be deployed at Hub and Spokes.
(iv). Hubs can be developed as telemedicine centers of consultation, to save deployment of specialists at spokes.
(v). Financial allocation of resources can be done better in the new hierarchy.
(vi). Collaboration between different networks in the given problem spaces.
(vii). Strengthening of primary healthcare services in a region by minimizing referral to secondary care.

1.4.2. Disadvantages

(i). Selection criteria for Hub selection is narrow- only in terms of one parameter i.e. Patient Load.
(ii). NO optimization done for selection of Hubs.
(iii). Disturbs the existing hierarchy of healthcare services, in a region by portioning the region into Hub and Spoke networks.

Some independent, stand alone information systems called Decision Support Systems (DSS) have been developed in the last two decades to improve the effectiveness of decision-making rather than its efficiency; they attempt to combine the use of models or analytical techniques with traditional data access and retrieval functions; Decision Support Systems specifically focus on features that make them easy to use by noncomputer people in an interactive mode; and Decision Support Systems emphasize the flexibility and adaptability to accommodate changes in both the approach of the decision maker and the environment in which they act. Currently, due to complex economic, social and political structures, the need for decision making techniques and support systems are greater than ever before. This is due to the complexity of business relationships, the greater number of decision makers and organizations that are involved in the decision process, online access to multiple external information sources, and the decrease in time allowed for decision making.

2. Literature Survey

Decision Support Systems (DSS) emerged in the 1970. In many situations, the quality of decisions is important; therefore, aiding the deficiencies of human judgment and decision making has been a major focus of science throughout history. It is defined as a computer-based system designed to actively interact with an individual decision maker in order to assist him to make better decisions based on information obtained [2].

The decision process is not a single task rather it can be defined as a collection of correlated tasks that include: gathering, interpreting and exchanging information; creating and identifying scenarios choosing among alternatives, and implementing and monitoring [3] a choice.

Large numbers of frameworks or topologies have been proposed for organizing our knowledge about decision support systems [1]. Five generic categories based on the dominant technology component are proposed, including Communications-Driven, Data-Driven, Document-Driven, Knowledge-Driven, and Model-Driven Decision Support Systems. Data-Driven DSS help managers organize, retrieve, and synthesize large volumes of relevant data using database queries, OLAP techniques and data mining tools. Model-Driven DSS use formal representations of decision models and provide analytical support using the tools of decision analysis, optimization, stochastic modeling, simulation, statistics, and logic modeling. Communication-Driven DSS rely on electronic communication technologies to link multiple decision makers who might be separated in space or time, or to link decision makers with relevant information and tools. Knowledge-Driven DSS can suggest or recommend actions to managers. Finally, Document-Driven DSS integrate a variety of storage and processing technologies to provide managers document retrieval and analysis.

The basic structure of classic DSS comprises following components as:-

(i). Database management capabilities with access to internal and external data, information and knowledge.
(ii). Powerful modeling function accessed by a model management system.
(iii). User interface design that enable interactive queries, reporting and graphic functions.

A regular decision support system helps decision makers to manipulate data and models. It does play the role of an intelligent assistant to the decision maker.

Hub and Spoke Model [4] 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, capacity of dispensary and excess load that the system (hospital) can handle. The output computed by this model is Excess load for a dispensary and excess load equivalent to present load- Capacity.

Distributed decision support systems offer a methodology which can be used to combine distributed and heterogeneous models and problem solving processes under a single unified framework [5].

Intelligent Decision Support Systems (IDSS) [6] is a result of combining decision support system (DSS) and artificial intelligence (AI). Its basic design is to combine the knowledge reasoning techniques of AI and the basic function models of DSS. IDSS is needed and is economically feasible for generic problems that require repetitive decisions. It is interactive computer-based systems that use data, expert knowledge and models for supporting DM's in organizations to solve semi structured problems by incorporating artificial intelligence technique. There may be different ways are available to make a DSS more intelligent; the most frequently suggested method is to integrate a DSS with an IS.

Collaboration is one of the major requirements in today's life and business. Collaborative activities are found at different levels and with different extents. Collaboration can be seen from classrooms to enterprises, [7] and all demand for appropriate support. In particular, information technology can provide such support, but it is not a trivial task. On one hand, collaborative systems may be complex, distributed, open, and dynamic applications; on the other hand, the human factor plays a very important role with respect to other application fields. Collaboration is by its own nature, distributed. Collaboration between different organizations can be achieved by the openness of the systems, a feature that could lead to global collaboration.

Increasing public costs for the care of the elderly have created fundamental changes that are re-defining the basic principles of health care funding. In the past, overall institutional funding was predominantly tied to spending. In view of the limitations of this approach to funding long-term care facilities, case-mix classification [8] tries to take into account the characteristics of the residents as a tool for predicting costs. Recently, a new case-mix classification based on the functional autonomy profile of the residents – ISO-SMAF profile – was developed in the Province of Quebec, Canada. This classification can be used to change the funding system to base it on the functional autonomy characteristics of the residents.

A DSS is a system under the control of one or more decision makers that assists in the activities of decision making by providing an organized set of tools intended to impose structures on portions of the decision making situation and to improve the ultimate effectiveness of the decision outcome [9].

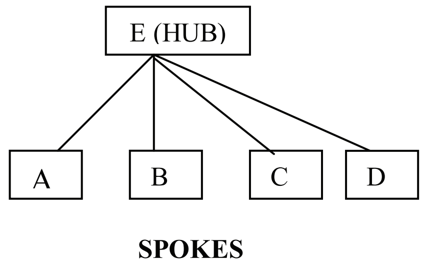

Fig. 1. Hub & Spoke N/W.

3. Hub & Spoke Model

Hub & 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 are redesigned to facilitate decentralization and load balancing. As an example we can show how load balancing can be achieved.

We assume a OPD slot of 6 hours per day and 5 minutes per patient per doctor. 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. Excess load for a dispensary is Present load – Capacity. Then total excess load in the network can be calculated as 724.The Hub is selected to absorb all excess load 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.

The new load distribution can now be calculated as follows:

The number of Doctors needed in Hub (E) is therefore 12. The health care managers can also choose 2 hubs for a district, in which case the dispensary with second highest load i.e. D (300) becomes the second hub. In this case both hubs share the total excess load transferred from the spokes equally. The hubs can also be chosen according to the distances between the dispensaries. The Decision support system is thus model driven and must have the capability of performing this load balancing analysis along with manpower and equipment planning using the same hub and spoke model. 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. Again search is performed in that network to determine if the request can be satisfied by the hub or by its spokes.

4. Model Analysis

The prolog code for Hub selection is as follows:

Table 2. Hub & Spoke Model Input.

Name Of dispensary	No. Of doctors	Present load / day	Capacity of dispensary	Excess load
A	2	200	144	56
B	1	150	72	78
C	2	250	144	106
D	1	300	72	228
E	2	400	144	256

Table 3. New Load Distribution

Name of distribution	New loads on distribution	Number of Doctors
A	144	2
B	72	1
C	144	2
D	72	1
E	724 + 144 = 868	12

4.1. Static Data

```
Pload (Cname, Pload)
disp (Centre Name, No.of doctors)
pload (a, 125).
pload (b, 150).
pload (c, 200).
pload (d, 250).
pload (e, 300).
disp (a,1).
disp (b,2).
disp (c,2).
disp(d,2).
disp(e,2).
getnodal(D):-bagof(Number, Name8pload(Name, Number), L),
maxlist(L,M),
write (M),nl,
pload (D,M),
write ('Nodal Dispensary'),nl,
write (D).
```

Explanation of above Data Codes: The programme for computing, the nodal dispensary or Hub uses the predicate getnodal. The input data for this predicate is – pload (Centre name, Patient load) and disp (Centre name, Number of doctors). This represents the static data input i.e. the data input at the start of computation. So, the input data consists of five centres- a, b, c, d and e with patient loads 125, 150, 200, 250 and 300, and number of doctors working at them being 1,2,2,2 and 2 respectively. The predicate getnodal returns the centre with maximum load as the Hub i.e. it returns the name of centre e as the Hub.

4.2. Dynamic Calculation of capacity

```
Dynamic Calculate Capacity / 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.
```

Explanation of above Data Codes: The dynamic data is the data computed during programme execution and asserted as facts into the evolving data base. So, the computation is done as follows,

The data represented by capacity and excess load for a centre are computed dynamically using the constraint equation written in Section 4.3. below.

The predicate getcap computes a centre capacity and excess computes the excess load for a centre.

4.3. Model Constraints

(i) $N_D = \{1, 2\}$

$$\text{Cap (center)} \longleftarrow 72(N_D = 1)$$

where N_D = no. of doctors at the center

(ii) Cap (center) $144(N_D = 2)$ Patients/Doctors/Hour = 12
$N_{HOURS} = 6$(center working hours)

(iii) E = PL-C where E = Excess load at a center.
PL = Patient load at a center
C = Capacity of a center.

(iv) New load distribution constraints (in the network):-

(a)

$$N_{SPOKE} <= C_{SPOKE}$$

where N_{SPOKE} is new load on a spoke.
C_{SPOKE} is capacity of a spoke.

(b)

$$N_{HUB} = C_{HUB} + T_{EXCESSLOAD}$$

where N_{HUB} is new load for a Hub.
C_{HUB} is capacity of Hub.
$T_{EXCESSLOAD}$ is total excess load in the n/w.

(v) Dynamic data for a center:-

Table 4. Model Computation

Centre Name	Patient Load	Number of Doctors	Capacity	Excess Load
A	125	1	72	53
B	150	2	144	06
C	200	2	144	56
D	250	2	144	106
E	300	2	144	156

(1) Excess load of a center.
(2) Capacity of a center.

(vi) Hub Selection:-
Hub is selected by maxload on a center. pload (a, L1), pload (b,L2), ... pload(n,Ln).
max (L1,L2.......Ln) = M. Alo, pload (H, M) = H is obtained as the center with maximum patient load.

(vii) Overload and Underload centers:-
(a) Overload center: - Excess load is +ive.
(b) Underload center: - Excess load is −ive.

(viii) No. of doctors at Hub after computation of New Loads:-

$$N_{HUB} = NL/72$$

where NL is new load on Hub and 72 is capacity of 1 center with 1 doctor for a
slot of 6 hours

(ix) Total free capacity in a network:

$$T_{free} = free_{HUB} + free_{SPOKES}$$

where T_{free} is total free capacity
free $_{HUB}$ is free capacity at Hub.
free $_{SPOKES}$ is free capacity at spokes.
This information is maintained in the metadata table for a given network.

4.4. *Computation of Hub*

Using Resolution, the proof tree for this goal can be generated as follows:

The predicate getnodal performs the following computations, which are shown in the above proof tree,

(i) Input list = [125, 150, 200, 250, 300]
(ii) Max (L, M) = M=300
(iii) Pload (D, M) = Gives the centre name with maximum patient load as the hub centre i.e. with M=300, D=e, from the data above. So, the proof tree for getnodal validates this computation.

Therefore Hub selected is e i.e. **D = e.** In view of analysis, remaining 4 centers i.e. a, b, c, d are the spokes. This gives Hub and Spoke structure for a single Hub and Spoke Network. Since the collaboration process maintains metadata about the networks in problem space, we assume there are 5 networks in the problem space, for purpose of analysis. Since these networks are named by their respective hubs, we assume they are: e, p, q, r, and s. Accordingly the distance matrix can be formulated giving the distance of hubs from each other:-

Therefore for the Hub e, hub p is the nearest hub. Accordingly, metadata for the network named by Hub p is displayed and free load can be estimated, facilitating collaboration through load transfer, between these two networks.

Table 5. Distance Matrix Showing Hub Connectivity.

	E	**p**	**q**	**R**	**s**
e	0	3	5	7	8
p	3	0	4	3	6
q	5	4	0	2	3
r	7	3	2	0	8
s	8	6	3	8	0

Table 6. Distance Matrix from One Hub to Other Hubs.

From	**To**	**Distance**
E	p	3
E	q	5
E	r	7
E	s	8

5. Collaborative Intelligent Decision Support System Algorithm

A cooperative DSS regulates the decision maker to modify, complete or re-address the suggestions given by the system, before sending them back to the system for evaluation. The system again improves, completes, and refines the suggestions of the decision maker and sent them back for validation. The whole process then starts again, until a consolidated solution is generated.A collaborative decision support system is one in which data is collected, analyzed and then is provided to a human component which then can help the system revise or refine it. It means that both a human component and computer component work together to come up with the best solution. This is the collaboration between the human and computer component. Collaboration between two networks is also of great advantage in terms of effective cost utilization, decentralization, load balancing and load sharing etc.. Collaboration is transfer of patient load between 2 networks. This is guided by metadata about the network. There are two tasks that must be done before the computation so that collaboration for a particular network starts with another network. These tasks are as follows:
(1). To prepare the 'Metadata Table' for the entire networks in the problem space. The information contained in the metadata table for a network is got by traversing through the HUB & SPOKE structure, corresponding to that network. This data is then entered into m-data table for the network. This cycle is repeated for all the networks in the problem space. The set of all such m-data tables is maintained in the master meta-data table which is accessed by the controller.
(2). To prepare the distance matrix that indicates the distance of health care center from other health care centers. The distance

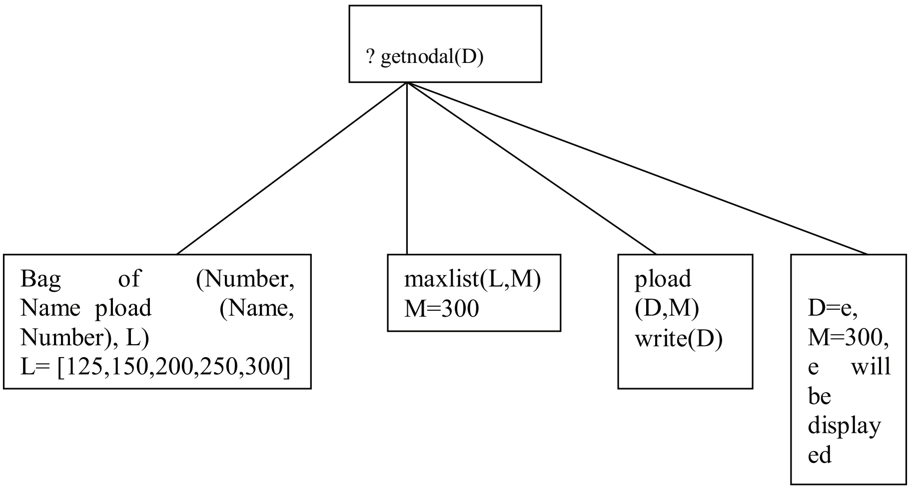

Fig. 2. Proof Tree for Goal getnodal (D).

Table 7. Meta Data for a Network.

Name of HUB	Name of SPOKES	Free capacity at HUB	Free capacity at SPOKE

Table 8. Distance Matrix for Hub & Spoke n/w.

	C_1	C_2	C_3.........Cn
C_1	d_{11}	d_{12}	d_{13} .... d_{1n}
C_2	d_{21}	d_{22}	d_{23}....... d_{2n}
...	...	....	.....

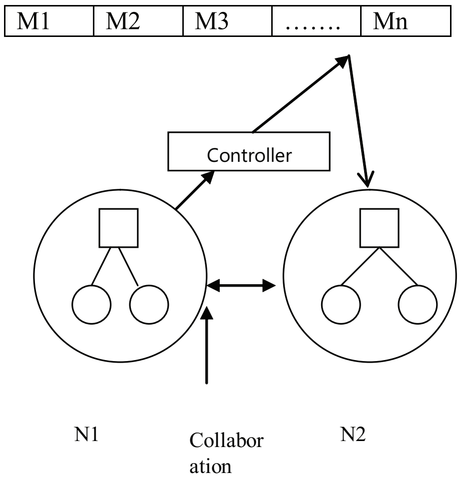

Fig. 3. Communication b/w to networks using metadata information.

matrix is calculated as follows:

The distances d_{11},d_{12}, d_{13} are the physical distance of a health care center from other centers in the network. The nearest distance from a requesting HUB center is its collaborating network. Now an algorithm is written to show how 2 networks can share their load with the help of metadata information. Here M1, M2... represents metadata information with the help of which a n/w will find a meta data for another network. Also a network determines its adjacent network using the distance matrix described above.

The Proposed Collaborative Decision support system algorithm is as follows:

6. Discussion

Primary health care data in a region is used to form a hub and spoke network for the region. This network seeks to collaborate with another similar network, for the purpose of Load Transfer, which signifies collaboration. The free capacity in the network is defined in the metadata table, created for the network. The total free capacity (F_T) in the network is the sum of free capacity at hub (F_H) + free capacity at spokes (F_S). The free capacity computation is done by traversing the Hub-Spoke network. This information is entered in the Metadata table for the network.

A request for collaboration is directed to Metadata Table by a controller, which controls the collaborative process. By searching the metadata table, the collaborative network is obtained for the requested network. After that free capacity computation is done for the networks which facilitate collaboration through load transfer. The metadata tables can be suitably updated after load transfer has taken place. The significance of this architecture lies in the fact that it is the hub in a network that determines the rules for collaboration. The spokes cannot take this decision at their level. The future extension of this model can implement collaboration for two networks belonging to two different service providers. Also the concept of priority can be used to designate a network as one that will satisfy priority requests. Accordingly metadata table can be suitably modified to accommodate priority of the networks.

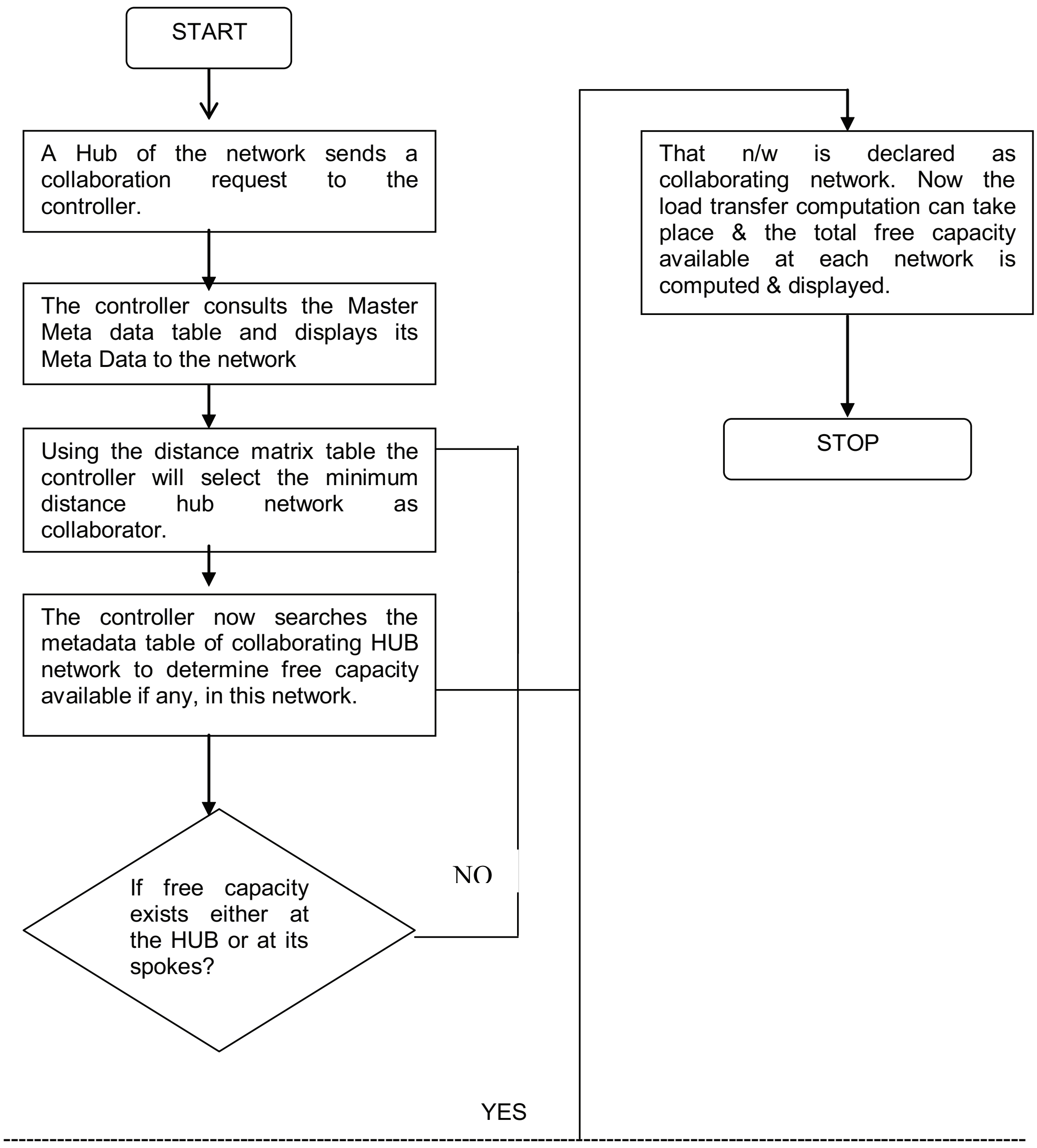

Fig. 4. Steps in the Proposed Algorithm.

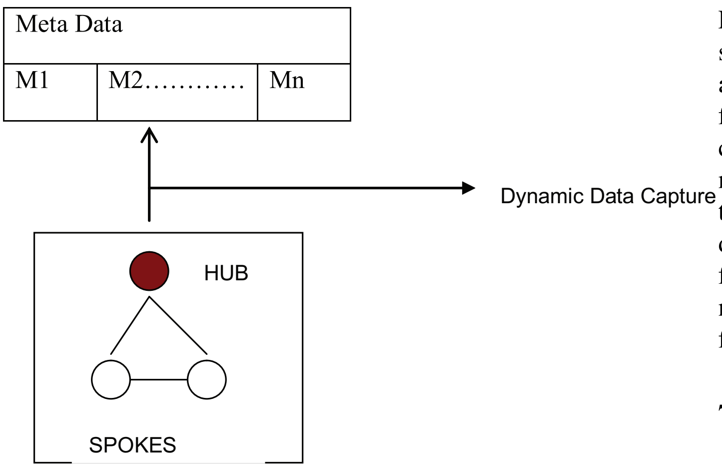

Fig. 5. Showing the Capturing of Dynamic Data.

Comparison with Other Models :- The Hub & Spoke Model is commonly used in logistics problems, for example in the Air Lines Industry. Here, this model is designed for the Healthcare sector wherein the Hub is chosen based on maximum patient load and Spoke centers are attached to it. Also, once such a network is formed, redistribution of load takes place within it. To facilitate collaboration through transfer of patient load between two such networks, a meta data table along with a distance matrix giving the distance between the identified Hubs, in the problem space is defined. This table and the distance matrix facilitates the search for a collaborating network. The most adjacent Hub for a given network with free capacity available is chosen at the collaborator for it.

7. Conclusions

In this paper we have redesigned the existing HUB & SPOKE Model. This model is used as the basis for collaboration. The concept of metadata and controller is illustrated. The future work of this proposed framework is linking a network and the structure shown in Fig 3 to the artificial Neural Network/Expert Systems which will use rule based knowledge to control the collaboration process. If no free capacity exists in minimum distance hub network, then the next minimum distance network is selected as the candidate network for the collaboration. In addition request satisfaction can be done dynamically by maintaining a queue of request in real time. The concept of priority can be used to designate some networks as priority network which will satisfy only primary requests and this concept can be implemented by priority scheduling algorithm using a priority field in Meta data for the network.

The code for the implementation of this model can be written in any programming language. In this paper, code for Hub selection was written in prolog, which can be extended to cover selection of spokes and the creation & manipulation of metadata. This results in the design of a knowledge based system that involves dynamic database updation.

This model can be tested on real data in further work and the distributed implementation can also be taken up in an extension of this work.

8. Open Problem(s)

Collaboration between any two Hub & Spoke network is implemented through metadata information and a controller. In this network we can collaborate with a similar network in same or different region generated similarly. We may develop such several Hub & network and search suitable network and region for them.

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References

[1] D. J. Power, "Supporting decision-makers: An expanded framework," *e-Proceedings Informing Science Conference*, pp. 431–436, June, 19–22 2001.

[2] P. G. W. Keen and M. S. S. Morton, *Decision Support Systems: An Organizational Perspective*. Reading, MA: Addison-Wesley, 1978.

[3] G. DeSanctis and R. B. Gallupe, "A foundation for the study of group decision support systems," *Management Science*, vol. 33, no. 5, pp. 589–609, 1987.

[4] R. Vohra, "Empowering primary healthcare services through e-governance –a case study from delhi government," *WEBIST-2007*, pp. 221–227, March, 3–6 2007.

[5] R. T. H. Chi, S. K. Rathnam, and A. B. Whinston, *A Framework for Distributed Decision Support Systems*. Department of Management Science and Information Systems, University of Texas, Austin, USA.

[6] F. Zhou, B. Yang, L. Li, and Z. Chen, "Overview of the new types of intelligent decision support system," *Third International Conference on Innovative Computing Information and Control*, 2008.

[7] G. Cabri, H. Zhu, and J.-B. Yang, "Special issue on collaboration support systems," *IEEE Transactions Systems, Man, and Cybernetics - Part A: Systems and Humans*, vol. 36, no. 6, pp. 1042–1044, 2006.

[8] P. W. Shaughnessy, R. E. Schlenker, and D. F. Hittle, "Case mix of home health patients under capitated and fee-for-service payment," *Health Services Research*, pp. 79–113, 1995.

[9] G. M. Marakas, *Decision Support Systems in the 21th Century*. Prentice Hal, 2nd ed., 2003.

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