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Studies on Multi-Layered Organization of Causal Knowledge for Grasping Deep Structures Implied in Societal Phemomena

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An architecture of a knowledge-based system is presented for decision support in sociopolitical domain. Human experts' decision making is characterized by their efficient heuristics: simplifying the world reality getting the idea on what kinds of events naturally belong together, and grasping what sorts of behavioral patterns appear in sequences of observed events. In this paper, the system is designed that can generate dynamic evolving patterns of events with different abstraction levels using meta-knowledge, that is universally accepted as human repetitive patternized social behaviors above the empirical knowledge represented as causally-chained networks. Those generated event patterns at each level evolve in parallel concurrently under the domination of a social behavioral plan-scheme of the upper level. Based on such a human memory-like knowledge organization, the system enables decision makers' flexible and efficient access to the knowledge store on their individual demands, as well as provides them with comprehensive information from global viewpoints, both of which contribute to explicating the problems in their pre-decision stages.

Key Words: Decision support system, cognitive map, multi-layered knowledge structure, script, man-machine interface.

1. Introduction

In a highly complex society, the interrelationships between such diverse aspects as economics, environment, and politics, make organizational decision problems difficult to deal with, primarily because they lack structure; that is, they appear to be virtually unbounded on all sides, hence are difficult to contain. In facing decision problems such as these, the decision maker must elicit, collect, sort, classify, evaluate, and structure sufficient information about the decision at hand in order to formulate rational alternatives in advance to reach the stage of choice. However, since there is likely to be doubt in the decision maker's mind at the outset concerning the nature of the problem domain, the stages of problem exploration and definition as well as of alternatives formulation have come to be immensely complicated tasks requiring computer support at these stages.

In actual practice, a specialized decision maker must have on hand a collection of relevant historical cases or episodes consisting of a wide variety of causally interrelated events, in which various actors of individuals, parties or organizations are involved. By the accumulation of his individual experiences and observations, he can get a better idea of what kind of events naturally belong together and what sort of general behavioral patterns appear in sequence of events. These may suggest familiar courses of actions that are then edited or modified according to the rational investigation of consequences. He can now understand the novel, newly-encountered situation through the cognitive retrieval of previous situations similar to present one, and can interpret new cases in terms of those with which he is already familiar. Appropriate behavior in the present situation is then determined referring to the behavior in those previous situations, but even when some information does not fit into the available preexisting pattern, he/she would seek for other clues such as similarities and analogies based on its deeper structural pattern.

This style of internal processing that depends much on the *episodic memory* is characterized by a *case-based reasoning* process, the modeling or formulation of which is a current major concern in the field of artificial intelligence as a problem solving methodology. Herein, the key issue is the clarification of how individual cases can be organized so that he/she can easily retrieve an essentially analogous case from his vast store of knowledge even though the two are not identical in their surface expressions. If we apply this to decision support systems, we have to investigate

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into how the human decision maker perceives and grasps the individual cases or classes thereof.

Actually in the face of the complex uncertainties of the real world, the limitations of human cognitive ability forces decision makers to abandon the details in favor of constructing simplified internalized world models at different levels of abstractions. These models simplify large sets of observable data into simple relationships and highlight the more salient variables and relationships, which are then used to predict future experiences. That is, by drawing on a whole range of similar experiences that are focused on adaptively depending on the current situation, expert decisionmakers somehow derive the "essence" of these experiences and generate a general set of expectations as to what will happen in a hypothetical situation during the world evolves as a typical norm. Then, driven by such a general expectation hypothesis, they can make sense out of a complex and uncertain reality and focus their attention on making a more sophisticated judgment. People behave rationally with respect to this simplified model, although such behavior is nowhere near optimal with respect to the real world. That is, to deal with the uncertainties and the complexities of the real world problem, people rely on heuristic devices that serve to keep the information-processing demands of a task within the bounds of their cognitive capacity, even though violating the principles of rational decision making. Such heuristics are closely related to the decision maker's systematical knowledge structure, which is organized around individual cases directly reported or observed [1).

In this paper, we introduce the idea of *script theory* as a methodology for modeling human decision behavior, and develop a methodology for a knowledge-based decision support system. For this purpose, first of all, we present a representational scheme of case descriptions of documentary data as causally-chained networks[(1)], upon which the procedures of successive abstraction processes of *part-to-whole* aggregation are described. Finally, an example of the constructed conversation system is given, which supports the decision makers' case-based reasoning process. By adaptively organizing contextual higher order knowledge structures of scripts around the stored individual cases in a bottom-up fashion, the system can respond to a decision maker's partial input and present useful information.

(1) As for a representational scheme of causally-chained sociopolitical events, there exists a method of cognitive map [2),3)], the purpose of which is to qualitatively evaluate how the policy alternatives can affect on the extreme utilities of the policy makers through the various societal factors. This does not deal with the analysis on how the policies *per se* are causally related with one another.

2. Causal Network Model Representation for Decision Support

The usual sources of our knowledge of previously experienced cases are documentary data in the form of verbal expressions on the relationships among a large variety of social aspects involving different actors. In order to store these case descriptions into a computer, the data has to be organized in such a way that the relationships are represented explicitly and do not lose any information critical to the context of the case as a whole; the encoded knowledge must be sufficiently well-formulated that the system can process the aggregation of the encoded knowledge towards the upper patterns smoothly and efficiently so that the deeper meanings behind it cannot fail to be conveyed. It will be essential for the coding to capture such essential components as the intervention of actors' intentions or decisions and the dynamic interactions among the interests and beliefs of the actors involved. Indeed, in the documented statements, those features are not always expressed so explicitly that they can be extracted as concrete descriptions, but they can be recognized easily in the context, and these must be made explicit in the coding process for organizing the upper knowledge structures. For this purpose, we have to introduce some meta-knowledge, that is universally accepted as human repetitive patternized social behaviors above the encoded knowledge represented as causally-chained networks.

3. Construction of Multilayered Networks of Causal Events

3.1 Primitive Events

In this paper, we propose a novel causally-chained network representation scheme consisting of nodes and linkages as in a conventional cognitive map. Different from cognitive maps, we classify nodes into the following three types: *Decision* Nodes (D nodes), *Perception* Nodes (P nodes), and *Value* or *Belief* Nodes (V nodes). Moreover, as linkages between these nodes, we define two kinds of causal linkages, *Cause* relations (C relations) and *Terminate* relations (T relations), as well as two sorts of *Sentiment* relations, positive sentiment relations ($+S$ relations) and negative ones ($-S$ relations). For instance, in the following description of documents:

> "The project of Shinkansen by JNR brought about the noise pollution, which peripheral residents suffer from to a great deal and complained

about. Residents decided to petition to Environmental Agency of Japanese Government to control the noise, then Government accepted this against JNR's will. Then, EA set a setting standard normatives which made a serious burden upon JNR, and EA forced JNR to reduce operating speed of the train."

can be represented with those kinds of nodes and linkages as a network as shown in Fig.1(a), whereas,

(N-1) Perception Nodes (P): these represent concrete contents of behaviors or events, that is, kinds of world aspects or states subject to change. The node $P2$("noise pollution") in Fig.1(a) illustrates this type of node.

(N-2) Decision Nodes (D): this type of nodes is the one for explicating the times of interventions of some actor's decisions or intentions. As $D1$("residents") in Fig.1(a) illustrates, D node is a kind of dummy node, which is encoded from the documents with names of actors without any concrete contents (concrete contents of those decisions are encoded as P-nodes).

(N-3) Value or **Belief Nodes** (V): these represent actors' abstract beliefs or interests and are also encoded with the names of actors as in D nodes. For instance in Fig.1(a), the node $V2$("residents") connected with the node $P3$("complaints of residents") represents the actor residents' values.

As for connected linkages between D and P, or P and P, the following four kinds of causal relationships are defined;

(L-1) Cause Relations (C): the content of the preceding node causes or initiates one of the following nodes.

(L-2) Terminating Relations (T): the content of the preceding node suppresses or disables the one of the following nodes. Some of the P nodes are directly connected with V nodes, and the relations between them represent sentiment relations rather than carrying the causality as C and T relations.

(L-3) Sentiment Relations ($+S$ and $-S$): the positive sentiment relation ($+S$) represents the fact that the content of the preceding P node contributes to the values of the actor of the following V node, and vice versa for the negative one ($-S$). Causality is propagated through C and T relations via P and D nodes but not V nodes, since $+S$ and $-S$ relations connected to V nodes carry only sentiment relationships, and no linkages go out of V nodes.

The configurations of possible connections among nodes determined as syntactically rational ones from an intuitive perspective are summarized as shown in Table 1(2). These types of nodes and linkages make it possible to recognize any metaphorically similar or equivalent causal structures of events, on the basis of their structural or syntactical equities apart from their semantic contents. That is, some ordered sets of categorized linkages and nodes can imply the structural meaning that is universally true whatever contents or actors those component nodes may have. This is because our recognition that social events, from human societal behavioral perspectives, can be universally defined without precise details by the combination of those purely syntactical elements such as decisive actions, resulting changes in social aspects, and emotional responses both positive and negative.

Here, we consider the nine cause-effect relationships shown in Table 1 between two out of three kinds of nodes, that is, D nodes and two kinds of P nodes connected to V nodes through $+S$ and $-S$ relations satisfying the configurations, which work as unitary structures offering the primitive meanings. According to whether the two actors concerned with an antecedent cause node and a consequent effect node are identical or not, each cause-effect relationship provides a different conceptual meaning. We define those as *intra-actor* primitive events when identical and *inter-actor* ones when different, as shown in right two columns of Table 1.

The elements listed in the upper six rows in Table 1 are the ones where a decision has intervened in some form, that is, whose unitary structures involve D nodes. For instance, `Problem` is an event where the occurrence of an aspect X undesirable to actor A (Node $P(X)$ connected to node $V(A)$ through $-S$ relation) causes him to decide (node $D(A)$ preceded by $P(X)$ through C relation), that is, an event representing the consciousness of a problematic situation. In this unitary structure, when the actor of the subsequent D node is replaced by a different actor from the one of its antecedent node, these two primitive events turn out to be `Inducement`, which represents an event where the situation faced by one actor causes another actor to decide something else.

The unitary structures in the lower three rows of Table 1 consist of chained non-intentional aspects of P nodes,

(2) In natural language understanding, studies on *semantic primitives* have been done actively such as primitive ACTs[4] for physical actions, DELTACTs[5] for understanding social plan, and primitive plot units[6] for story understanding with respect to emotional responses. In this paper, we define a new set of primitives from purely syntactical perspectives.

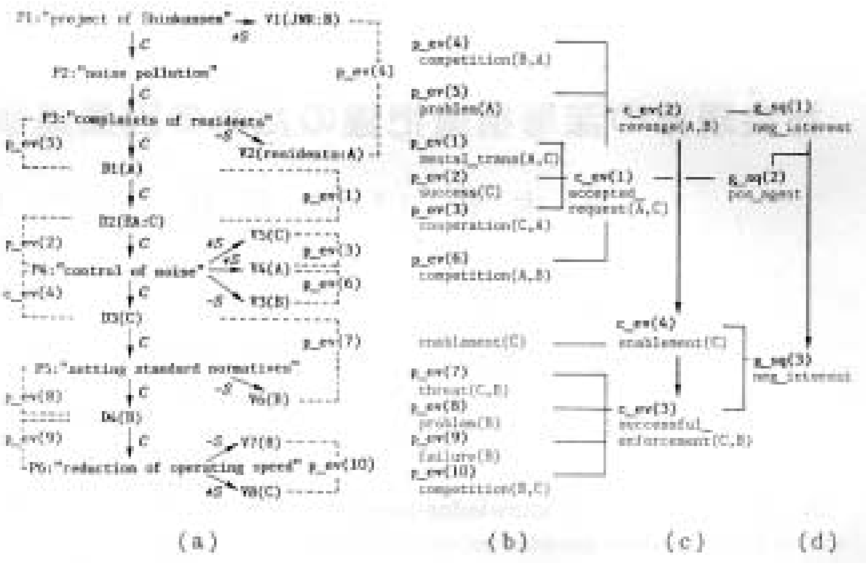

Fig. 1 An illustration of multi-layerd knowledge structure (a) a causal network (b) primitive events (c) complex events (d) goal interaction relationships

where the initiating and the ending P nodes are connected to V nodes, representing goal interaction relationships within one actor or between different actors. For instance, `Cooperation`represents an event of the successive occurrence of desirable aspects for two different actors.

	(a) A = B	(b) A ≠ B
$V(A) \xrightarrow{-S} P(X) \xrightarrow{C} D(B)$ ①	[problem,[A],[X]]	[inducement,[A,B],[X]]
$V(A) \xrightarrow{+S} P(X) \xrightarrow{C} D(B)$ ②	[enablement,[A],[X]]	[promotion,[A,B],[X]]
$D(A) \xrightarrow{C} P(X) \xrightarrow{+S} V(B)$ ③	[success,[A],[X]]	[commitment,[A,B],[X]]
$D(A) \xrightarrow{C} P(X) \xrightarrow{-S} V(B)$ ④	[failure,[A],[X]]	[threat,[A,B],[X]]
$D(A) \xrightarrow{C} D(B)$ ⑤	[motivation,[A],[]]	[mental_trans,[A,B],[]]
$D(A) \xrightarrow{T} D(B)$ ⑥	[abandon,[A],[]]	
$V(A) \xrightarrow{a} P(X) \xrightarrow{b} P(Y) \xrightarrow{c} V(B)$, $a \cdot b \cdot c = -1$ ⑦	[trade_off,[A],[X,Y]]	[competition,[A,B],[X,Y]]
$V(A) \xrightarrow{-S} P(X) \xrightarrow{b} P(Y) \xrightarrow{c} V(B)$, $b \cdot c = -1$ ⑧	[dilemma,[A],[X,Y]]	[adversity,[A,B],[X,Y]]
$V(A) \xrightarrow{+S} P(X) \xrightarrow{b} P(Y) \xrightarrow{c} V(B)$, $b \cdot c = +1$ ⑨	[concord,[A],[X,Y]]	[cooperation,[A,B],[X,Y]]

Table 1 Primitive events defined above causal networks (a) intra-actor ones (b) inter-actor ones

3.2 Complex Events

Fig.1(b) shows illustrations of primitive events, all of which are found in the causal network model representation of Fig.1(a). As this figure shows, it now becomes possible to rewrite what is represented by three kinds of nodes and four sorts of relations of causal network model into an evolutionary sequence of primitive events. However, it is still too micro as compared with what we understand intuitively and conceptually in reading each statement corresponding to the causal network model representation of Fig.1(a). It is natural that frequently-appearing ordered sequences of primitive events are considered as being integrated as a whole into larger conceptual chunks.

In the sociopolitical domain, these chunks are considered to be the routine sequence of steps to be taken that involve not only an actor's eventual decisions but also his purposes or intentions, as well as and the results produced or the resulting responses of the other actor to those decisions. For instance, let us consider a subsequence of primitive events `Problem`, `Success`and `Concord`, which is a typical sequence of events that occur when an actor intentionally resolves the problem, and it can be aggregated into the more comprehensive chunk of `Intentional-Resolution`as a whole. In contrast to the primitive events, we call such a larger conceptual unit a *complex event*. What is important here is that such a complex event can be defined syntactically as a combination of primitive events. Therefore, whatever actors or contents its component primitive events may have, the complex events hold true universally as long as they satisfy constraints on their causal ordering and maintain a consistency among entities. We define a number of complex events as ordered sets of primitive events as shown in Table 2[(3)]. These complex events are classified into either

(3) The number of complex events cannot be determined definitely, but is to be defined according to the purpose of the system in use as well as its domain. In our case, for decision support in the sociopolitical domain, several events necessary for the structural analysis of the problem are defined which mainly concern trade and communication activities observed

inter-actor complex events or *intra-actor* ones, depending on whether or not they involve inter-actor primitive events as part of it or not.

The definition of the complex event can be written as an ordered set of primitive events as shown in Table 2, which is implemented as a horn-clause of `Prolog`. In this definition, unification is used for representing constraints among entities. This binding represents the constraints on causal connections among primitive events or appropriate correspondences among entities of the complex event and its component primitive events. Based on this representation, each of the complex events is searched for within a given causal network representation in a top-down fashion.

(a)		intentional_resolution :- problem → success* → concord goal_pursuit :- enablement → success* → concord recovery :- failure → problem → success* ....
(b)	Consistency	compensation :- competition → enablement → inducement → commitment relief :- inducement → success* → cooperation accepted_request :- mental_trans → success* → cooperation ....
	Contradiction	revenge :- competition → problem → success* → competition obstruction :- promotion → success* → competition rejected_request :- mental_trans → success* → competition successful_enforcement :- threat → problem → failure* → competition ....
	Mutual-Homicide	failed_request :- mental_trans → failure* → adversity ....

Table 2 Concept formation rules for complex events defined as ordered sets of primitive events (a) intra-actor ones (b) inter-actor ones

Fig.1(c) shows the four complex events found from a series of primitive events presented in Fig.1(b): c-ev(1): `Successful-Enforcement`, c-ev(2): `Revenge`, c-ev(3): `Accepted-Request`, and c-ev(4): `Enablement`(4). Wherein, a complex event of `Revenge` is organized by replacing its original component of primitive event of `Success` by another complex event of `Accepted-Request`. This complex event of `Accepted-Request` can be regarded as an instrumental means of the actor's global planned behavior of `Revenge` by letting another actor B cooperate. In the definition of Table 2, such primitive events that can be replaced with another complex event as a means are denoted by "*".

repeatedly in our experiences.

(4) The last event of c-ev(4) is originally a primitive event playing a role of connecting complex events. We deal with such a primitive event as a complex event exceptionally.

Thus, the extracted events are formed into patterns of complex events called *scripts*[7] via two kinds of binary relations of temporality and means-ends. Initiating events having no preceding events are called triggering events, and there found scripts out of a given causal network as many as the triggering events. From a causal network of Fig.1(a), two scripts shown in Fig.2 are derived.

3.3 Goal Interactions

As more actors become involved in the problem and as complex more individual actor's policies or goals become interwoven with each other, the more complex the problem becomes. So it seems plausible to consider another level of representation. When actually faced with such a problem, to judge whether some policy should be adopted or not a decision maker at first attempts to predict its consequences, especially with regard to whom that policy favors or disfavors, which suggests that the explication of the ways in which how individuals intervene with the goals of others, that is, goal interaction relationships, are of great significance for supporting decision makers in envisioning their political scenarios.

In principle, such goal interactions occur when two different actors participate in the same complex event, and evolve according to the alterations of actors along a sequence of complex events. In script 1 shown at the end of the previous subsection, the triggering event c-ev(2) `Revenge` is showing typically a state of conflict `Negative-Interest`(`Neg-Int`) between two actors A ("residents") and B ("JNR"). This relation causes a third actor C's ("Environmental Agency (AE)") complex event of `Enablement` on "setting standard normatives", and then this is followed by a complex event by two actors B and C of `Successful-Enforcement`, which is a new state of conflict between those two actors. Actor A's triggering event of `Revenge` has another complex event of actor C's `Accepted-Request` as its means, wherein two actors A and C are in a state of cooperation. Since such a cooperative relation is established within the means-ends relations, we refer to this relation as `Positive-Agent`, distinguishing this from `Positive-Interest` that is a relation for two actors in the equivalent partners. In Fig.2 goal interactions are denoted along the two scripts.

As for the types of goal interactions, the following three *interest-relations* are defined: a state of cooperation `Positive-Interest`, a state of conflict `Negative-Interest`, and a state of antagonism `Antagonistic-Interest`, which are determined according to the classification of the inter-actor complex event; "consistent," "inconsistent," and "mutually-homicidal" relations, as shown

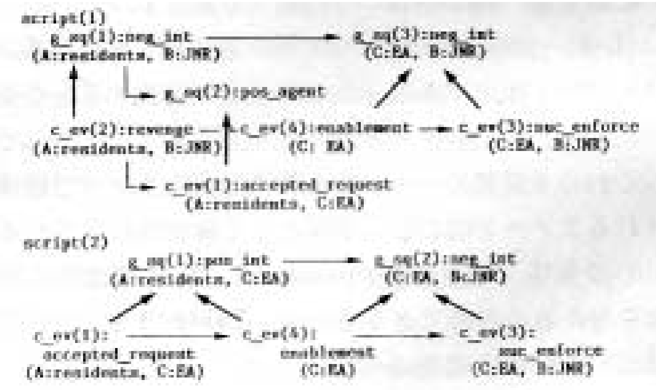

Fig. 2 Two sequences complex events (scripts) and their implying goal interaction relationships of a causal network for Fig.1

in Table 2. As for an inter-actor complex event functioning as an instrument of another complex event, for which there exists no contingent event, we consider the interactions occurring there as *agent-relations* representing the fact that an actor of the latter complex event depends on the execution of the attainment of his goal on another actor's performance. These relations defined for such complex events are categorized into two classes `Positive-Agent` meaning successful agent relations and `Negative-Agent` denoting failed ones, according to whether the complex event is replaced with `Success*`, i.e., "consistent" ones, or with `Failure*`, i.e., "inconsistent" or "mutually-homicidal" ones in Table 2.

Complex events	Interest	Agent
Consistency	positive_interest	positive_agent
Contradiction	negative_interest	negative_agent
Mutual-Homicide	mut_interest	

Table 3 Goal interaction relationships for three kinds of inter-actor complex events

4. Conversation System for Decision Support Using the Multilayered Causal Networks

4.1 Initial Focusing of a Decision maker's Interest

Based on the idea of structuring the causal networks via a part-to-whole aggregation, we are now developing a prototype of an intelligent decision support system with respect to the same problem domain as dealt with in the examples so far. In this system, a user at first inputs two perceptual nodes corresponding to a source node and a sink node. Then, the system retrieves all the nodes and binary relations existing along all the paths connecting those two nodes. Next, a user inputs a list of actors of his/her interest. Then, the system excludes all the D and V nodes whose actors are not in the list.

4.2 Construction of Schema Systems

As mentioned before, the search of the complex events is conducted in a top-down way rather than in a bottom-up fashion, in which all possible events existing in the causal network representation are extracted and then checked to find out whether some of these form the complex events. All complex events must be tested one by one to determine whether its component primitive events are found in a given causal network satisfying the constraints for the variable bindings. Such a top-down approach is more efficient, since the encoded causal network contains too many primitive events to test all their possible combinations. Indeed, it may happen that some primitive events are missed in the search process because they are not aggregated into any larger complex events. However, as far as the global view governing the whole causally-chained network is concerned, it may be neglected as a local one in the sense that it does not play a role in forming any complex events. Therefore, the top-down approach contributes to explaining the lower level event essential to its dominant evolutionary flow of events at the upper level, as well as to avoid the combinatorial explosion caused by extracting such local primitive events.

The events extracted from the case description are registered and stored as *schemata* so that they do not lose the information concerning with the mutual relations among them. For all kinds of event-types at three different abstraction levels, primitive, complex, and goal interactions, the system stores their general specification forms as a *template schema.* Each template schema has a corresponding set of attributes of events as slots, and their values. Fig.3(b) illustrates an instantiated schemata of complex event c-ev(2) `Revenge`. Here, the following kinds of slot-value pairs are prepared; the first slot defines its *event type* `Revenge` and the second and the third attributes show two *actors* and two *contents*, respectively, where the numbers of actors or contents are determined according to the corresponding event-type. In addition to those, a schema has a number of pointers showing its relations with other schemata as *a-part-of*, *has-part*, and *means-by* relations. Each of these denotes its upper-level event schema, its lower-level event schemata, and its instrumental event schema, respectively. Through these pointers, the relative positions within the overall knowledge organization is explicitly defined.

Fig.3(a) illustrates a graphical display by the system showing a main stream of script (1) implied within a part of causal network shown in Fig.1(a). Wherein, a part enclosed by a dotted line corresponds to a complex event c-ev(2) `Revenge` and its subordinate primitive events as well as its means-ends complex event c-ev(1). Looking into the top layer of goal interactions of this script, we can recognize as the followings; initially actors A and B's goals are in conflict, then a cooperative relation emerge between actors A and C, forming a stable triad relationships among actor A, B and C, which leads to emergence of another state of conflict between actors C and B. Such an evolutionary shift of dynamical relationships among three actors are actually abiding by the law of structural balance of sociometry. Thus, this sequence of goal interactions itself may be an instance of another larger schema.

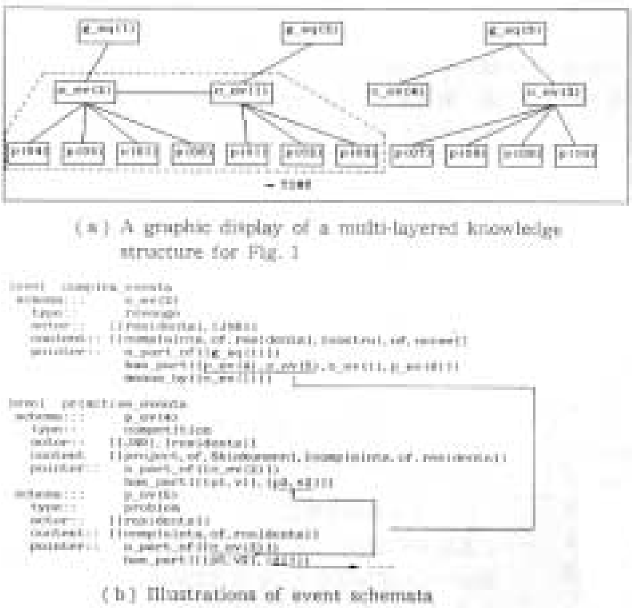

Fig. 3 (a) A graphic display of a multi-layered knowledge structure for Fig.1 (b) Illustrations of event schemata

4. 3 Retrieval of the Supplementary Information

As mentioned so far, the event schemata are constructed by the combination of the factual data of causal network and the common sense knowledge concerning with the sociology implied in the syntactical rules defining primitive and complex events. Such organization in hierarchical structures does offer significant clues for satisfying the user's various retrieval requirements.

The queries acceptable to the system in the current version are restricted to styles beginning with "Find" and its following noun clauses that are preceded by interrogatives of "what", "whom" and "who". For instance, consider the query "Find to what EA agrees with residents" as shown in Fig.4(a). The system identifies that this query is concerning with a complex event of `Accepted-Request`(c-ev(3) in Fig.3) from the word "agree" in the input, and then retrieving a value of its content slot, the system returns [control, of, noise] as an answer. If more than two instance schemata exist that match with the partial one, all the corresponding values are returned as possible answers.

Fig. 4 Illustrative conversations between the user and the system (the user's inputs are underlined) (a) What-type query (b) Why-type query (c) How-type query

4. 4 Presentation of Events from Multiple Viewpoints

The system can also accept not only such supplementary-specification queries but a query asking to present some events from a different viewpoint by usage of its contextual relationships with the surrounding schemata. That is, for queries with "when" asking the timing of some event, the system finds the preceding event in the horizontal causal order of event sequence in the same abstraction level by climbing up and going down through a-part-of and has-part pointers from the identified instance schema referred to in the query. For queries with "why" asking for a more comprehensive event concept explaining the event from a more global viewpoint, the system climbs up in the multilayered knowledge structure in the schemata base through an a-part-of pointer of this schema and finds its upper level instance schema as a reply to the query. On the contrary, for queries with "how", the system descends in the multilayered knowledge structure in the schemata base through a has-part pointer of this schema.

In Fig.4(b) a user asks "Find why JNR suffers from setting standard normatives." Having identified the instance schema referred to in the query, in this case p-ev(8): `Problem`, the system climbs up in the multilayered knowledge structure in the schemata base through an a-part-of pointer of this schema and finds its upper level instance schema, c-ev(3): `Successful-Enforcement` in Fig.3. Then, the system translates this schema into natural language and presets "Because EA force(s) reduction of operating speed on JNR" as a reply to the query. In Fig.4(c) a user asks "Find how residents revenges on JNR for project of Shinkansen." For this query, the system outputs a series of replies listing the contents of primitive events (p-ev(4), p-ev(5), c-ev(1), and p-ev(6)) making up complex event c-ev(2): `Revenge` in Fig.3[(5)].

5. Conclusions

In this paper, to develop a decision support system that can reduce this undesirable factor, we at first discussed a knowledge representation formalism for societal problems to store descriptive information on past cases in the computer, and then developed methodologies to integrate the information via a part-to-whole aggregation. The underlying idea behind these integration methodologies is that "intelligence" is by no means a closed collection of causal relationships extracted from documents explicitly, but it exists in a product resulting from them at the more conceptual levels, or in the procedures to adaptively utilize them. Based on this idea, we developed a knowledge structuring methodologies, and the resulted knowledge structures made possible to explicate the conceptual and sophisticated principles implicitly represented in the surface expressions and to provide the decision maker with a variety of interpretations for an identical piece of knowledge.

The system only deals with syntactical and graph-theoretical aggregation, and capabilities of adaptively reorganizing an appropriate part of its knowledge base via semantic relationships and of generalization from instances are actually needed. Such self-organizing, inductive capability will be really valid in dealing with an open-ended problem domain and in making decision makers focus their attention in the uncertain, complicated reality.

(5) Within the system, the grammar rules are defined that are required to parse the fifteen different styles of query sentences. Each parsing rule is defined according to a Definite Clause Grammar (DCG). In DCG, each syntactical rule is defined as a *horn clause* of `Prolog`, and the parsing proceeds utilizing efficiently the automatic backtracking capabilities of `Prolog`. As for the dictionary, it comprises frequently-utilized interrogatives, articles and prepositions as well as verbs, which are restricted to the ones appearing in the lists of text slots of the template schemata.

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