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A Four-Way Interaction Model: A Holistic Approach to the Group Decision Support Systems

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Abstract

This study adopts the general systems theory and proposes a four-way interaction model which uses nth logic function to represent interactions of a Group Decision Support System (GDSS) to examine the interaction issues when designing a GDSS. Task type and decision guidance are used to illustrate the application of the proposed model.

Introduction

GDSS are computer-based social technical systems which combine computer, decision support models and tools, communication, and processes to support idea generation and problem formulation and solution. The purpose of GDSS is to increase the effectiveness of group decision making by facilitatiing the interactive sharing and use of information among group members and also between the group members and the system.

Although the coordination among people and conflict resolution among machines have manifested their importance in recent research, there has been a lack of a holistic view in studying the interact of GDSS (i.e., men and machines interacting simultaneously). This study adopts the general systems theory and proposes a four-way interaction model, which uses nth logic function to represent interactions of a GDSS to examine the interaction issues when designing a GDSS. Two dimensions, task type (McGrath, 1984) and decision guidance (Silver, 1990), are used to illustrate the application of the proposed model.

A brief literature review is discussed in the next section. Then the proposed model which addresses the shortcomings of GDSS research is formulated, illustrated and discussed. An application of the proposed model is followed. Finally, the contribution and limitation of this propose model are discussed.

Literature Review

Pertinent previous research related to this study are summarized in Table 1 chronologically with an emphasis on interaction and their major focuses.

Table 1. Literature Review

Author	Interaction	Major Focus
Mc Grath	N to N	Communication, Interaction of (1984) Groups
DeSanctis Gallupe (1987)	M to N	Framework of GDSS
Nunamaker et. al. (1989)	N to M M to M	Three interacting factors: user profile, task domain and technology
Gray, Olfman (1989)	M to N N to M	User interface issues
Tanniru, Jain (1989)	N to M M to M	The characteristics of a communication support facility in enhancing communication among group members
Silver (1990)	M to N N to M	Decision guidance and systems restrictiveness
Dennis et. al. (1991)	N to M	Three dimensions of group meeting framework: group size, time dispersion & group proximity
Vetschera (1991)	M to N N to N	The evaluation procedure of an individual affects and is affected by others.
Chen (1992)	N to N M to N N to M	Use logic function to handle interaction problem and have an integral study of user's responsibility and user modeling
Turoff et. al. (1993)	M to N N to M	Distributed group support system
Sengupta Te'eni (1993)	M to N N to M N to N	The importance of cognitive feedback in GDSS
Horton Biolski	N to N N to M	Comparison of well and poorly coordinated group (1993-1994) using tools in a computer supported meeting environment
Vickers (1994)	N to M M to M	Layered functionality within GDSS

Key: M stands for Machine and N stands for Man (e.g. M to M means Machine to Machine)
From Table 1 we can conclude that various interacting factors are important to the success of a GDSS. Nevertheless most of the previous research has focused on limited aspects of interaction.

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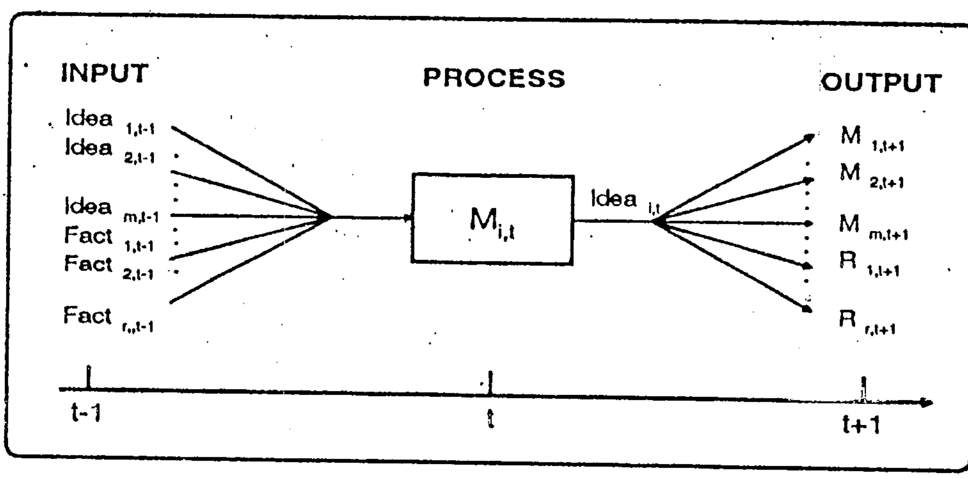
Proposed Model

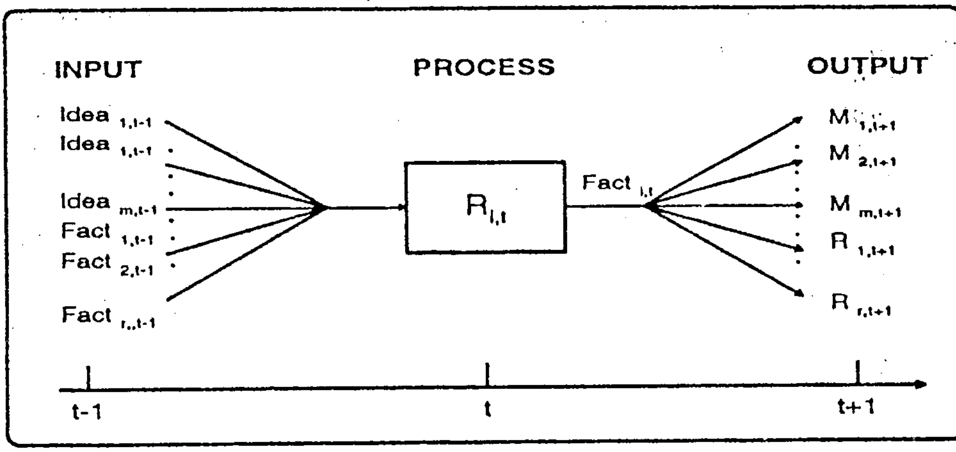
The interaction aspect of a GDSS is more than interfacing. The cognitive feedback and reciprocal influence is more than an aggregation of optimized solution or a refined evaluation procedure. Conceptually based on general systems theory (Kast and Rosenberg, 1971), the interaction should have four directions: man to man, man to machine, machine to machine and machine to man, all of which need to be considered fully and simultaneously when designing a GDSS. The proposed four-way interaction is illustrated in Fig. 1 and Fig. 2. Interaction components are the group members and the knowledge base rules.

Figure 1. Idea Generation Process



Where:
Member (M): 1..m
Rule (R): 1..r
Idea$_{i,t}$: I ∈ [1..m]
M$_{i,t}$:the ith member of stage t, creates Idea$_{i,}$ at stage t

Figure 2. Facts Generation Process



Where:

$Fact_{j,t}$ j ∈ [1..r]
$R_{j,t}$: the jth Rule at stage t, generates $Fact_{j,t}$ at stage t.

The Idea created by member I at stage t affects all the interaction components at stage t + 1. The Fact generated by rule j at stage t affects all the interaction components at stage t + 1. All the outputs generated from all the interaction components from the previous stage affect every interaction component at the current stage. These stimulative effects make the influence diagrams look like a source and a sink (Fig. 3 and Fig. 4)

Fig. 3. Source

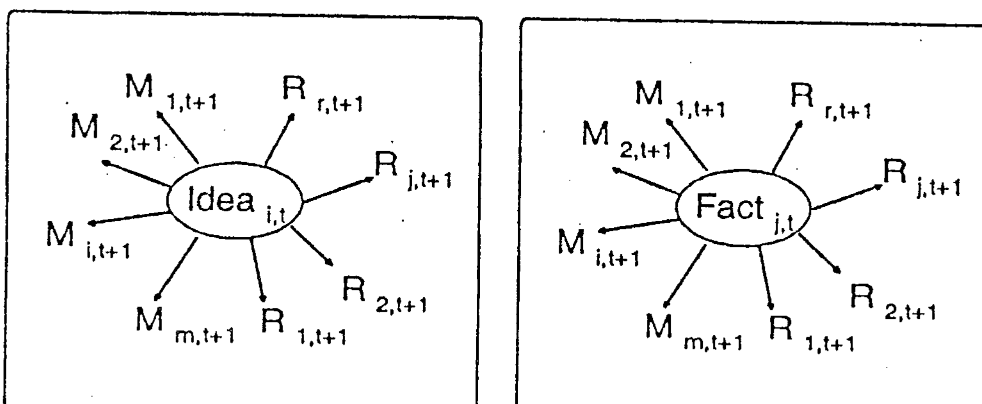
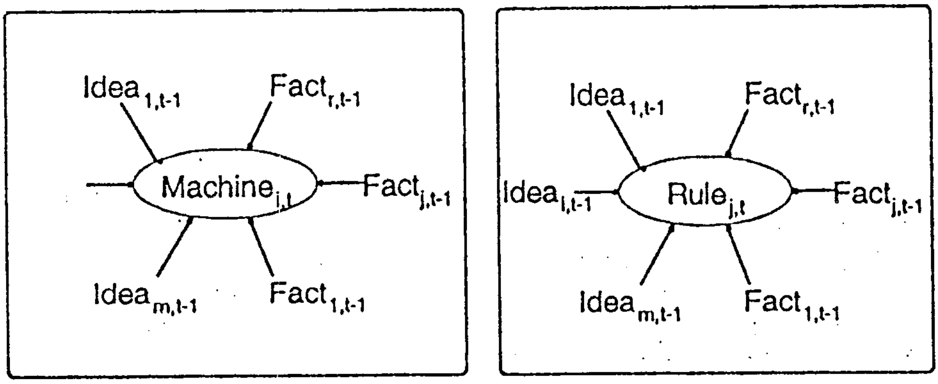


Figure 4. Sink



Characteristics of a GDSS based on the proposed four-way interaction model include:
1. Both men and machines are working on activities of Input-Process-Output (as shown in Fig. 1 and 2) iteratively and their interdependencies are reciprocal.
2. The radiative interaction is stimulative and influential.
3. The pattern of transition between sequential stages is similar to a MarKov Chain Process.
4. Conflict resolver and public screen can eliminate the incomplete information problems.
5. The interaction components can learn and can be stimulated by the output of the previous stage.

Based on the above five characteristics, the outputs of interaction components can be represented by a nth order logic function (Chen, 1992). The output of member I at stage t, is affected by all the outputs from all the interaction components in the previous stage. This can be represented by the following two functions.

$$Idea_{o,t} = Idea_{i,t}\,(Idea_{1,t-1}, \ldots Idea_{i,t-1}, \ldots, Idea_{m,t-1}, Fact_{1,t-1}, \ldots Fact_{j,t-1}, lll, Fact_{r,t-1})$$

$$Fact_{j,t} = Fact_{jt}\,(Idea_{1,t-1}, \ldots Idea_{i,t-1}, \ldots, Idea_{m,t-1}, Fact_{1,t-1}, \ldots Fact_{j,t-1}, lll, Fact_{r,t-1})$$

With this formulation, it becomes easy to keep track of group memory and to evaluate the effect of reciprocal interdependency and cognitive feedback.

Application of the Proposed Model

Numerous dimensions (such as communication medium, management style, degree of participation of group members, tools of problem solving, reciprocal interdependency among group members, task type, and decision guidance, etc.) have been proposed to be important factors of a GDSS problem domain. IN this study, we use task type and decision guidance (directed and nondirected change) to illustrate the application of the proposed model. These two dimensions are used to determine the weights of interaction components in a user's preference file. Every member and every rule holds a weight in a GDSS. The weight is determined by the task type and decision guidance requirements. Then the user's profile can be illustrated as follows.

$W_{1,m}$		$W_{i,m}$		$W_{m,m}$	$W_{i,r}$		$W_{j,r}$		$W_{r,r}$

Where:
$W_{1,m}$: weight of the idea created by the ith member.
$W_{j,r}$: weight of the fact generated by the jth rule.

Given the user's profile, the decision function U_t, can be calculated by the following formula

$$U_2 = \sum_{I=1}^{m} W_{i,m} * \text{Idea}_{i.} + \sum_{j=1}^{r} Wj,m * \text{Fac}_{tjt}$$

The calculation of the decision function at teach stage continues if the iterative process continues. A feasible solution is reached when the decision function converges. Based on the formulation of the decision function and dimensions of problem domain, the extent of importance of each dimension in determining weights for a user's profile may vary. These ratings of importance affect the input and output components of the next stages. As an illustration, we use task type and decision guidance to demonstrate the degree importance (H:High, L:Low) of four-way interactions between Man to Man (N_N), Man to Machine (N-M), Machine to Man (M-N), and Machine to Machine (M-M) which is listed in Table 2.

The proposed four-way interaction model establishes a basic protocol for a holistic view of the interaction problem in a GDSS design

Conclusion

This paper proposes a four-way interaction model which addresses some of the shortcomings of the existing GDSS literature. The proposed model can be used as a framework to determining the importance of various interactions of man and machine during the decision making process. One major limitation of this proposed model is the inclusion of problem domain dimension. Future research should include other problem domain dimensions for modeling the problem.

Table 2. Relative Importance of Four-Way Interaction

Task Type	Directed Change		Nondirected Change	
Planning	N-N:H M-N:H	N-M:L M-M:L	N-N:H M-N:L	N-M:H M-M:L/H
Creativity	N-N:L M-N:H	N-M:L M-M:H	N-N:H M-N:L	N-M:H N-N:L
Intellectual	N-N:L M-N:H	N-M:H M-M:H	N-N:H M-N:H	N-M:H M-M:L
Preference	N-N:L M-N:H/L	N-M:L M-M:H	N-N:H M-N:L	N-M:H M-M:L
Cognitive Conflict	N-N:L M-N:H	N-M:L M-M:H	N-N:H M-N:H	N-M:H M-M:L
Mixed Motives	N-N:L M-N:H	N-M:H M-M:H	N-N:H M-N:L	N-M:H M-M:L/H

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