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Decision Support System for Tele-Medical Transportation Management *(pp.195-212)*

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Abstract: In this paper, a Decision Support System for Management of Tele-Medical Transportation Services has been designed and developed. The system is developed with symbiotic approach to achieve the aim of providing the necessary Quality based Information Resources for real life interaction among Decision Members of Tele-Medical Transportation System to enable speedy decision management by scanning the future. The salient features of the System are: quick and interactive communication, instant content support, anonymity of the member's identity, vast resources of content and system support.

Keywords: tele-medical management, decision making, transportation management

1 INTRODUCTION

Telemedicine is defined as the use of electronic Information and Communication technologies (ICTs) to provide and support health care when distance separates the participants. The delivery of healthcare from a distance uses exchange of electronic patient information and medical data using computers, medical equipment, videoconferencing, the Internet, satellite, and wireless communications. For telemedicine to be successful there must be an ability to clearly transmit a clinical situation, including clinical information of diagnostic quality, to a clinician located far from the point of need, and the ability for that clinician to effectively communicate concerns, additional requirements needed for diagnosis, or the provision of a diagnosis back to the point of need. Therefore, there is a need to develop a system that can be useful to handle this complex decision making process. Decision Making has always been a difficult task. When considered in the context of our social and economic goals and behaviours it is also a very important task. A Decision Support System (DSS) is a tool used to improve the process of decision making in complex systems, particularly where information is uncertain or incomplete.

Thurskya and Mahemoff (2007) explored the use of user-centered design techniques for developing the requirements for an antibiotic decision support system (DSS) in an intensive care unit (ICU). Models were constructed to demonstrate cultural, workflow, sequence/trigger events and other artefacts used to support antibiotic prescribing in the ICU.

TREAT is a decision support system for antibiotic treatment in inpatients with common bacterial infections and based on a causal probabilistic network that uses a cost–benefit model for antibiotic treatment, including costs assigned to future resistance (Paul et al.2006).

Soo *et al* (2006) presented a conceptual intelligent DSS framework which provides a holistic framework to perform analytical assessments of integrated emergency vehicle pre-emption and transit priority systems. Three analytical tools are presented for incorporation into future DSS design: the first addresses the potential impact of transit travel time reduction on transit operating costs; the second addresses the potential impact of reduced emergency vehicle crashes at signalized intersections on fire and rescue operating costs; and the third integrates fuzzy sets concepts and multi-attribute decision-making methods to rank order transit signal priority strategy alternatives at the intersection level.

Trivedi and Daly (2007) described how the Texas Medication Algorithm Project (TMAP) and the Sequenced Treatment Alternatives to Relieve Depression (STAR*D) trial has confirmed the need for easy-to-use clinical support systems to ensure fidelity to guidelines. To further enhance guideline fidelity, they developed an electronic decision support system that provides critical feedback and guidance at the point of patient care.

Carson and Batta (1990) used past call-data statistics and a network representation of the Amherst Campus of the State University of New York (SUNY) at Buffalo to find a dynamic positioning strategy for the campus ambulance. As measure of performance they used the system-wide average response time to a call. They solved one-median problems on several network "states" to determine optimal locations for the ambulance.

Westerman et al (2007) described a consumer decision support in the context of Internet and in-store applications. A sample ($n = 30$) of experienced runners made running shoe selections in either 'product only', 'decision support system only', or 'decision support system and product' conditions. Participants' decisions tended to be more uniform and of better quality when the DSS was available.

In this paper an attempt has been made to design and develop a Decision **S**upport System, TMT-DSS, for Management of **T**ele-**M**edical **T**ransportation services. The main idea to develop a DSS for the Tele-Medical Services is to improve its efficiency by including the intelligence on information processing itself.

2 ARCHITECTURE OF THE DECISION SUPPORT SYSTEM

The system consists of following components which comprise of Dialog Management, Central Decision Making Desk, Tele-Medical Services Module, Central Vision Exhibit Board, and Data Base Management Subsystem.

1) Dialog Management Subsystem (DMS)

The Dialog Management Sub-system (DMS) is designed for Decision Members with a variety of Tele-Medical Transportation Management decision-making needs. The DMS captures the Decision Members preferences, degree of expertise, skills and then receives and interprets their input, which is conveyed to Central Vision Exhibit Board and finally presents the output in the form of charts, text, graphs and tables. The DMS capabilities of TMT-DSS System are broadly classified into two categories: Query Support Display Desk and Decision Support Display Desk due to variety of users with different decision making tasks. While Query Support Display Desk allows adhoc retrieval of Tele-Medical information, Decision Support Display Desk supports the Tele-Medical decision making tasks and allows the user to generate a number of displays from the data available in the system.

The processed data from Database Management Subsystem is accepted as the input data for Central Decision Making Desk. After the interaction of related Tele-Medical Services Module, the output results are transmitted in real time through Central Vision Exhibit Board to the Dialog Management Subsystem, for display, analysis, and decision.

2) Application Module

The Application Module consists of Tele-Medical Services Management System. This system visits the DBMS information analysing system and model base subsystem to get optimized solutions.

3) Central Decision Making Desk

The main goal of Central Decision Making Desk is to give optimize and prioritized solution according to the demand of the user by utilizing the information offered by the database and Information Analysis System. The Central Decision Making Desk comprises of Optimization Model base Subsystem which comprises of the Multi-Objective Fractional Mobile Van Transportation Problem with Bottleneck Time to generate optimal solution and Information Analyzer system.

- *Optimization Model Base Subsystem:* The Optimization Model base Subsystem accepts data from Data Base Management Subsystem, interact with Tele-Medical Services Module, and display the result through Central Vision Exhibit Desk. The Optimization Model Base Subsystem comprises of an optimization model which is used to determine feasible transportation schedule that minimizes the multiple transportation cost and also minimizes the maximization of time involved in transporting the Mobile Van from various origins to various destinations.
- *Information Analyzer Subsystem:* The Information Analyzer Subsystem is responsible for data mining and knowledge discovery using case based reasoning, fuzzy techniques, Artificial Intelligence Techniques. Case based reasoning is a knowledge base problem solving paradigm that resolves new problem by adapting the solutions used to solve problem of a similar nature in the past. This system is responsible for constructing problem solving models supported by Knowledge base and Optimization Model Subsystem.

4) Central Vision Exhibit Board (CVEB)

The CVEB for Tele-Medical Transportation Management system is based on independent and interactive knowledge based agents such as Data Completion, Data Analysis, Information Visualization, and Prediction and Control functions. It stores the optimized / prioritized solutions which are displayed to the users.

5) Data Base Management Subsystem (DBMS)

The Tele-Medical Transportation System utilizes a relational Data Base Management Subsystem for simplification, preparation, and pre–processing of input data for Tele-Medical Transportation Services Management. The relational database is comprised of daily mobile van transport analysis report as given by Tele-Medical Transportation Corporation. The main task of the Database Management Subsystem is the simplification, preparation, and pre-processing of input data of Tele-Medical Transportation Services Management, and also control and verify the bulk of data required by the Modules. The Subsystem consists of a central data depository that contains all the relevant historic and current data, and tools to automatically extract the necessary data for their primary sources of storage and re-store them in the database warehouse.

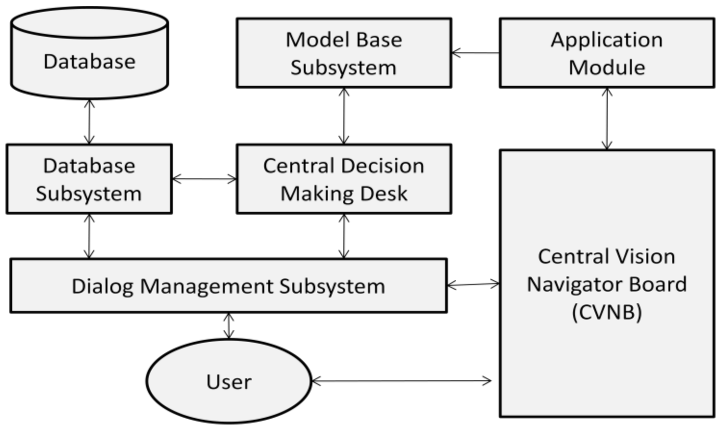

Figure 1: DSS for Tele-Medical Transportation Management Architecture

3 THE MULTIPLE OBJECTIVES FRACTIONAL MOBILE VAN TRANSPORTATION PROBLEM WITH BOTTLENECK TIME OPTIMIZATION MODEL

The Optimization Model Base Subsystem consists of Multiple Objective Fractional Mobile Van Transportation Problem with Bottleneck Time. Algorithm to determine the Multiple Objective Fractional Mobile Van Transportation Problem with Bottleneck Time of Tele-Medical Transportation Services can be stated as follows:

(MOFCBTTPI)
$$\min z_1 = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} c_{ij}^{1} x_{ij}}{\sum_{i=1}^{M}\sum_{j=1}^{N} d_{ij}^{1} x_{ij}} \quad (1)$$

$$\min z_2 = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} c_{ij}^{2} x_{ij}}{\sum_{i=1}^{M}\sum_{j=1}^{N} d_{ij}^{2} x_{ij}} \quad (2)$$

$$\vdots$$

$$\min z_L = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} c_{ij}^{L} x_{ij}}{\sum_{i=1}^{M}\sum_{j=1}^{N} d_{ij}^{L} x_{ij}} \qquad (3)$$

and

$$\min t = \max_{(i,j)} \left\{ t_{ij} \;\middle|\; x_{ij} > 0 \right\} \qquad (4)$$

subject to

$$\sum_{j=1}^{N} x_{ij} = a_i \qquad (i=1,\ldots, M) \qquad (5)$$

$$\sum_{i=1}^{M} x_{ij} = b_j \qquad (j=1,\ldots, N) \qquad (6)$$

$$x_{ij} \geq 0, \quad (i=1,\ldots,M;\ j=1,\ldots N) \qquad (7)$$

where

a_i = amount of the commodity available at the i^{th} supply point,

b_j = requirement of the commodity at the j^{th} demand point,

x_{ij} = amount of commodity transported from the i^{th} supply point to the j^{th} demand point.

t_{ij} = time of transportation of commodity from the i^{th} supply point to the j^{th} demand point and is independent of the amount of commodity so long as $x_{ij} > 0$,

c^{L}_{ij}, d^{L}_{ij} = proportional contribution to the value of L^{th} fractional objective function of shipping one unit of commodity from the i^{th} supply point to the j^{th} demand point.

The objective function (1), (2) and (3) subject to constraints (5), (6) and (7) defines the Multiple Objective Fractional Transportation Problem and the Bottleneck Objective Function (4) subject to constraints (5), (6) and (7) defines the Time Transportation Problem.

Setting $M'=\{1,\ldots,M\}$, $N'=\{1,\ldots,N\}$, $P'=\{1,\ldots,P\}$; $J'=\{(i, j)|i\in M', j\in N'\}$, the MOFTPBT can be re-written as

$$"\min"\left[\begin{array}{l} Z = \dfrac{\sum_{(i,j)\in J`} c_{ij} x_{ij}}{\sum_{(i,j)\in J`} d_{ij} x_{ij}} \\ t = \max_{(i,j)} \left\{ t_{ij} \middle| \; x_{ij} \; > \; 0 \right\} \end{array} \middle| \begin{array}{ll} \sum_{j\in N`} x_{ij} = a_i & \text{for all } i \in M` \\ & \text{for all } j \in N` \\ \sum_{i\in M`} x_{ij} = b_j & x_{ij} \geq 0, \quad \text{for all } (i,j) \in J` \end{array} \right] \quad (8)$$

where $Z \in R$, set of real numbers, $c_{ij} = \left(c_{ij}^1, ..., c_{ij}^L\right)^T$ and $d_{ij} = \left(d_{ij}^1, ..., d_{ij}^L\right)^T$.

The operator "min" in (8) indicates that all solutions for (8) are to be determined that are efficient iff x^o is feasible solution for (8) and there is no other feasible solution x', for (8) such that

$$Z' = \frac{\sum_{(i,j)\in J`} c_{ij} x'_{ij}}{\sum_{(i,j)\in J`} d_{ij} x'_{ij}} \leq \frac{\sum_{(i,j)\in J`} c_{ij} \hat{x}_{ij}}{\sum_{(i,j)\in J`} d_{ij} \hat{x}_{ij}} = \hat{Z}$$

Assumptions:

- a_i $(i \in M')$ and b_j $(j \in N')$ are given non-negative numbers
-
- $\sum_i a_i = \sum_j b_j$

the denominator of the objective function Z of (8) is positive for all feasible solutions

The Lexicographic Minimum Transportation Problem

If the transportation system decision maker decides the priorities with respect to the attainment of the considered objectives, this trade-off concept may be represented by a vector of objective functions, which are to be minimized lexicographically. The MOFTPBT is formulated as a Lexicographic Minimum Transportation Problem (LMTP):

$$\text{"lex min"}\begin{bmatrix} Z_1 = \dfrac{\sum_{(i,j)\in J`} c_{ij}x_{ij}}{\sum_{(i,j)\in J`} d_{ij}x_{ij}} \\ Z_2 = \sum_{(i,j)\in J`} g_{ij}x_{ij} \end{bmatrix}\left|\begin{matrix} \sum_{j\in N`} x_{ij} = a_i, \ \ for \ \ all \ \ i \in M' \\ \sum_{i\in M`} x_{ij} = b_j, \ \ for \ \ all \ \ j \in N' \\ x_{ij} \geq 0, \ \ for \ \ all \ \ (i,j) \in J' \end{matrix}\right] \qquad (9)$$

with
$$g_{ij} := [e_c], \quad (i,j) \in \gamma_c, \quad c = (1,..,h) \qquad (10)$$

A feasible solution for Z of (8), which is a unique optimal solution with respect to the fractional cost objective function Z_1 (1), is an optimal basic solution for Z_1 of (9) and, therefore, an efficient basic solution for Z of (8). But if there is no unique optimal basic solution with respect to the fractional cost objective function Z_1 (1), some of these optimal basic solutions may not be efficient solutions for Z of (8). By the LMTP, denoted by (9), one feasible basic solution which is optimal with respect to Z_1 (1) is also efficient to Bi-criteria Transportation Problem (BTP).
The above formulation of the LMTP is done by modifying the solution methodology of Chandra and Saxena (1987), the corresponding BTP reads

$$\text{(BTP)} \quad \text{lexmin}\begin{bmatrix} Z_1 = \dfrac{\sum_{(i,j)\in J`} c_{ij}x_{ij}}{\sum_{(i,j)\in J`} d_{ij}x_{ij}} \\ Z_2 = \sum_{c=1}^{h} e_c \sum_{(i,j)\in J`} x_{ij} \end{bmatrix}\left|\begin{matrix} \sum_{j\in N`} x_{ij} = a_i, \ \ for \ \ all \ \ i \in M' \\ \sum_{i\in M`} x_{ij} = b_j, \ \ for \ \ all \ \ j \in N' \\ x_{ij} \geq 0, \ \ for \ \ all \ \ (i,j) \in J' \end{matrix}\right] \qquad (11)$$

The MOFTPBT Algorithm

An algorithm is provided to determine all efficient basic solutions to corresponding BTP in a finite number of iterations and also an optimal solution with respect to the second objective function. The steps are given below.

Step1: Determine the lower bound t^l (Chandra and Saxena, 1987) on t to reduce the dimension of the vectors g_{ij} in (10). Now $t^l > t_{ij}$ for at least one pair $(i, j) \in \gamma$. Here $\gamma_c, \ (c = 1,...,h)$, contains all $(i, j) \in \gamma$ with $t^l > t_{ij}$.

Step 2: Determine an initial feasible basic solution X^1 to the LTP by NWCR method.

Step 3: From X^1, obtain the resulting bottleneck transportation time to determine an upper bound t^U.

Step 4: Partition the set $\gamma := M \times N$ into subsets γ_c (c=1,...,h) and determine the g_{ij} for all $(i,j) \in \gamma$ according to (10) to obtain the matrix for BTP.

Step 5: Designate the set of pairs of indices (i, j) of the basic variables by I and determine recursively the L-dimensional vector-valued row multipliers u^1_i, u^2_i (i=1,...,M) and vector-valued row multipliers u^t; L-dimensional vector-valued column multipliers v^1_j, v^2_j (j=1,...,N) and vector-valued column multipliers v^t defined such that

$$c_{ij} - \left(u_i^1 + v_j^1\right) = 0 \qquad (12)$$

$$d_{ij} - \left(u_i^2 + v_j^2\right) = 0 \qquad (13)$$

$$g_{ij} - \left(u_i^t + v_j^t\right) = 0 \qquad (14)$$

(for those i, j for which x_{ij} is in the basis)

Step 6: Compute the reduced criterion vectors Δ^1_{ij} by extending the duality results of Swarup (1968) and Chandra et al (1987) for multiple objective fractional transportation problem

$$\Delta_{ij}^1 = \left[V_2 \cdot c_{ij}^{'} - V_1 \cdot d_{ij}^{'}\right] \qquad (15)$$

where

$$c_{ij}^{'} = c_{ij} - \left(u_i^1 + v_j^1\right) = 0$$

$$d_{ij}^{'} = d_{ij} - \left(u_i^2 + v_j^2\right) = 0$$

$$V_1 = \left[\sum_{i \in M'} u_i^1 a_i + \sum_{j \in N'} v_j^1 b_j\right]$$

$$V_2 = \left[\sum_{i \in M'} u_i^2 a_i + \sum_{j \in N'} v_j^2 b_j \right] \quad \text{for all } (i, j) \in J`\backslash I.$$

Step 7: If Δ^1_{ij} are lexicographically greater than or equal to the zero vector for all (i, j)$\in$ J′\I, then the current feasible basic solution is optimal to LTP and also initial efficient basic solution to BTP. Go to step 10, otherwise go to Step 8.

Step 8: Select

$$\Delta^1_{i_o j_o} = lex \min \left[\Delta^1_{ij} \mid \Delta^1_{ij} \underset{\sim}{<} 0 \right] \tag{16}$$

By applying the selection rule (44), the variable $x_{i_o j_o}$ becomes a basic variable of the new feasible basic solution. Change the current solution to the new feasible basic solution using the standard transportation method. Go to step 5.

Step 9: Let $\hat{X}{}^1 = \left(\hat{x}{}^1_{ij} \right)$ is the optimal solution to LTP, then $\hat{X}{}^1$ is the initial efficient basic solution to BTP. Denote this initial efficient basic solution to BTP by $\overset{\wedge}{\mathbf{X}}{}^{\mathbf{1}}$.

Step 10: For the initial efficient basic solution to BTP, compute the relative criterion vectors $\Delta^*_{\mathbf{ij}}$

$$\Delta^*_{\mathbf{ij}} = g_{ij} - \left(\mathbf{u^t} + \mathbf{v^t} \right) \tag{17}$$

It is to be noted here that for each non-basic variable $\mathbf{x_{ij}}$ of the current efficient basic solution, Δ^1_{ij} indicates the fractional cost variations and the c[th] component Δ^{*c}_{ij} of Δ^*_{ij} indicates the commodity flow (BF) increase with respect to the transportation time which is related to γ_c (c=1,...,h).

Step 11: Generate Δ_{ij} from $\Delta^*_{\mathbf{ij}}$ [from (17)] and Δ^1_{ij} [from (15)].

Step 12: If all $\Delta^{*}_{ij} \underset{\sim}{\geq} 0$ for all (i, j)□∈ J′\I, the current efficient basic solution of BTP is optimal with respect to the second objective. Go to step 17. Otherwise go to step 13 to determine the non-basic variable which is to become the basic variable of the new efficient basic solution.

Step 13: Let $\hat{c}$ be the index of the first positive component of the vector Z_2 and let $\Delta^{*c}_{ij}, < 0$ for at least one pair $(i,j) \in J'\backslash I$. Then each non-basic variable $x_{i_0 j_0}$ with

$$\frac{\hat{\Delta}^{1}_{i_0 j_0}}{\hat{\Delta}^{*\hat{c}}_{i_0 j_0}} = \min\left[-\frac{\hat{\Delta}^{1}_{ij}}{\hat{\Delta}^{*\hat{c}}_{ij}} \;\middle|\; \hat{\Delta}^{*}_{ij} \underset{\sim}{<} 0,\ \hat{\Delta}^{*\hat{c}}_{ij} < 0,\ (i,j) \in J'\backslash I \right] \quad (18)$$

has to be made the basic variable of an adjacent efficient basic solution. Now go to step 15. If selection rule (46) does not apply, go to step 14.

Step 14: Apply selection rule

$$\hat{\Delta}^{1}_{i_0 j_0} = lex\min\left[\Delta^{1}_{ij} \;\middle|\; \Delta^{1}_{ij} \underset{\sim}{<} 0\right] \quad (19)$$

Now by applying the selection rule (19), let $\hat{x}_{i_0 j_0}$ be the new basic variable. If its value, $\hat{x}_{i_0 j_0} = 0$, go to step 16. If $\hat{x}_{i_0 j_0} > 0$ the current e.b.s yields the optimal bottleneck time (BT) and the optimal bottleneck flow (BF). Go to Step 17.

Step 15: Now $\hat{x}_{i_0 j_0}$ becomes a basic variable of the new efficient basic solution which is adjacent to the current efficient basic solution. Change the current solution to the new efficient basic solution.

Step 16: Determine recursively the L-dimensional and associated vector-valued row and column multipliers from equation (12), (13), (14). Go to Step 11.

Step 17: All efficient basic solutions to BTP have been determined.

Case Study

The algorithm is applied to determine a feasible mobile van transportation schedule which minimizes the total actual/total standard mobile van fuel cost, total actual/total standard mobile van manpower cost and total actual/total standard mobile van maintenance cost and also minimizes the maximum of mobile van shipping time involved.

The Multiple Objective Fractional Transportation Problem with Bottleneck Time (MOFTPBT) of mobile van Transportation can be stated as follows:

$$\min z = \frac{\sum_{i=1}^{4}\sum_{j=1}^{4} c_{ij}^{L} x_{ij}}{\sum_{i=1}^{4}\sum_{j=1}^{4} d_{ij}^{L} x_{ij}}$$

and $$\min t = \max_{(i,j)} \{ t_{ij} \mid x_{ij} > 0 \}$$

subject to

$$\sum_{j=1}^{4} x_{ij} = a_i$$

$$\sum_{i=1}^{4} x_{ij} = b_j$$

$x_{ij} \geq 0$, (i = 1, 2, 3, 4;j = 1, 2, 3, 4; L = 1, 2, 3, 4)

Consider MOFTPBT of Ambulance Transportation with:

Fractional Costs as

$$\begin{bmatrix} \begin{bmatrix}5\\8\\9\end{bmatrix} \begin{bmatrix}4\\5\\4\end{bmatrix} & \begin{bmatrix}6\\6\\7\end{bmatrix} \begin{bmatrix}4\\9\\1\end{bmatrix} & \begin{bmatrix}8\\7\\8\end{bmatrix} \begin{bmatrix}2\\6\\8\end{bmatrix} & \begin{bmatrix}8\\4\\6\end{bmatrix} \begin{bmatrix}1\\2\\1\end{bmatrix} \\ \begin{bmatrix}6\\9\\5\end{bmatrix} \begin{bmatrix}5\\10\\11\end{bmatrix} & \begin{bmatrix}5\\2\\10\end{bmatrix} \begin{bmatrix}7\\5\\7\end{bmatrix} & \begin{bmatrix}4\\5\\3\end{bmatrix} \begin{bmatrix}3\\7\\9\end{bmatrix} & \begin{bmatrix}7\\8\\4\end{bmatrix} \begin{bmatrix}4\\9\\4\end{bmatrix} \\ \begin{bmatrix}5\\3\\7\end{bmatrix} \begin{bmatrix}2\\6\\3\end{bmatrix} & \begin{bmatrix}8\\4\\2\end{bmatrix} \begin{bmatrix}2\\8\\9\end{bmatrix} & \begin{bmatrix}2\\3\\9\end{bmatrix} \begin{bmatrix}3\\2\\6\end{bmatrix} & \begin{bmatrix}2\\5\\5\end{bmatrix} \begin{bmatrix}2\\1\\3\end{bmatrix} \\ \begin{bmatrix}6\\1\\1\end{bmatrix} \begin{bmatrix}5\\2\\4\end{bmatrix} & \begin{bmatrix}8\\2\\6\end{bmatrix} \begin{bmatrix}8\\3\\3\end{bmatrix} & \begin{bmatrix}8\\3\\3\end{bmatrix} \begin{bmatrix}7\\7\\7\end{bmatrix} & \begin{bmatrix}3\\4\\7\end{bmatrix} \begin{bmatrix}2\\8\\7\end{bmatrix} \end{bmatrix}$$

shipping time:

$$T = \begin{bmatrix} 3 & 6 & 6 & 5 \\ 10 & 8 & 4 & 2 \\ 3 & 6 & 4 & 5 \\ 2 & 11 & 6 & 8 \end{bmatrix}$$

and $(a_1, a_2, a_3, a_4) = (7, 6, 8, 6)$; $(b_1, b_2, b_3, b_4) = (3, 5, 12, 7)$.

The first step of the algorithm is to determine the lower bound the row threshold and column threshold = (5, 2, 4, 6, 2, 6, 4, 5), gives the lower bound for MOFTPBT as $t^l = 6$. By the NWCR, the initial feasible basic solution to this MOFTPBT is:

$$x_{11} = 3,\ x_{12} = 4,\ x_{22} = 1,\ x_{23} = 5,\ x_{33} = 7,\ x_{34} = 1,\ x_{44} = 6$$

From the initial basic feasible solution X^1 with the bottleneck transportation time of 8, an upper bound $t^U = 8$ is obtained. Partition the set $\gamma = M \times N$ into subsets γ_c. Hence c=4 and so γ has 4 subsets:

$\gamma_1 := \{ (i, j) \in \gamma \mid t_{ij} > 8\}$, $\gamma_2 := \{ (i, j) \in \gamma \mid t_{ij} = 8\}$,

$\gamma_3 := \{ (i, j) \in \gamma \mid t_{ij} = 6\}$, $\gamma_4 := \{ (i, j) \in \gamma \mid t_{ij} < 6\}$

Now the matrix of following related LMTP

$$\text{(LMTP)}\quad \text{lex min}\left[\begin{array}{c|c} Z_1 = \dfrac{\sum_{i=1}^{4}\sum_{J=1}^{4} c_{ij}x_{ij}}{\sum_{i=1}^{4}\sum_{J=1}^{4} d_{ij}x_{ij}} & \begin{array}{l} \sum_{i=1}^{4} x_{ij} \quad j = 1,2,3,4 \\ \sum_{j=1}^{4} x_{ij} \quad i = 1,2,3,4 \end{array} \\ Z_2 = \sum_{i=1}^{4}\sum_{J=1}^{4} g_{ij}x_{ij} & x_{ij} \ge 0, \quad for\ \ all\ \ (i,j) \in J' \end{array}\right]$$

with $g_{ij} := (e_c)$ $(i, j) \in \gamma_c$, $c = (1,...,h)$

can be written as:

$$\begin{bmatrix}
\begin{bmatrix}\begin{bmatrix}5\\8\\9\end{bmatrix} & \begin{bmatrix}4\\5\\4\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}6\\6\\7\end{bmatrix} & \begin{bmatrix}4\\9\\1\end{bmatrix}\\ \multicolumn{2}{c}{e_3}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}8\\7\\8\end{bmatrix} & \begin{bmatrix}2\\6\\8\end{bmatrix}\\ \multicolumn{2}{c}{e_3}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}8\\4\\6\end{bmatrix} & \begin{bmatrix}1\\2\\1\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix}\\
\begin{bmatrix}\begin{bmatrix}6\\9\\5\end{bmatrix} & \begin{bmatrix}5\\10\\11\end{bmatrix}\\ \multicolumn{2}{c}{e_1}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}5\\2\\10\end{bmatrix} & \begin{bmatrix}7\\5\\7\end{bmatrix}\\ \multicolumn{2}{c}{e_2}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}4\\5\\3\end{bmatrix} & \begin{bmatrix}3\\7\\9\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}7\\8\\4\end{bmatrix} & \begin{bmatrix}4\\9\\4\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix}\\
\begin{bmatrix}\begin{bmatrix}5\\3\\7\end{bmatrix} & \begin{bmatrix}2\\6\\3\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}8\\4\\2\end{bmatrix} & \begin{bmatrix}2\\8\\9\end{bmatrix}\\ \multicolumn{2}{c}{e_3}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}2\\3\\9\end{bmatrix} & \begin{bmatrix}3\\2\\6\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}2\\5\\5\end{bmatrix} & \begin{bmatrix}2\\1\\3\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix}\\
\begin{bmatrix}\begin{bmatrix}6\\1\\1\end{bmatrix} & \begin{bmatrix}5\\2\\4\end{bmatrix}\\ \multicolumn{2}{c}{e_4}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}8\\2\\6\end{bmatrix} & \begin{bmatrix}8\\3\\3\end{bmatrix}\\ \multicolumn{2}{c}{e_1}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}8\\3\\3\end{bmatrix} & \begin{bmatrix}7\\7\\7\end{bmatrix}\\ \multicolumn{2}{c}{e_3}\end{bmatrix} & \begin{bmatrix}\begin{bmatrix}3\\4\\7\end{bmatrix} & \begin{bmatrix}2\\8\\7\end{bmatrix}\\ \multicolumn{2}{c}{e_2}\end{bmatrix}
\end{bmatrix}$$

Table 1 shows the transportation tableau for mobile van transportation problem with the initial feasible basic solution X^1 The amount x_{ij} are shown in the top right corner of each cell. The marginal column contains the values of $u^1{}_i$, $u^2{}_i$ and u^t while marginal row contains the values of $v^1{}_j$, $v^2{}_j$ and v^t . Δ_{ij} are shown in the left corner. The values of b_j are displayed in the top row of the table while a_i in the first left column. For all $(i, j)\in J'\backslash I$, reduced criterion vectors $\Delta^1{}_{ij} \geq 0$, hence the current feasible basic solution is optimal to the LTP and also initial efficient to the BTP. Denote this efficient basic solution by $\mathbf{X^1}$. Here

$$Z(\mathbf{X^1}) = \begin{bmatrix} 98,\ 125,\ 190 \\ 85,\ 154,\ 155 \\ 0,\ 7,\ 4,\ 16 \end{bmatrix}$$

	7	6	8	6	vector valued row multipliers
3	$x_{11}=3$	$x_{12}=4$	$\Delta_{13}=\begin{bmatrix}59.0\\317.0\\290.0\\0\\1\\0\\-1\end{bmatrix}$	$\Delta_{14}=\begin{bmatrix}59.0\\-78.0\\1360.0\\0\\1\\-1\\0\end{bmatrix}$	$\begin{bmatrix}5,8,9\\4,5,4\\0,0,0,1\end{bmatrix}$
5	$\Delta_{21}=\begin{bmatrix}366.0\\-355.0\\-1275.0\\1\\-1\\1\\-1\end{bmatrix}$	$x_{22}=1$	$x_{23}=5$	$\Delta_{24}=\begin{bmatrix}59.0\\-22.0\\1155.0\\0\\0\\0\\0\end{bmatrix}$	$\begin{bmatrix}4,4,12\\7,1,10\\0,1,-1,1\end{bmatrix}$
12	$\Delta_{31}=\begin{bmatrix}745.0\\-1096.0\\-945.0\\0\\-1\\1\\0\end{bmatrix}$	$\Delta_{32}=\begin{bmatrix}915.0\\616.0\\-3120.0\\0\\-1\\1\\0\end{bmatrix}$	$x_{33}=7$	$x_{34}=1$	$\begin{bmatrix}2,2,18\\7,-4,7\\0,1,-1,1\end{bmatrix}$
7	$\Delta_{41}=\begin{bmatrix}451.0\\125.0\\-1615.0\\0\\-2\\1\\1\end{bmatrix}$	$\Delta_{42}=\begin{bmatrix}732.0\\1212.0\\-910.0\\1\\-2\\0\\1\end{bmatrix}$	$\Delta_{43}=\begin{bmatrix}33.0\\404.0\\-670.0\\0\\-1\\1\\0\end{bmatrix}$	$x_{44}=6$	$\begin{bmatrix}3,1,20\\7,3,11\\0,2,-1,0\end{bmatrix}$
vector valued column multi-pliers	$\begin{bmatrix}0,0,0\\0,0,0\\0,0,0,0\end{bmatrix}$	$\begin{bmatrix}1,-2,-2\\0,4,-3\\0,0,1,-1\end{bmatrix}$	$\begin{bmatrix}0,1,-9\\-4,6,-1\\0,-1,1,0\end{bmatrix}$	$\begin{bmatrix}0,3,-13\\-5,5,-4\\0,-1,1,0\end{bmatrix}$	$Z=\begin{bmatrix}98,125,190\\85,154,155\\0,7,4,16\end{bmatrix}$

Table 1: MOFTPBT for X^1

It is to be noted that for the current efficient basic solution $\mathbf{X^1}$, the total actual/total standard mobile van fuel, manpower and maintenance costs are (1.153, 0.812, 1.276) respectively, the bottleneck time is 8 and the bottleneck flow is 7. As Δ^*_{ij} in Δ_{ij} are lexicographically smaller than zero vector, hence $\mathbf{X^1}$ is not optimal with respect to the second objective. In order to determine an efficient basic solution $\mathbf{X^2}$, apply selection rule (19). The new efficient basic solution is:

$x_{11} = 3$, $x_{12} = 4$, $x_{22} = 1$, $x_{23} = 5$, $x_{33} = 1$, $x_{34} = 7$, $x_{43} = 6$

Proceeding in the same manner, the efficient solutions and the values of the considered objectives for various iterations are:

$$\mathbf{X}^2 = \begin{bmatrix} 3 & 4 & 0 & 0 \\ 0 & 1 & 5 & 0 \\ 0 & 0 & 1 & 7 \\ 3 & 0 & 6 & 0 \end{bmatrix} \text{Fractional Cost} = \begin{bmatrix} 1.174 \\ 0.922 \\ 1.032 \end{bmatrix}, \text{Bottleneck Flow} = 1, \text{Bottleneck Time} = 8$$

$$\mathbf{X}^3 = \begin{bmatrix} 2 & 5 & 0 & 0 \\ 0 & 0 & 6 & 0 \\ 0 & 0 & 1 & 7 \\ 3 & 0 & 5 & 0 \end{bmatrix} \text{Fractional Cost} = \begin{bmatrix} 1.223 \\ 0.909 \\ 0.985 \end{bmatrix}, \text{Bottleneck Flow} = 10, \text{Bottleneck Time} = 6$$

$$\mathbf{X}^4 = \begin{bmatrix} 0 & 5 & 0 & 2 \\ 0 & 0 & 6 & 0 \\ 0 & 0 & 3 & 5 \\ 3 & 0 & 3 & 0 \end{bmatrix} \text{Fractional Cost} = \begin{bmatrix} 1.347 \\ 0.884 \\ 1.016 \end{bmatrix}, \quad \text{Bottleneck Flow} = 8, \text{Bottleneck Time} = 6$$

Here $\mathbf{X}^4$ (Table 2) is the efficient basic solution which is optimal with respect to the second objective.

	7	6	8	6	u_i
3	$\Delta_{11}=\begin{bmatrix} -607.0 \\ 234.0 \\ -260.0 \\ 0 \\ 0 \\ 1 \\ -1 \end{bmatrix}$	$x_{12}=5$	$\Delta_{13}=\begin{bmatrix} 0.0 \\ 303.0 \\ 133.0 \\ 0 \\ 0 \\ 1 \\ -1 \end{bmatrix}$	$x_{14}=2$	$\begin{bmatrix} 6,0,8 \\ 0,-2,1 \\ 0,0,-1,2 \end{bmatrix}$
5	$\Delta_{21}=\begin{bmatrix} -132.0 \\ -138.0 \\ 498.0 \\ 1 \\ 0 \\ 1 \\ -2 \end{bmatrix}$	$\Delta_{22}=\begin{bmatrix} 29.0 \\ 9.0 \\ 1776.0 \\ 0 \\ 1 \\ -1 \\ 0 \end{bmatrix}$	$x_{23}=6$	$\Delta_{24}=\begin{bmatrix} 29.0 \\ -213.0 \\ 1528.0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$	$\begin{bmatrix} 2,3,-4 \\ 1,2,6 \\ 0,0,-1,2 \end{bmatrix}$
12	$\Delta_{31}=\begin{bmatrix} 347.0 \\ -768.0 \\ 0.0 \\ 0 \\ 0 \\ 1 \\ -1 \end{bmatrix}$	$\Delta_{32}=\begin{bmatrix} 1144.0 \\ -501.0 \\ 1282.0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$	$x_{33}=3$	$x_{34}=5$	$\begin{bmatrix} 0,1,7 \\ 1,-3,3 \\ 0,0,-1,2 \end{bmatrix}$
7	$x_{41}=3$	$\Delta_{42}=\begin{bmatrix} -66.0 \\ 723.0 \\ 891.0 \\ 1 \\ 0 \\ -2 \\ 1 \end{bmatrix}$	$x_{43}=3$	$\Delta_{44}=\begin{bmatrix} 37.0 \\ -357.0 \\ -629.0 \\ 0 \\ 1 \\ -1 \\ 0 \end{bmatrix}$	$\begin{bmatrix} 6,1,1 \\ 5,2,4 \\ 0,0,0,1 \end{bmatrix}$
v_j	$\begin{bmatrix} 0,0,0 \\ 0,0,0 \\ 0,0,0,0 \end{bmatrix}$	$\begin{bmatrix} 0,6,-1 \\ 4,11,0 \\ 0,0,2,-2 \end{bmatrix}$	$\begin{bmatrix} 2,2,2 \\ 2,5,3 \\ 0,0,1,-1 \end{bmatrix}$	$\begin{bmatrix} 2,4,-2 \\ 1,4,0 \\ 0,0,1,-1 \end{bmatrix}$	$Z=\begin{bmatrix} 128,114,129 \\ 95,129,127 \\ 0,0,8,19 \end{bmatrix}$

Table 2: MOFTPBT with $\mathbf{X}^4$

4 CONCLUSION

In order to effectively manage the Tele-medical services a TMTSDSS is developed in the paper. The developed system will help in identifying the useful information and provide optimum strategy for the Management of Tele-Medical Transportation Service. It will guide the behaviour of the service participant so as to make the system highly efficient. The developed system TMTSDSS will also help in developing intelligent search ability even when the requests given are fuzzy or incomplete.

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