The Markov Chain Models in GDSS

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Contents

1. Introduction

The mathematical description of the behavior of a network system consisting of a large member of elements is extremely complicated. This direction of research covers many problems of biology, economics, sociology etc. We consider in this paper such problems in the context of "Group Decision Support Systems (GDSS)". There are 4 types of GDSS according to the duration of the decision making session and the degree of physical proximity of group members. (1) Decision Room, (2) Local Decision Network, (3) Teleconferencing, (4) Remote Decision Making (DeSanctis and Galupe 1985). Here we focus on Remote Decision Making. This type of GDSS is characterized by uninterrupted communication between remote members in a geographically dispersed organization. We assume that the members in the network system interact randomly. In a previous paper (Kigawa, 1990) we investigated a different convergent model without utility functions in GDSS. In this paper we use utility functions to represent preference of members, and consider a system based on cardinal preference information in the aggregation process or the negotiation process. The group takes decisions on the basis of unanimity. It is assumed that the decision process proceeds in a way that the group members first determine their own opinions about decision alternatives and next by a random interaction the opinions of other group members will often cause one member to reconsider and modify his or her evaluation about decision alternatives. For example, finding out that other group members pay considerable attention to one attribute might lead a member to give this attribute also more importance or conversely other member's view that one attribute is not important might lead to a member to give this attribute also less importance. Such feedbacks from the group to individual opinions are empirically observable phenomena in group decision making (Pruitt 1971). The collective behavior of the group member is described by Markov chains.

Next, we explore the implications and limitations of the above models from the several ideas of organization based on metaphors that lead us to see and understand organizations in distinctive yet partial ways. Morgan (Morgan, 1986) has explored and developed the metaphorical thinking. In this paper we examine three metaphors that exert influence on our models. These are the organismic metaphor, the brain metaphor and the political metaphor.

2. Mathematical Model of GDSS

Before we explore the mathematical model of GDSS, we begin this section with a discussion of individual preferences. In our model there is a set of N individuals, prosaically named 1 to N, and known collectively as the group. In our illustrative examples in the latter part, N is usually a fairly small number. The other 'raw material' of the model is a set of alternatives. In this paper there is a set of M alternatives. These are the things over which individuals have preferences. In this paper we consider an illustration of a group car buying problem. Therefore a set of alternatives consisted of M different types of car. In general, the alternatives are any situations about which some judgement or choice is to be made, and, from a formal point of view, it does not matter what these alternatives are. Each of our N individuals holds a preference concerning the alternatives. In this paper individual's preferences concerning the alternatives are expressed as utilities. We adopt here cardinal utility. Utilities that correspond to preference statement are cardinal. Member gives alternatives the absolute sizes of utility numbers. Cardinal utilities do have a role in social choice theory because they form the basis of utilitarian social choices. Rational decision makers are assumed to select the alternative that maximizes their utility.

2-1 Group Decision Rules and Interaction Mechanism in GDSS

Next, we consider the group decision rules. The procedures by which the group comes to a decision have an important bearing on the outcome of the decision making process. Every group uses some kind of decision rule. In this paper we presume that the group take decision on the basis of unanimity. If this is the case, the group can only reach a decision if every group member agrees that the solution selected is optimal.

Next, we consider the interaction mechanism in GDSS. Assume each decision member works individually with the single-user remote DSS procedure for group car buying problem.

The car utility u_n for member n is the M-dimensional real vector which is the M-permutations with repetition of M utility values, 0, 1, 2, ... , M-1. The number of permutation in question is,

$$U(M, M) = M^M \tag{1}$$

Here it is possible to assign the same utility value to several cars. Then each of the members can take a finite number of sates describing by a vector u. The sate of the whole network system is described by a matrix with the column vectors which are the M-dimentional vectors, that is, $(u_1, u_2, \ldots, u_N)$. Here two matrices which have the same column vectors are regarded as the same matrix or the same state of the network system because we are interested in the widely divergent set of viewpoint in group activity involving complex issues, regardless of which individual expresses which utility vector. Therefore the positions of the column vector are interchangeable with each other.

Let us determine also the rules of interaction between members as follows :

(a) At each step of the system's functioning only two member interaction can be possible. These probabilities of interaction are equal to

$$\mathrm{Pint} = 1 / \binom{N}{2} \tag{2}$$

(b) Assume that before the interaction the pair of member n and m were in the state $u_n =$

$(\cdots, i, \cdots)'$, and $u_m = (\cdots, j, \cdots)'$, where i and j are the utilities for the same car and $i > j$. The next state of the pair of member n and m after the interaction are $u_n = (\cdots, i, \cdots)'$, and $u_m = (\cdots, j+1, \cdots)'$ or $u_n = (\cdots, i-1, \cdots)'$, and $u_m = (\cdots, j, \cdots)'$ with probability α and $1-\alpha$ $(0<\alpha<1)$ respectivly, where " ' " mean a transpose of a matrix.

If $i=j$ then the next states after interaction are the same for both members.

Let $\{X_n\}$ be a Markov chain with state space $S = \{(u_1, u_2, \ldots\ldots, u_N)\,;\, u_n, (n=1, \ldots N)$ is the vector of utilities of cars for the member $n\}$.

Next we consider a state space of the Markov chain to be coded as matrices of $(u_1, \cdots\cdots, u_N)$, where u_i $(i=1, \cdots, N)$ is the column vector which is the M-dimentional vector. For example, if $N=2$, $M=2$, then the following possibilities exist :

$$\begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}, \begin{pmatrix} 0 & 0 \\ 0 & 1 \end{pmatrix}, \begin{pmatrix} 0 & 1 \\ 0 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}, \begin{pmatrix} 0 & 1 \\ 1 & 1 \end{pmatrix}, \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}, \begin{pmatrix} 1 & 1 \\ 0 & 0 \end{pmatrix}, \begin{pmatrix} 0 & 0 \\ 1 & 1 \end{pmatrix}, \begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}.$$

As we are interested in the pattern of the network system, two matrices which have the same column vector are regarded as the same matrix or the same state of the network system irrelavant to the column possition. For example, we can define that

$$\begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix} \equiv \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix}$$

, that is vector $(0, 0)'$, $(1, 0)'$ are interchangable in posision eachother.

A state in this chain will be absorbing if all the menbers of the network has the same utility vector.

As time progress, the behavior of the chain will be described by either (1) a transition to an absorbing state, (2) a transition to a state from which there may be a transition to an absorbing state with some nonzero probability, or (3) a transition to a state from which there is no probability of transitioning to an absorbing state in a single step. Thus the states can be indexed such that the state transition matrix, P, for the chain satisfies

$$P = \begin{bmatrix} I_a & O \\ R & Q \end{bmatrix} \tag{3}$$

, where I_a is an axa identity matrix describing its absorbing states, R is a txa transition substochastic matrix describing transions to an absorbing state, O denote the matrix of zero elements, Q is a txt transition substochastic matrix describing transitions to transient states and not to an absorbing state, and a and t are positive integers. By the fundamental matrix method (Isaacson and Madsen 1976), the way to get the expected absorption time from the transient states is to calculate

$$N = (I-Q)^{-1} \tag{4}$$

If $1'$ denotes a column vector of ones then $N1'$ is a vector, μ' in which the i-th entry is the expected absorption time from the i-th transient state. The absorption probabilities from the transient states into the various persistent states are given by NR. In addition to finding the mean of the absorption times to the persistent states, the fundamental matrix can be used to find the second moments, and is given by

$$\mu^{(2)'} = N\ (2\mu'-1') \tag{5}$$

where μ is the expected absorption times. Therefore the standard deviation of the absorption time is given by

$$SD' = \sqrt{\mu^{(2)'}-\mu^2} \tag{6}$$

2-2 Convergence Properties of GDSS

The behavior of the chain (3) satisfies

$$P^n = \begin{bmatrix} I_a & O \\ N_nR & Q^n \end{bmatrix} \tag{7}$$

where P^n is the n-step transition matrix, $N_n = I_t + Q + Q^2 + \cdots + Q^{n+1}$, and I_t is a txt identity matrix, and I_a is an axa identity matrix. As n tend to infinity,

$$\lim_{n \to \infty} P^n = \begin{bmatrix} I_a & O \\ N \cdot R & O \end{bmatrix} \tag{8}$$

(R. Goodman, 1988, p.158).

Therefore, given infinite time, the chain will transit with probability one to an absorbing state. The number of absorbing states in such a chain is M^M, because absorbing states are those *in which* each member has the same car utility vector and the number of car utility vectors is M^M which is shown as equation (1).

3. Numerical Example

In this section, we will illustrate the approach developed above by numerical examples. we consider two cases. One case is that a group of two persons has to decide about the purchase of a car from two alternatives. Second case is that a group of three persons has the same problem.

3-1 Case of two members (M=N=2)

Let us consider a network system of 2 members. Each member first is asked individually without consulting other member or revealing preferences to other members, to determine his or her preference about 2 decision alternatives or 2 types of car. The car utility value u_n for member n (n=1, 2) is the 2-dimensional vector $(i, j)'$, $(i, j=0, 1)$ where 0, 1 are cardinal utility values. The number of the 2-permutation with repetition of 2 members is

$$U(2, 2) = 2^2 = 4. \tag{9}$$

The list of this permutation is given by

$$\begin{pmatrix}0\\0\end{pmatrix},\ \begin{pmatrix}0\\1\end{pmatrix},\ \begin{pmatrix}1\\0\end{pmatrix},\ \begin{pmatrix}1\\1\end{pmatrix}. \tag{10}$$

The states of the whole network system are given by 10 matrices,

$$S_1=\begin{pmatrix}0\,1\\0\,0\end{pmatrix},\ S_2=\begin{pmatrix}0\,0\\0\,1\end{pmatrix},\ S_3=\begin{pmatrix}0\,1\\0\,1\end{pmatrix},\ S_4=\begin{pmatrix}1\,0\\0\,1\end{pmatrix},\ S_5=\begin{pmatrix}1\,1\\0\,1\end{pmatrix},\ S_6=\begin{pmatrix}0\,1\\1\,1\end{pmatrix},$$
$$S_7=\begin{pmatrix}0\,0\\0\,0\end{pmatrix},\ S_8=\begin{pmatrix}1\,1\\0\,0\end{pmatrix},\ S_9=\begin{pmatrix}0\,0\\1\,1\end{pmatrix},\ S_{10}=\begin{pmatrix}1\,1\\1\,1\end{pmatrix}. \tag{11}$$

The set $T=\{S_1, S_2, S_3, S_4, S_5, S_6\}$ is the set of transient states and the set $A=\{S_7, S_8, S_9, S_{10}\}$ is the set of persistent states or absorbing states. Matrices Q, R, and NR (the matrix of transition probabilities from the transient states T into various persistent states A) of Markov chain P with state space $S=\{T, A\}$ is given by

$$Q=\begin{pmatrix}0&0&0&0&0&0\\0&0&0&0&0&0\\\frac{1}{4}&\frac{1}{4}&0&0&\frac{1}{4}&\frac{1}{4}\\\frac{1}{4}&\frac{1}{4}&0&0&\frac{1}{4}&\frac{1}{4}\\0&0&0&0&0&0\\0&0&0&0&0&0\end{pmatrix},\ R=\begin{pmatrix}\frac{1}{2}&\frac{1}{2}&0&0\\\frac{1}{2}&0&\frac{1}{2}&0\\0&0&0&0\\0&0&0&0\\0&\frac{1}{2}&0&\frac{1}{2}\\0&0&\frac{1}{2}&\frac{1}{2}\end{pmatrix},\ N\cdot R=\begin{pmatrix}\frac{1}{2}&\frac{1}{2}&0&0\\\frac{1}{2}&0&\frac{1}{2}&0\\\frac{1}{4}&\frac{1}{4}&\frac{1}{4}&\frac{1}{4}\\\frac{1}{4}&\frac{1}{4}&\frac{1}{4}&\frac{1}{4}\\0&\frac{1}{2}&0&\frac{1}{2}\\0&0&\frac{1}{2}&\frac{1}{2}\end{pmatrix}. \tag{12}$$

Using the fundamental matrix N, he vector of the expected absorption time from the transient sates T is given by

$$\mu' = N1'=(1,\ 1,\ 2,\ 2,\ 1,\ 1)'. \tag{13}$$

The vector of second moments is given by

$$\mu^{(2)\prime} = (1, 1, 4, 4, 1, 1)'. \tag{14}$$

Therefore the vector of standard deviations is given by

$$SD' = (0, 0, 0, 0, 0, 0)'. \tag{15}$$

Next, we show the structure of states according to the vector of the expected absorption time from the transient states T, that is, equation (13).

Fig.1 presents the absorbing states in two dimensional grid. The horizontal axis shows the utility of type 1 car, and the vertical axis shows the utility of type 2 car. The vector of utilities of each member is located in this grid. Each small dot in four corners in Fig.1 presents that two members have the same vector of utility and are located at the same coordinates. Therefore, for example the small dot located at (0, 1)' represents the network sate S_9 which indicates that we should select the type 2 car. If we reach either of the states S_7 or S_{10} then we have to select one car by coin tossing or reference to a higher authority.

Fig.2 presents the transient states from which it takes 1 unit time to the absorbing states. In Fig.2 network state is presented by a rectangle. **Fig. 3** presents the transient states from which it takes 2 units time to the absorbing states. Therefore the network states S_3, and S_4 presented in Fig.3 are the most widely divergent sets of preference of members. From these facts we construct a partial order in the set of network states according to the expected absorption time.

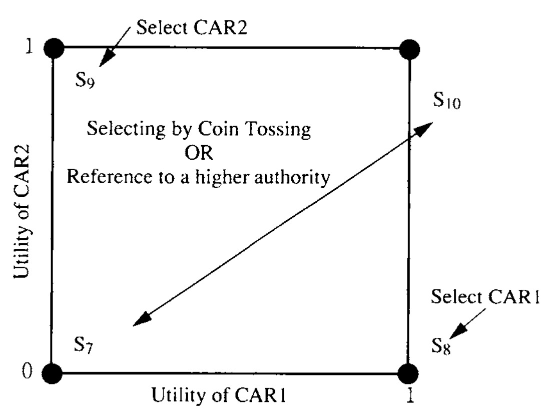

Fig.1 Absorbing states

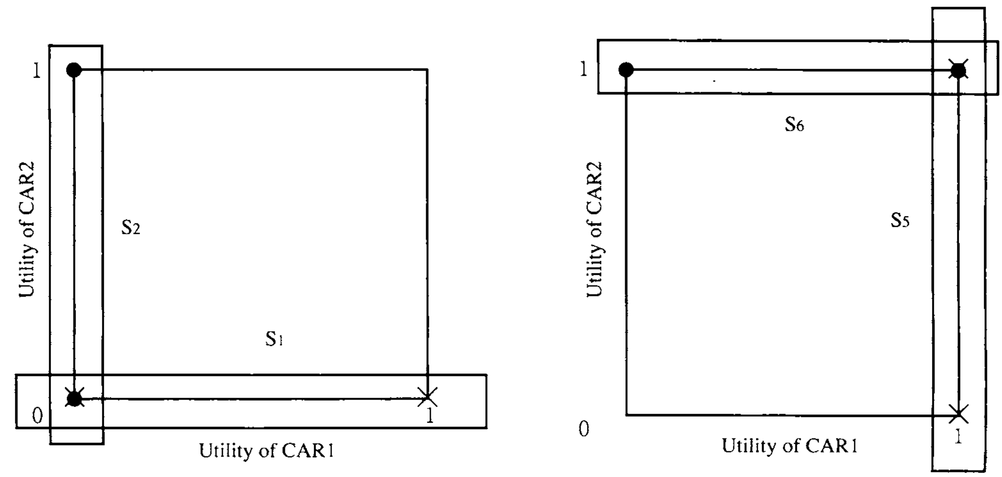

Fig.2 Transient states from which it takes 1 unit time to the absorbing states

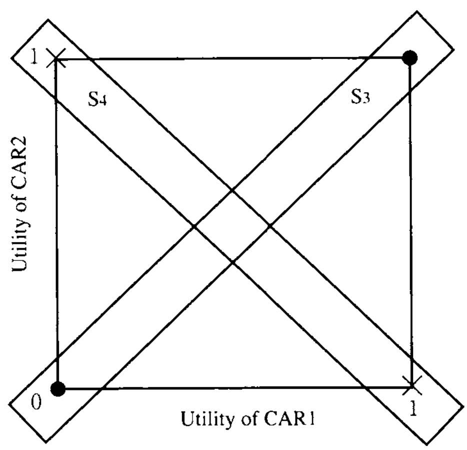

Fig.3 Most widely divergent sets of prefence

3-2 Case of three members (M=2, N=3)

Let us consider a network systems of 3 members. The states of the whole network system are given by 20 matrices.

$$S_1 = \begin{pmatrix} 0\,1\,1 \\ 0\,0\,0 \end{pmatrix},\ S_2 = \begin{pmatrix} 0\,1\,1 \\ 0\,1\,1 \end{pmatrix},\ S_3 = \begin{pmatrix} 0\,0\,1 \\ 0\,0\,0 \end{pmatrix},\ S_4 = \begin{pmatrix} 0\,0\,0 \\ 0\,0\,1 \end{pmatrix},\ S_5 = \begin{pmatrix} 0\,0\,1 \\ 0\,0\,1 \end{pmatrix},$$

$$S_6 = \begin{pmatrix} 0\,0\,1 \\ 0\,1\,0 \end{pmatrix},\ S_7 = \begin{pmatrix} 0\,1\,1 \\ 0\,0\,1 \end{pmatrix},\ S_8 = \begin{pmatrix} 0\,0\,1 \\ 0\,1\,1 \end{pmatrix},\ S_9 = \begin{pmatrix} 0\,1\,1 \\ 1\,0\,0 \end{pmatrix},\ S_{10} = \begin{pmatrix} 0\,1\,1 \\ 1\,1\,1 \end{pmatrix},$$

$$S_{11} = \begin{pmatrix} 0\,0\,1 \\ 1\,1\,0 \end{pmatrix},\ S_{12} = \begin{pmatrix} 0\,0\,0 \\ 0\,1\,1 \end{pmatrix},\ S_{13} = \begin{pmatrix} 0\,0\,1 \\ 1\,1\,1 \end{pmatrix},\ S_{14} = \begin{pmatrix} 1\,1\,1 \\ 0\,1\,1 \end{pmatrix},\ S_{15} = \begin{pmatrix} 1\,1\,1 \\ 0\,0\,1 \end{pmatrix},$$

$$S_{16} = \begin{pmatrix} 1\,0\,1 \\ 0\,1\,1 \end{pmatrix},\quad S_{17} = \begin{pmatrix} 0\,0\,0 \\ 0\,0\,0 \end{pmatrix},\quad S_{18} = \begin{pmatrix} 0\,0\,0 \\ 1\,1\,1 \end{pmatrix},\quad S_{19} = \begin{pmatrix} 1\,1\,1 \\ 0\,0\,0 \end{pmatrix},\quad S_{20} = \begin{pmatrix} 1\,1\,1 \\ 1\,1\,1 \end{pmatrix}.$$

The set T= $\{S_1, S_2, \ldots\ldots, S_{16}\}$ is the set of transient states and the set A= $\{S_{17}, S_{18}, S_{19}, S_{20}\}$ is the set of persistent states or absorbing states. Matrices Q, R, and NR (the matrix of transition probabilities from the transient states T into various persistent states A) of a Markov chain P with state space S= $\{T, A\}$ is given by equation. (16).

$$R = \begin{pmatrix}
1/3 & 0 & 1/3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1/3 & 0 & 0 & 0 & 0 & 1/6 & 1/6 & 0 & 1/6 & 0 & 0 & 0 & 1/6 & 0 & 0 \\
1/3 & 0 & 1/3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1/3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/3 & 0 & 0 & 0 & 0 \\
0 & 0 & 1/6 & 1/6 & 1/3 & 0 & 1/6 & 1/6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1/4 & 1/4 & 0 & 0 & 1/12 & 1/12 & 1/6 & 0 & 1/6 & 0 & 0 & 0 & 0 & 0 \\
1/4 & 1/6 & 0 & 0 & 1/6 & 1/12 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/4 & 1/12 \\
0 & 1/6 & 0 & 0 & 1/6 & 1/12 & 0 & 0 & 0 & 0 & 0 & 1/4 & 1/4 & 0 & 0 & 1/12 \\
1/6 & 0 & 0 & 0 & 0 & 1/6 & 0 & 0 & 1/3 & 0 & 0 & 0 & 0 & 0 & 1/6 & 1/6 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/3 & 0 & 0 & 1/3 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1/6 & 0 & 0 & 0 & 0 & 1/3 & 1/6 & 1/6 & 0 & 0 & 1/6 \\
0 & 0 & 0 & 1/3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/3 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/3 & 0 & 0 & 1/3 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/3 & 1/3 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1/3 & 1/3 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1/12 & 1/12 & 1/6 & 1/4 & 1/6 & 0 & 0 & 1/4 & 0 & 0
\end{pmatrix},$$

$$Q = \begin{pmatrix}
0 & 0 & 1/3 & 0 \\
0 & 0 & 0 & 0 \\
1/3 & 0 & 0 & 0 \\
1/3 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1/3 \\
0 & 0 & 0 & 0 \\
0 & 1/3 & 0 & 0 \\
0 & 1/3 & 0 & 0 \\
0 & 0 & 0 & 1/3 \\
0 & 0 & 1/3 & 0 \\
0 & 0 & 0 & 0
\end{pmatrix},\quad
N\cdot R = \begin{pmatrix}
1/3 & 0 & 2/3 & 0 \\
1/9 & 2/9 & 2/9 & 4/9 \\
2/3 & 0 & 1/3 & 0 \\
2/3 & 1/3 & 0 & 0 \\
4/9 & 2/9 & 2/9 & 1/9 \\
4/9 & 2/9 & 2/9 & 1/9 \\
2/9 & 1/9 & 4/9 & 2/9 \\
2/9 & 4/9 & 1/9 & 2/9 \\
2/9 & 1/9 & 4/9 & 2/9 \\
0 & 1/3 & 0 & 2/3 \\
2/9 & 4/9 & 1/9 & 2/9 \\
1/3 & 2/3 & 0 & 0 \\
0 & 2/3 & 0 & 1/3 \\
0 & 0 & 1/3 & 2/3 \\
0 & 0 & 2/3 & 1/3 \\
1/9 & 2/9 & 2/9 & 4/9
\end{pmatrix}. \qquad (16)$$

The vector of expected absorption time from transient states T is given by

$$\mu' = N1' = (3,\ 45/8,\ 3,\ 3,\ 45/8,\ 21/4,\ 21/4,\ 21/4,\ 45/8,\ 3,\ 45/8,\ 3,\ 3,\ 3,\ 3,\ 21/4). \quad (17)$$

The vector of second moment of the expected absorption time is given by

$$\mu^{(2)'} = (15,\ 41.34,\ 15,\ 15,\ 41.34,\ 36.94,\ 36.94,\ 36.94,\ 41.34,\ 15,\ 41.34,\ 15,\ 15,\ 15,\ 15,\ 36.94). \quad (18)$$

Therefore the vector of standard deviation is given by

$$SD' = (2.45,\ 3.11,\ 2.45,\ 2.45,\ 3.11,\ 3.06,\ 3.06,\ 3.06,\ 3.11,\ 2.45,\ 3.11,\ 2.45,\ 2.45,\ 2.45,\ 2.45,\ 3.06). \quad (19)$$

According to the same representation as the case of two members, **Fig.4** presents the absorbing states in two dimensional grid. **Fig.5** presents the transient states from which it takes 3 units time to the absorbing states. **Fig.6** presents the transient states from which it takes 21/4 units time to the absorbing states. **Fig.7** presents the transient states from which it takes 45/8 units time to the absorbing states. Therefore the states S_2, S_5, S_9, and S_{11}

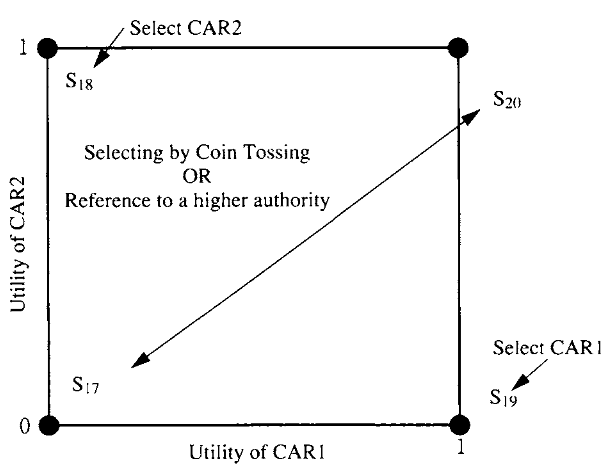

Fig.4 Absorbing states

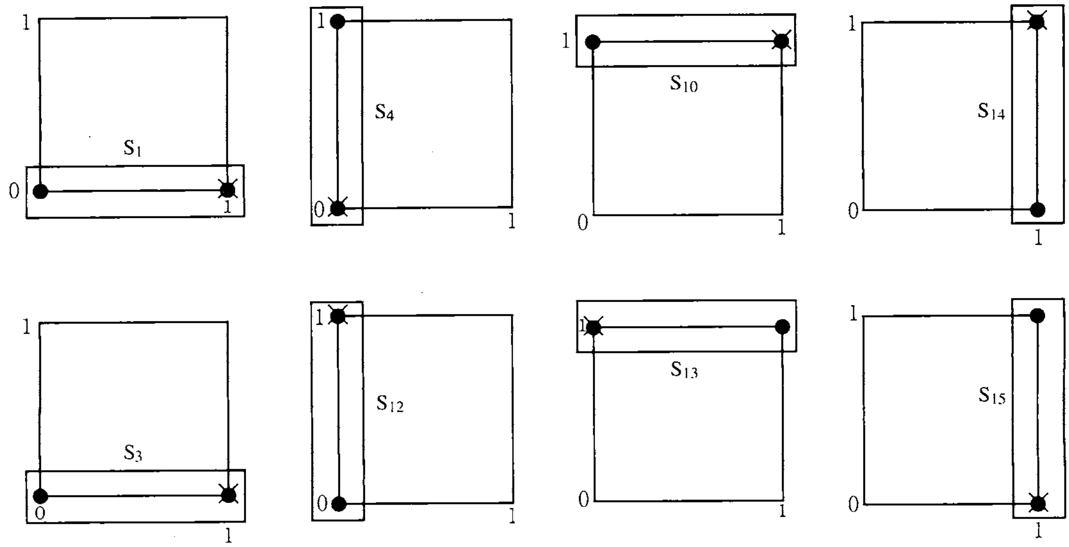

Fig.5 Transient states from wich it takes 3 units time to the absorbing states

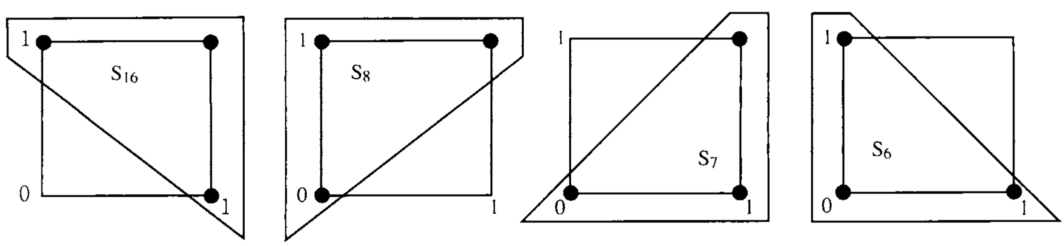

Fig.6 Transient States from which it takes 21/4 units time to the absorbing states

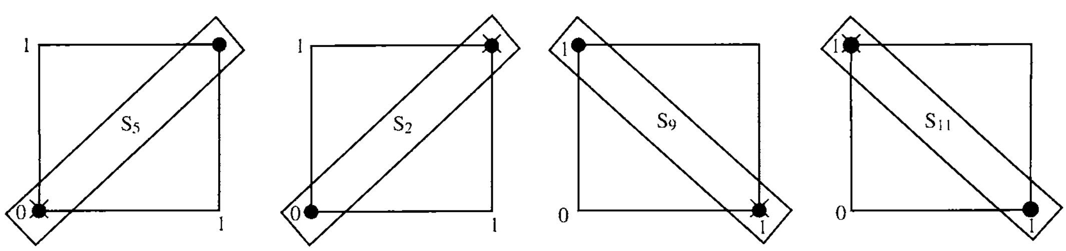

FIg.7 Most widely divergence sets of preference

presented in Fig.7 are the most widely divergent sets of preference of members. So we construct a partial order in the set of network states according to the expected absorption times as the case of two members. In Fig.4, 5, 6, 7 the symbol ●, × are different vectors of utility.

4. Implications and Limitations of our Model

In this section we explore the implications and limitations of my model from the several ideas of organization based on metaphors that lead us to see and understand organizations in distinctive yet partial ways. In other words, metaphor is a function which separate the objects into a ground and a figure. The important point is that there are many methods for this separation.

At first we examine the image of organizations as organisms, for this metaphor make it possible to explore effectively the implications of my model.

The first idea of organizations we explore is the organizations as open systems. It is this kind of thinking that now underpines the "systems approach" to organization which takes its main inspiration from the work of a theoretical biologist Ludwig von Bertalanffy. The pragmatic use of the systems approach rests in the attempts to establish congruencies between different systems (Morgan 1986). So the systems approach can be used to establish consensus between different members in the group (Warfield 1995). Here the principles of requisite variety, interaction and integration are important concepts. The principle of requisite variety which was originally formulated by the English cybernetician W. Ross Ashby (1952) suggests that the internal regulatory mechanisms of a system must be as diverse as the environment with which it is trying to deal. The principle of requisite variety is particularly important in designing control systems or for the management of internal and external boundaries - for these must embrace the complexity of the phenomena being controlled or managed to be effective. The widely divergent set of viewpoint in group activity involving complex issues i. e., "Spreadthink" (Warfield 1995) cannot be seen as a 'bad' phenomenon because requisite variety must embrace the complexity of the environment if the collective knowledge of group members is representative of the full context and scope pertaining to the complex issue.

The modern contingency theory, particularly reinforced and developed by Paul Lawrence and Jay Lorsch (1967), yielded important insights on modes of interaction and integration. The contingency theory explains why network systems such as multidisciplinary projects teams are effective as integration devices in turbulent environments. The network system is also effective as modes of interaction in research and development departments whic face ambiguous goals and have long time horizons. The reason is that network system can adapt less formalized modes of interaction. Also in their work, the successful use of these integrative devices was shown to be dependent on achieving an intermediate stance between the units being coordinated ; on the power, status, and competence of those involved ; and on the presence of a structure of rewards favoring integration. If power should enter into the model, we must distinguish each individual. For example, the matrix $\binom{0\,1}{0\,0}$ cannot be assumed to be equal to the matrix $\binom{1\,0}{0\,0}$ and also control the probability α in our model. The concept of power is also considered in a political metaphor of organization in the later part of this paper.

Next, we examine the ideas of information-processing and self-organization, or the image of organizations as brain.

The image of organization as brain, focus on the idea that the brain is an informatin-processing system and self-organizing system.

Organizations are information systems. They are communication systems. And they are decision-making systems. In organic and network organizations, they are more ad hoc and free flowing. This approach now is known as "the decision-making approach". In the decision-making approach, the process models have been developed mainly in psychological approaches to decision making. The basic idea is that decision making is a time-consuming process, in which various kinds of activities, taking place at different moments, can be discerned. In most of the process models, at least three basic activities are distinguished : (1) Problem identification, (2) Generation of a alternative solution and (3) valuation of alternative (Simon 1965). The decision maker first has to recognize the situation as one calling for decision making, in our case, the group member must recognize the group car buying problem. In the second phase, possible alternatives for reaching a desired solution are searched for, in our case, several kinds of car are chosen. Thirdly, the options generated have to be evaluated, in our case, each of the group member evaluate the different kinds of car according to his preference. In this evaluation phase, our model provides for reevaluation of each of group members after interaction between group members. Our model focuses mainly on the evaluation phase, and the first and the second phase are taken as given.

H. Simon & J. March explored the parallels between human decision making and organization decision making. We also aim at exploring this connection. Simon argued that people as the human decision maker settle for a "bounded rationality" of "good enough" decisions because of their limited knowledge and capacity and limited search and information.

After Simon, much of this work has focused on how organizations deal with the complexity and uncertainty presented by their environment. J. Galbraith (1977) has given attention to the relationships between uncertainty, information processing, and organization design. Uncertain task such as group car buying problem and staff employment problem require that greater amounts of information be processed between decision makers during task performance. As the modern contingency theory has explored, hierarchy provides an effective means for controlling environment that is fairly certain, but in uncertain and turbulent environment more organic form of organization become effective. While the former are based on information and decision making systems that are highly programmed and preplanned, the latter are typically based on processes which are flexible and ad hoc.

In the longer term, it is possible to see organizations becoming synonymous with their information systems, since microprocessing facilities such as PC, WS create the possibility of organizing without having an organization in physical terms. This new technology make it possible to decentralize control and decision, allowing workers engaged in related tasks to work in remote locations. For example, GDSS have already been used to design products and managing the R&D activities in remote locations.

Next, we examine the ideas of self-organization.

Organization is also a very complex phenomenon. The complexity or variety, measured by the number of distinguishable states, is phenomenal and well beyond the conscious control of any individual. In my model, when the number of group members increases, combinatorial explosion occurs. But when the number of individuals and alternatives is small we can construct a reasonable model which can be seen as self-organizing.

Another aspect of self-organization is the organization as a distributed knowledge system (Bond and Gasser 1988, Davis and Smith 1983), whose effective decision-making is the result not so much of individuals acquiring more and more knowledge as of finding ways of utilizing widely distributed organizational knowledge. The network system of the organization needs to be seen as a distributed knowledge system. The output of the group decision-making in the network system is not programmed in advance, but it emerge as an interaction between group members.

Next, we examine the ideas of holographic systems.

Holography demonstrates that it is possible to create a process where the whole can be encoded in all the parts, so that each and every part represents the whole. Neuroscientist Karl Pribram (Pribram 1971) has suggested that the brain functions in accordance with holographic principles. The memory is distributed throughout the brain and can thus be reconstituted from any of the parts. The holographic character of the brain is most clearly reflected in the patterns of connectivity through which each neuron is connected with others, allowing a system of functioning that is both generalized and specialized. It is believed that each neuron may be as complex as a small computer and capable of storing vast amounts of information. The connectivity of the brain creates a much greater degree of cross-connection and exchange than may be needed at any given time. The redundancy allows the brain to operate in a probabilistic rather than a deterministic manner, allows considerable room to accommodate random error, and create an excess capacity that allows new activities and functions to develop. In other words, it facilitates the process of self-organization whereby internal structure and functioning can evolve along with changing circumstances. Our model takes its main inspiration from this holographic metaphor.

Next, we examine the ideas of autopoiesis, the logic of self-producing systems.

Both contingency theorists and population ecologists believe that the major problems facing modern organization stem from changes in the environment, that is changes in the environment are viewed as presenting challenges to which the organization must respond. But this basic idea is criticized by the implication of a new approach to system theory developed by two Chilean scientists, Humberto Maturana and Francisco Varela (Maturana & Varela 1980). They argue that all living systems are organizationally closed, autonomous systems of interaction that make reference only to themselves. In other word, all living systems are the systems that produce for themselves all the elements which are essential to sustain of their operations. This view is very different from the view that living systems are open to an environment. This view is chracterized by three principals : (1) autonomy, (2) circularity, (3) self-reference. These lend them the ability to self-create. Maturana & Varela have coined the term autopoiesis to refer to self-pruduction through a closed systems of relations. Autopoiesis is the third generation of system theory. The first generation of system theory was constructed on the concepts of dynamical equilibrium theory, particularly, built by Bertalanffy. The second generation of system theory was built by Prigogine and Haken. In our model, network systems can be seen as closed systems and produce continuously interactive communications in the system. Therefore our model of communication network system is characterized as autopoiesis. The idea of autopoiesis can be applied to the information processing system. The information processing system also cannot 'get' information from an environment. Information is always constructed internally. Of course, systems can't operate and exist without the world. And operations of systems presume connection with the world, but this connection only exist at the level of a stimulus i.e. a chemical stimulus, not at level of operations. The environment is a source of perturbation and alteration to the process of the autopoietic systems. The effect of this perturbation and alteration depends on the structure of the systems.

Next we consider the evolution and change of the organization from the idea of autopoiesis. The theory of autopoiesis locates the source of change in random modifications introduced through processes of reproduction, or through the combination of random interactions and connections that give rise to the development of new system relations. In our model it is through this mechanism that evolution and change of the group activity comes from.

Next, we consider a political metaphor, particularly focus on conflict resolution and power. Power is one of most effective medium through which conflicts of interest are resolved. In recent years organization and management theorists have become increasingly aware of the importance of power in the organization. There are many kinds of the definition of power. Here we cite the definition of American political scientist Robert Dahl (1957). He has defined that power involves an ability to get another person to do something that he or she would not otherwise have done. What is the source of power? Since we are interested in group decision-making processes, we consider an ability to influence the outcomes of group decision-making processes as the source of power. We consider here group decision rule to be employed and structure of organization.

We can find two types of group decision rules. (1) Unanimity, (2) Majority vote. We have already considered unanimity. Majority decision rules can be unqualified (i.e. half of the number of group members plus one), or qualified (e.g. a two-third majority). In both cases the voting rule used is of importance : if group members are allowed to vote for one option only a different outcome may prevail than when group members can rank order all options. In the Borda voting system, each voter's most preferred candidate gets the maximum number of points, the next more preferred one point fewer, and so on with the least preferred getting zero points (Allison and Messick 1987 : pp.125). More generally : if M is the number of alternatives, the most preferred gets M-1 points, number two M-2 points, and so on.

In many organizations, the flow of information can be controlled by the structure and use of communication network systems, that is the structure of interaction can be an accelerating or restraining factor of the communications (Bavelas 1952). Different types of communication network systems can be distinguished. The degree of centralization is the most important feature of a communication network systems. Most typical of very small groups is the situation in which every group member communicates with all the others. This type of communication network systems is called the completely connected network and we consider this type of communication network system in this paper. In a completely connected network system, no centralization whatever has taken place. In other words, this type of system is called the "polycentric system" (Polanyi 1951). Therefore this type of network system can be seen as most democratic system. Other basic communication network systems are the wheel network systems and the chain network systems. The chain network system and the wheel network are more centralized, and suggest a hierarchy or at least a pronounced role differentiation with the group. These structures imply stringent restriction to group interaction and the flow of information and knowledge. In practice, technology is often used to increase power at the center. The designers and users of such communication network systems have been acutely aware of the power in information, decentralizing certain activities while centralizing ongoing surveillance over their performance.

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