Case-based Support System for Problem Analysis in Business Information Systems Planning

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Abstract: A structural model which represents the causal relationships of problems using a directed graph is one of the effective techniques for problem analysis in business information systems planning. However, it is very difficult for novice system planners to make a structural model of reasonable quality, since advanced skills, such as acquiring and selecting nodes in a structural model, relating the nodes and so forth, are needed for structural modeling. In this paper, we propose a support method of structural modeling by providing useful information from case-base for a user. The case-base is constructed from cases of structural models by using a technique in which nodes of structural models are divided into four parts. From the case-base, effective information for creating appropriate nodes is retrieved and provided for a user. We have developed a support system for structural modeling based on the proposed method, named SMAP. As a result of evaluation, the effectiveness of SMAP for structural modeling could be recognized.

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1 Introduction

Currently, business and information systems are inseparably related. Therefore, traditional system planning approaches [1] which orientate to designing business and information systems separately, become insufficient. Both business and information systems should be taken into consideration at early stages of system planning[2][3][4].

In the first stage of business information system planning, system planners have to understand their target business system including current status, restrictions, problems, desires, objections and so forth. In particular, system analysis, in which complicated and obscure problems are clarified and essential issues are identified, is one of the most critical activities in system planning. Structural modeling is an effective technique for system analysis. A structural model represents causal relationships of problems by using a directed graph. Nodes of the graph represent problems. Edges of the graph represent causal relations. However, it is quite difficult to

Table 1: Examples of Applying The Node Dividing Method

Node	Objects	Character	Difference	Value
Sales activity cannot be performed systematically.	sales activity		lack	systematization
Modification of design specification is often delayed.	design specification	modification	delay	
Stock locations are insufficiently managed.		stock location	management	insufficiency

Table 2: Output of Cause Information Retrieval

	Objects	Character	Value
Input	client information	management	creativeness
Output	sales activity	assessment	systematization
	marketing	establishment	preciseness
	commercial strategy	execution	...
	basic design	feedback	...
	command chain	...	...

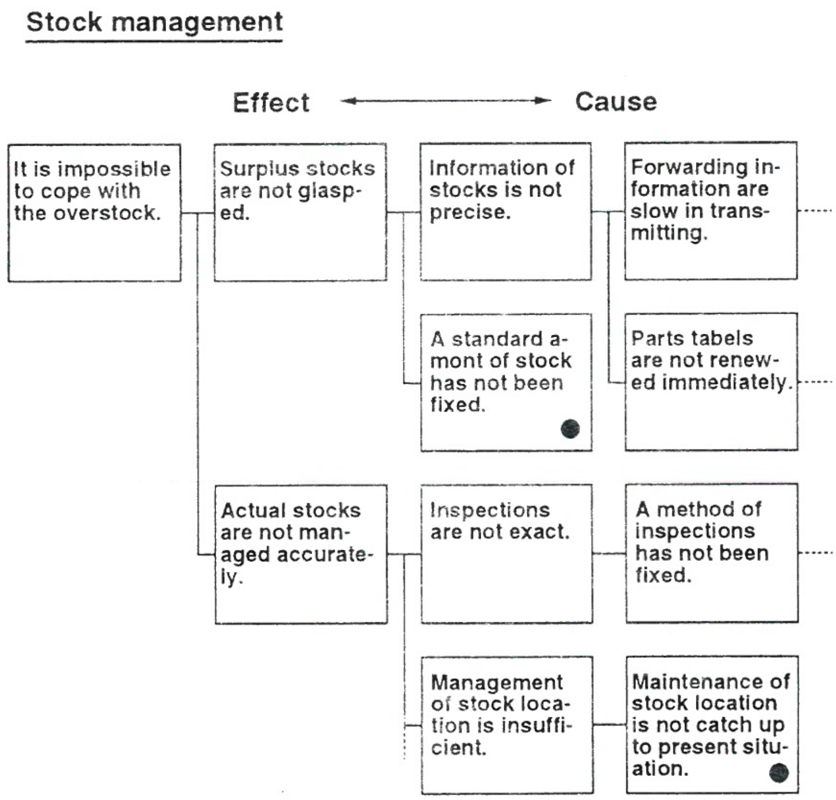


Figure 1: An Example of A Structural Model

make a sufficient and appropriate model. High ability and rich knowledge obtained through experience are required to make such a structural model. Development of a software tool which efficiently assists these tasks is demanded [5][6].

As a result of a case-study of various structural models constructed in real system planning processes, essential bottlenecks in constructing structural models have been found out. Based on this recognition, we propose a support system for structural modeling in business information system planning. This system is named SMAP(Structuring Modeling Assist system for Problem analysis) [7]. One of the features of SMAP is extraction of serviceable knowledge from various existing cases of structural models. SMAP supports the creation of high quality nodes by providing appropriate information from extracted knowledge on a timely basis. In addition, SMAP is equipped with a conceptual nodes selection method. With this method, irrelevant retrieved items are screened out by using a relational map which represents affinity relationships among all cases of structural models included in the case base. The relational map is automatically created by calculating similarity of cases. A user can get high quality ideas for nodes creation and reduce the time for getting appropriate ideas by referring carefully screened information retrieved from the case base. We evaluate the effectiveness of SMAP for nodes creation in structural modeling. From this evaluation it could be confirmed that SMAP provided useful information for creating nodes with high quality.

2 System Requirements

2.1 A Structural Model

An example of a structural model used at problem analysis in business information system planning is shown in Figure 1. A structural model is composed of nodes and edges. Each node represents one problem, such as "*Management of stock location is insufficient*". Causal relationships between nodes are represented by edges. Generally, a complete structural model is constructed with 20 or 30 nodes. Since the structural model can identify global structure of complicated problems, project members can get common recognition of problems of the target business information system, and can find out essential points of issue. For instance, nodes marked with a black point are essential points which are found out as a result of problem analysis, and these should be challenges to system planning.

A structural model is made up by a business task. A general procedure of structural modeling is the following:

1. Collecting concerned matters from related people.
2. Categorizing collected information by a business task.
3. Selecting and setting a few important matters as initial nodes from collected information that belongs to one category.
4. Considering candidate nodes assumed to be cause or effect of setting nodes.
5. Putting acquired appropriate nodes into the structural model.
6. Confirming the entire figure of the structural model and, if necessary, repeating procedure 4 and procedure 5.
7. Describing the completed structural model as formal documents.

2.2 Problems in Structural Modeling

Skill of structural modeling depends on expertise. It is very difficult for people of little experience to create a model of sufficient quality. Frequently occurring structural modeling problems, especially caused by inexperienced system planners, are the following;

- There is a leap in the causal relationships between nodes.
- Nodes cannot be successfully connected so that the structural model cannot be completed.

Experts who make structural models successfully can create appropriate nodes through the thinking process shown in Figure 2. Firstly, they imagine several businesses related to concerned nodes from the viewpoint of an ideal business process. And they guess about various events which may occur in the imagined business. On the other hand, they understand the status of business process from the collected concerned matters. By comparing the combination of business and events and the current business process, some combinations are assumable as most possible to occur, are selected and represented as a sentence of a node.

Among the experts' thinking processes, the processes of "*Imaging ideal business process*" and "*Guessing events which may occur in the*

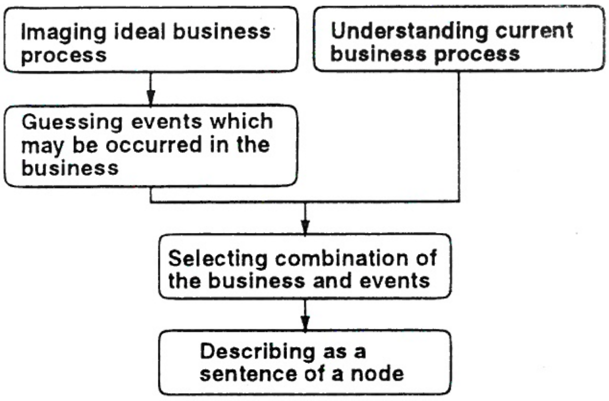


Figure 2: Experts Thinking Process

business" require rich experience and knowledge. Therefore, it is very difficult for inexperienced system planners to practice these processes successfully. Specifically, inexperienced system planners cannot create ideas of nodes from the viewpoint of an ideal business process and make the ideas take shape concretely as a node. These are principal sources of two problems caused by inexperienced system planners, which were mentioned at the beginning of this Sub-section.

2.3 Requirements for A Support System

Based on the argument mentioned in the previous Sub-section, we propose a support method for creating appropriate nodes in structural modeling by timely providing the following two kinds of information for a user.

- Information about business related to concerned nodes from the viewpoint of an ideal business process.
- Information about events which may occur in the business.

The following requirements are needed for the development of a support system for structural modeling.

Requirement 1: Constructing databases storing information about ideal business process and events which may occur in the business.

Requirement 2: Development of information presenting techniques for user from the constructed database.

For constructing the database mentioned at Requirement 1, we attempt to extract information from the existing cases of structural models. One of the reasons why using cases for constructing the database is that cases made by experts must include rich knowledge. Another reason is that to extract information from cases formalized as documents is easier than to extract it from hearing to experts.

To meet Requirement 2, it is needed to timely present useful information which stimulates a user to create appropriate nodes. Therefore, we provide interactive environment between a user and a computer.

3 An Approach To Developing A Support System

3.1 Construction of the Case-base

Generally, a structural model is used for common recognition of problems structure. Therefore, cases of structural models often include nodes of obscure expression and lack for a part of useful information, when a third person refers the cases. For this reason, it is difficult to extract useful information from crude cases. Therefore, we introduce a framework within which useful information from the cases of structural models, is successfully extracted. The framework provides a node expression method in which each node of structural model cases is divided into the following four parts:

1. **Objects part**
2. **Character part**
3. **Difference part**
4. **Value part**

Objects part represents an object of a problem described by a node. Here an object stands for one of the system factors such as function, information and entity. Entity implies substances such as commodities, products and stocks. Character part represents states and behavior of objects part. Difference part represents a gap between expectation and current states. Value part represents value, criterion and restrictions of objects part or character part. On applying this method, important keywords can be acquired successfully. Examples of applying the dividing method to some nodes are shown in Table 1. Some nodes have no character or value part.

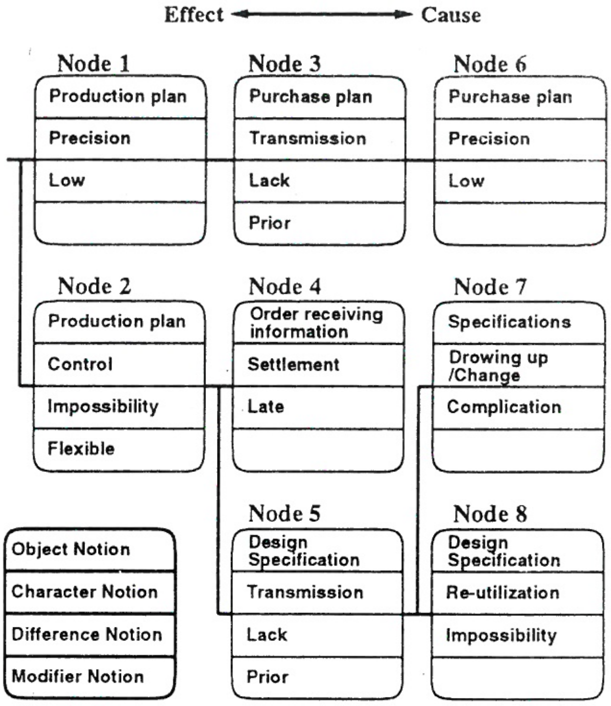


Figure 3: An Example of A Graph

Along the dividing process for each node of cases, a graph can be constructed, as shown in Figure 3. Each node of the graph consists of four parts. Nodes are connected by edges which represent causal relationships between nodes. A chain of objects part connected with edges in the graph can be interpreted as one of the expressions of business process, because business process can be expressed as relationships of function, information and entity. Character and value parts imply behavior and value of objects part. These parts closely relate to events which may occur in the objects. Objects, character and value parts can be useful information for stimulating a user to create appropriate nodes in a structural model.

As a result of the application of the node dividing method to cases in which problems of several business tasks, such as client information management, production control and so forth, are analyzed, about 80% of nodes were successfully divided into four parts. This result can be interpreted in the manner that most parts of cases can be expressed as useful information for creating appropriate nodes in structural modeling by applying the proposed node dividing method.

By unifying a lot of the graphs created from cases of structural models if applying the node dividing method, a case-base is constructed.

3.2 Information Provided from the Case-base

In structural modeling, one of the problems frequently occurring is that that there is a leap of causal relations between nodes, as previously mentioned. The main reason for this problem is that candidate nodes assumable as being cause or effect of the setting nodes, are often created without consideration of the ideal business process. Another problem is that nodes are disconnected, so that a structural model is not well-arranged into a graph. The reason for this problem is that nodes which properly connect several related nodes cannot be created.

Therefore, the support system for nodes creating should benefit the following three functions for information retrieval from the case-base. Using these retrieval functions, a user can get suitable information for creating nodes, meeting the demands.

Cause retrieval function retrieves information related to input words in the direction of the cause.

Effect retrieval function retrieves information related to input words in the direction of the effect.

Relation retrieval function retrieves information related to both input words.

We give an example of cause information retrieval in a graph shown in Figure 3. If the user inputs a word of *production plan*, the input word hits objects parts of node 1 and node 2. Next, the nodes linked to node 1 and node 2 in the direction of the cause, namely, nodes 3, 4 and 5, are retrieved. As a result, items such as *purchase plan*, *order receiving information* and *design specification*, which are objects parts of nodes 3, 4 and 5, are presented for the user. If the user inputs a word of *transmission*, the input word hits character parts of node 3 and node 5. Then, the nodes linked to node 3 and node 5 in the direction of the cause, namely, nodes 6, 7 and 8, are retrieved. Consequently, items such as *precision*, *drawing up*, *change* and *re-utilization* are presented for the user.

Examples of output items by cause information retrieval from the case-base we have constructed, are shown in Table 2. Input keywords are *client information* of objects part, *management* of character part and *creativeness* of value part. Output items such as *sales activity*, *marketing* and *commercial strategy*, which are closely related to input keyword *client information*, have been retrieved. For instance, by considering a combination of output items such as *sales activity* of objects part, *assessment* of character part, and *systematization* of value part, a user may easily create nodes such as "*Assessment of individual sales activity is not justifiable,*" or "*Sales activity has not been performed systematically.*"

4 Conceptual Node Selection

4.1 An Approach to Node Selection

The items of cases which have strong relationships with the current target problem from the analysis theme point of view are useful for node creation. However, retrieved items sometimes include nodes less relevant to the target so that, inversely, these nodes should prevent a user from effectively creating nodes[8]. Therefore, it is required to narrow down the retrieved items from the case base to proper ones.

With a view at significantly screening the retrieved items, we introduce the relational map of the case-base, which represents the relevance of cases as distances between the cases on the space. Figure 4 illustrates an overview of the node selection by the relational map filter. The target structural model under construction is located on the relational map the same way as a case in the case-base is. The retrieved items are filtered based on the relational map that is constructed in advance. As a result, only the items that are included in the cases nearest to the target structural model on the relational map are presented to the user.

4.2 Construction of A Relational Map

The analysis theme of each case can be estimated by the keywords used in the case. So, the similarity between two cases can be defined as the number of keywords that are common to both of them .

The relational map of the case base is constructed using the multi-dimensional scaling (MDS) method[9]. In the MDS, the locations of the objects on the space are calculated based on their similarity.

4.3 Relational Map Filter

The constructed relational map plays a filter role in selecting retrieved items. Firstly, the structural model that is being considered for the current target is mapped to the constructed relational map of the existing cases. Next, the retrieved items that are included in the cases strongly related to the mapped target structural model are presented to the user as the final result of retrieval in the following way.

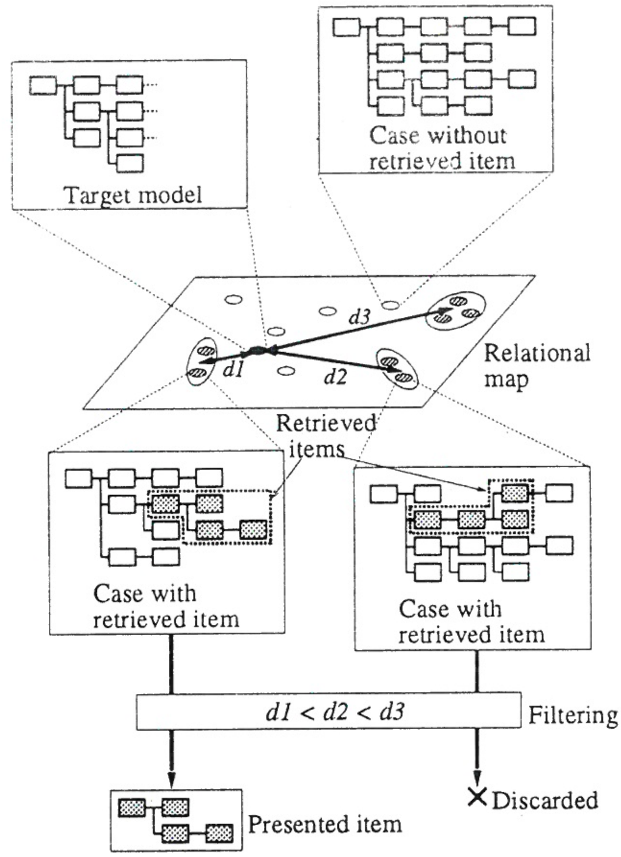


Figure 4: Node Selection by Relational Map Filter

1. Classify the cases including the retrieved items by cluster analysis based on the distance on the relational map.

2. Present the items included in the cases in a cluster nearest to the target structural model.

In this procedure, the cluster of cases on the map is introduced to eliminate the effect of noisy cases that impair the accuracy of filtering.

5 SMAP

5.1 System Configuration

We have developed Structural Modeling Assist system for Problem analysis, named SMAP, to support structural modeling based on the method previously described in this paper. The system configuration is shown in Figure 5. SMAP is constructed from an engine, a database and a human interface. The engine consists of a drawing tool for briefly depicting structural models, a retrieval function from the database and a database maintenance function. The database consists of the case-base, thesaurus files and user files. The thesaurus files are used in information retrieval to retrieve words similar to input keywords. The user files store various structural models made by users. SMAP has three kinds of windows, such as a main window, a search window and a memo window, as a human interface.

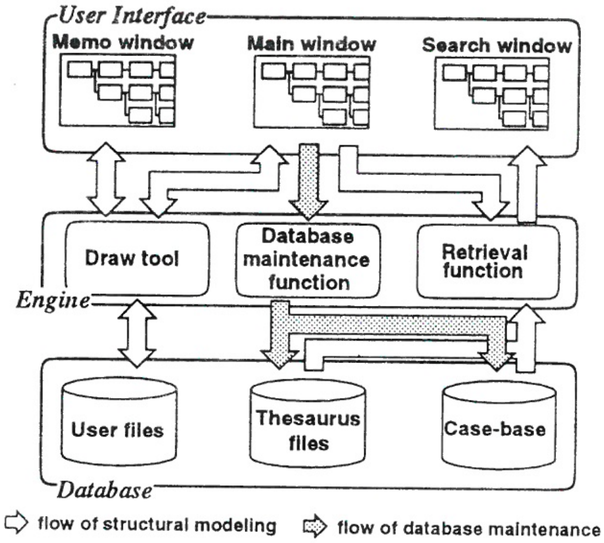


Figure 5: A System Configuration of SMAP

Database SMAP has three types of databases, namely user files, thesaurus files, and a case-base.

User files store the data of structural models made by users, and their EPS(Encapsulated PostScript) formatted data.

Thesaurus files include sets of words, which resemble each other in meaning, such as "*client's needs*" and "*Market trends*", or "*discover*" and "*find out*", and have strong relationship such as "*small lot*" and "*each client*" and so on and so forth. The thesaurus files currently include about two hundred sets of words.

Retrieval Function SMAP enables an information retrieval from the case-base to support nodes creation for a user. SMAP retrieves information related to input words according to designated way, such as cause, effect or relation. Information retrieval is also performed for words similar to input words by referring to the thesaurus files. The retrieved items are selected using the relational map filter and only filtered items are displayed on a search window. Referring the retrieved information, a user can make a structural model on a main window using a drawing tool.

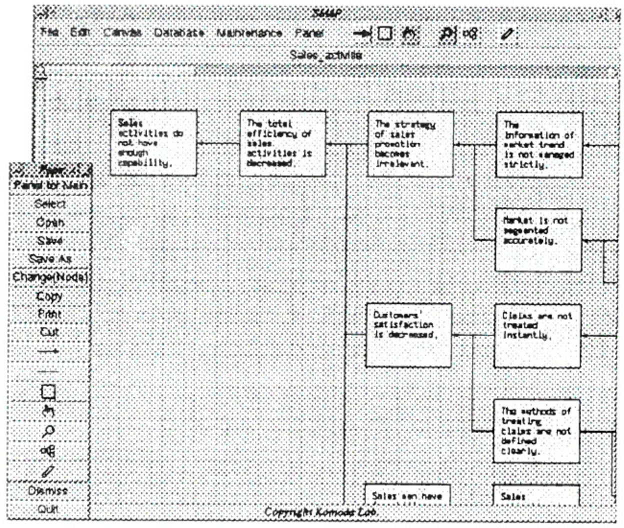


Figure 6: A Main Window of SMAP

User Interface The main window, shown in Figure 6, is equipped with a mouse-driven user interface, named menu-bar (see Figure 7). The menu-bar has several basic menus and several pull-down sub-menus.

A **File** menu is for the management of user files which store structural models of their target information system. Creating a new file and saving a structural model are included. An **Edit** menu is for editing boxes, texts and arrows which compose a structural model on a window named Canvas. A Canvas is managed by using a **Canvas** menu. Using a **Database** menu, information retrieval in the case-base takes place and a search window on which retrieved information is indicated is opened. A **Maintenance** menu performs maintenance of the case-base

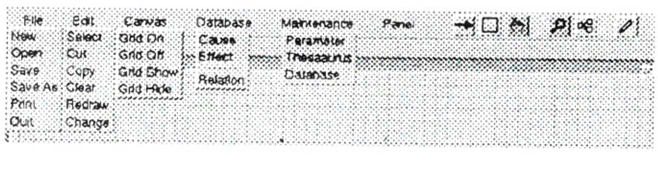


Figure 7: The Menu-bar of SMAP

and the thesaurus. A **Panel** menu starts a floating menu, shown as a left-side small window in Figure 6. Several menus with buttons in frequent use are arranged on the floating menu.

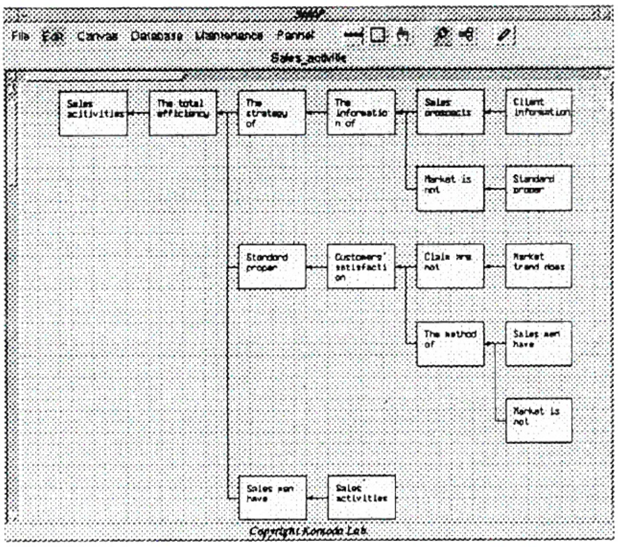


Figure 8: Windows of SMAP

Three buttons marked with (1) in Figure 7 switch depicting modes. When an arrow button has been selected, the user can depict and move arrows. When a box button has been selected, the user can depict boxes and texts in boxes. The user can select and move items in the structural model by selecting a hand button.

The main window has two indication modes. One mode is for editing a structural model and other mode is for confirming an entire figure of a structural model. Two buttons marked with (2) switch indication modes. When a left button has been selected, the nodes of the structural model are represented as large rectangles with full sentences. When a right button has been selected, the mode is changed to an entire indication mode as shown in Figure 8. The nodes are represented as small rectangles beginning with three letters of sentences. User can make a structural model confirming an entire figure of the model by switching two indication modes.

A button marked with (3) opens a memo window. On a memo window, a user can describe and save any items using a drawing tool. Saved information on the memo window can be referred to any time. The memo window supports the arrangement of thinking process.

5.2 Indication of Retrieved Data

Information retrieval is performed by simple words input such as *client management*, *sales amount*, *rationalization* and so on and so forth. Let us suppose that the structural model shown in Figure 9 is being constructed.

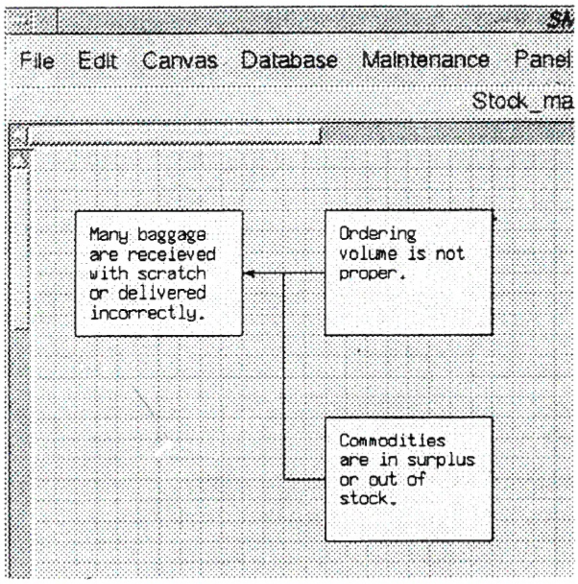


Figure 9: An Example of A Halfway Structural Model on The Main Window

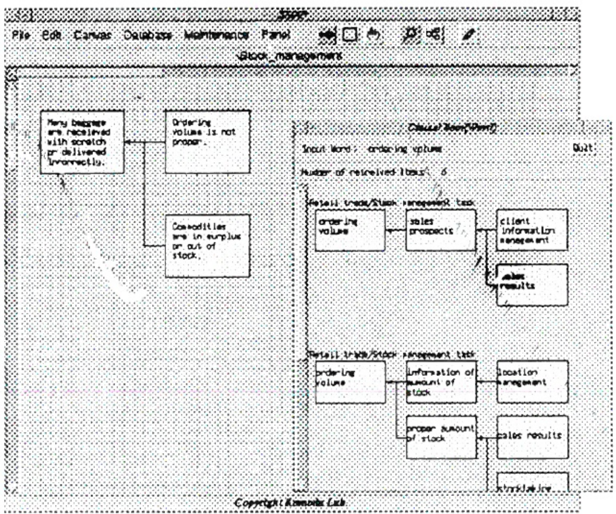


Figure 10: An Example of A Search Window

This is an example of analysis in stock management task of wholesale trade. When the user wants to know causal information of right upper node, *"ordering volume is not proper"*, in

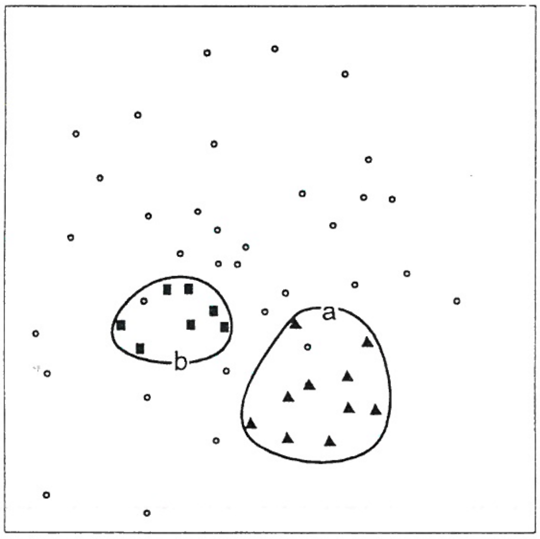
Figure 9, the **Cause** sub-menu is selected and trigger words such as *ordering volume* are input into an emerged dialog window. Then a search window on which the causal information is indicated appears on the screen, as shown in Figure 10. On a search window, causal relationships between retrieved items and input words are expressed in the form of a graph. Using a **Paste** sub-menu, a user can easily put retrieved items into a structural model on a main window.

6 Evaluation

6.1 Profile of A Constructed Case-Base

The case- base constructed for evaluation totally consists of 51 cases summarized in Table 3. Table 4 shows a part of the estimated similarities between cases in the case- base.

An example of the constructed relational map for these 51 cases of the structural models is illustrated in Figure 11. In Figure 11, for example, the areas of a and b contain the cases about production planning and merchandising respectively. We can see that the similarity of the cases from the viewpoint of analysis theme is reflected onto the map.



▲ *Productuion planning*
■ *Merchandising*
∘ *Other tasks*

Figure 11: An Example of Relational Map

6.2 Method of Evaluation

To determine the usefulness of retrieved items through the relational map filter, we have compared the node selection using the relational map filter with the node selection based on the types of industry and the types of tasks. In the latter selection method, the items extracted from the cases for the same industry and task as the target are only presented to the user. For the sake of convenience , let us call the former selection method the SBR (selection based on the relational map) and the latter method the SBT (selection based on the. The evaluation procedure is shown as follows.

1. Prepare test cases of the structural models that are not stored in the case base of the SMAP.

2. Mask a part of each test case of the model and consider unmasked part of the model as a target structural model that is supposed to be constructed.

3. Execute the retrieval and filtering under the supposed target structural model.

4. Count the number of effective items and ineffective items in the retrieved items.

Table 3: Contents of The Case Base

Type of industry	Type of task	# of cases
Retail trade	Business strategy	1
	In-store working	3
	Client information management	1
	Merchandising	2
	Logistics	3
	Marketing	1
	Production planning	1
	Supply task	3
Manufacturing industry	Merchandising	3
	Quality control	1
	Logistics	3
	Product development	1
	Process management	1
	Facilities	1
	Production planning	6
	Maintenance	2
Whole sale	Purchase management	4
trade	Sales activity	5
	Logistics	4
	Production planning	3
	Profits management	1
	Merchandising	2
TOTAL		51

Table 4: A Part of Similarities Between Cases

No.	Industry/Task	A	B	C	D	E	F	G	H	I	J
A	Retail trade/Product planning	—	19	6	16	4	5	1	2	9	2
B	Retail trade/Market management	—	—	7	13	0	0	4	3	12	0
C	Retail trade/Client info. management	—	—	—	3	0	0	0	1	4	0
D	Manufacturing/Product planning	—	—	—	—	9	6	1	13	8	2
E	Manufacturing/Production planning	—	—	—	—	—	1	1	7	9	0
F	Manufacturing/Distribution task	—	—	—	—	—	—	0	0	3	3
G	Whole sale trade/Maintenance	—	—	—	—	—	—	—	0	3	0
H	Whole sale trade/Distribution task	—	—	—	—	—	—	—	—	6	0
I	Whole sale trade/Sales activity	—	—	—	—	—	—	—	—	—	0
J	Whole sale trade/Purchase planning	—	—	—	—	—	—	—	—	—	—

Table 5: Test Cases of Structural Models

No.	Industry/Task	# of nodes (unmasked)	# of nodes (total)	Input word
1	Retail trade/Stock management	14	20	stock
2	Manufacturing/Distribution task	5	10	stock
3	Manufacturing/Sales planning	10	16	product planning
4	Whole sale trade/production	19	24	production planning
5	Whole sale trade/Sales activity	6	15	sales
6	Whole sale trade/Purchasing	2	7	commodity
7	Whole sale trade/Sales activity	6	13	market tendency
8	Whole sale trade/Sales activity	8	19	sales
9	Whole sale trade/Sales activity	3	11	client information
10	Whole sale trade/Sales activity	22	33	sales activity

Table 6: The Result of Evaluation

No.	1	2	3	4	5	6	7	8	9	10
# of total retrieved items	14	14	6	11	8	14	13	7	12	8
# of effective items (SBR)	2	6	5	1	1	4	5	2	2	2
# of effective items (SBT)	0	5	1	4	0	2	2	1	2	1
# of ineffective items (SBR)	2	1	0	0	0	0	0	0	1	1
# of ineffective items (SBT)	1	1	0	3	1	1	0	1	1	0
# of effective items (without selection)	5	7	6	5	2	6	7	5	6	3
# of ineffective items (without selection)	9	7	0	6	6	8	6	2	6	5

At step 4, the effective item is defined as the item containing the same keyword as one in the masked part of the test structural model. Similarly, an ineffective item is defined as the item that has no common keyword in the masked part of the test model.

6.3 Results of Evaluation

We prepared ten test cases of structural models. The profile of the test structural models is shown in Table 5. Figure 12 shows an example of a relational map by mapping a test structural model. '•' represents the point of the target structural model. In the Figure, the hatched circles indicate the cases that contain retrieved items and the white circles indicate the cases that have no retrieved items.

Table 6 shows the result of retrieval and filtering for each test model. As shown in Table 6, the SBR offers more numbers of effective cases than the SBT does and excludes more numbers of ineffective cases for most of the test structural models.

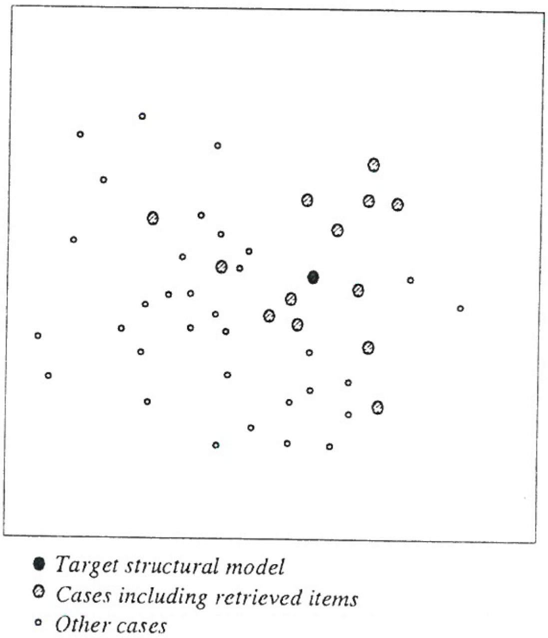


Figure 12: Relational Map with The Mapped Target Structural Model

We can evaluate the node selection method from two kinds of criteria, such as the rate of the effective items for all of the retrieved effective items and the rate of the ineffective items for all of the retrieved ineffective items. The method giving a high score of the former and a low score of the latter is regarded as satisfactory. Table 7 represents the average of the evaluation values for all structural models. As shown in Table 7, effective items are selected more precisely if using the SBR instead of the SBT. In addition, the SBT succeeded in selecting more than a half of all the effective items and excluding almost all of the ineffective items.

Table 7: The Average of Evaluation Values

	SBR	SBT	without selection
Avg. of the rate of the effective items	0.58	0.25	1.00
Avg. of the rate of the ineffective items	0.09	0.16	1.00

7 Conclusion

In this paper, we clarified some problems in structural modeling and derived requirements for a structural modeling support system from the problems. We proposed a node dividing method in which useful information for node creating can be extracted from cases of structural models. On applying this method, we have constructed a case-base and developed the support system for structural modeling, named SMAP.

SMAP has a mechanism for selecting items useful in structural modeling. The mechanism is introduced by constructing the relational map of the existing cases based on similarities between the cases. Using the relational map makes it possible to relate the cases to each other from the viewpoint of analysis theme, such as the type of industry, the type of business task and the type of target problem. From the evaluation it has been found that SMAP can select the effective items and exclude the ineffective items in comparison with the method of selecting the items based on the task of the target structural model.

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