REFINING SOWA'S CONCEPTUAL GRAPH THEORY FOR TEXT GENERATION

by

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Abstract

In project GENTEXT we aim at developing a system which will be able to generate texts in the French language, starting from knowledge structures expressed in the form of extended conceptual graphs. We had to extend the conceptual graph model mainly because in Sowa's approach temporal knowledge is not specified in a uniform way, and, monadic relations (i.e. PAST, FUTR) are not precise enough for expressing verb tenses in roman languages such as French, Spanish or Italian.

In our model we use conceptual graphs for describing non-temporal knowledge structures which are called "states". Temporal knowledge is expressed by a temporal label which is related to a state by a "period" relation (PER).

In order to specify verb tenses we use an approach which was first proposed by Reichenbach and distinguishes for every statement three temporal markers : S (time of locutor), E (time at which occurred the event) and R (time of the temporal reference).

This model is used for specifying conceptual structures from which sentences are generated in French.

1. Introduction

As computer applications become more sophisticated, there is a growing need for improving the communication between the systems and their users. Natural language generation (NLG) is a research domain in which are studied the various approaches and techniques which enable a system to respond to a user using natural language utterances (Danlos 1985) (McKeown 1985) (McDonald 1987a). Various types of application need a NLG sub-system such as question answering systems, explanation facilities in expert systems, communication component in intelligent tutoring systems etc. (McKeown 1986).

A well-accepted approach for NLG (McKeown 1986) consists in dividing the generation process in two phases which enable the system to focus on two questions : *what shall I say?* and *how shall I say it?* In the first phase the "strategic component" of the system has to decide what to say and when to say it (topic collection and organization phase in the PAULINE system (Hovy 1988)). The output of the strategic component is a structured message which is passed in the second phase to the tactical component. The tactical component has to determine how to express the message in the target language, using a grammar and a dictionary (realization phase in the PAULINE system (Hovy 1988)). Hovy indicates that a third question arises : *why should I say it?* He claims that the answer is largely provided by pragmatics. But this last concern has been largely unaddressed by the NLG community (Hovy 1988).

At the strategic level, the TEXT system (McKeown 1986) determines what information to present to the user, by using "discourse strategies" which have been encoded in the knowledge base after observing which strategies are commonly used by people. A discourse strategy consists in a schema which encodes the main transitions of the communication activity. In PAULINE (Hovy 1988), Hovy has implemented the strategic component as a planning system which is able to interleave the planning and realization activities : text planning is performed only when necessitated by the realization process.

McDonald (1987b) indicates : "Individual generation systems are unusually hard to compare, mostly because generation starts with an empirically unknown representation : the thoughts, conceptualizations and intentions of the human mind. Different projects inevitably work from different representations and focus on different technical problems". This issue of non-standard knowledge representation structures used as a starting point for NLG is also emphasized by Danlos (1985) and Weischedel (1986).

The theory of conceptual graphs (Sowa 1984) provides a knowledge representation approach which is compatible with most conceptual modelling techniques used in artificial intelligence, databases design, cognitive psychology, linguistics etc. We believe that the conceptual graph (CG) approach can be used as a common representational framework for text generation. Sowa has proposed various guidelines for NLG (Sowa 1984), but few papers have been reporting developments in this area (Velardi et al. 1988). We have encountered some difficulties when we tried to apply the conceptual graph approach for NLG, especially when we had to express temporal knowledge. In this paper we propose an extended CG model to overcome these difficulties.

In project GENTEXT (Generation of Text) we aim at developping a system which will be able to generate texts in the French language, starting from knowledge structures expressed in the form of extended conceptual graphs. These knowledge structures can be proposed by a user or generated by a planning system (Lizotte and Moulin 1989 a, b and c).

In section 2 we will present briefly the conceptual graph approach and identify some problems which arise when we try to apply it to text generation. In order to overcome these difficulties we propose to extend the CG approach in order to distinguish and process separately non-temporal and temporal knowledge (section 3). In section 4 we present an overview of the text generation system which derives a text in French from these extended conceptual graphs.

2. The conceptual graph approach and text generation

2.1 An overview of the conceptual graph approach

We will consider here the only characteristics of Sowa's approach which are relevant for our discussion of NLG. More details can be found in (Moulin and Kabbaj 1990), (Sowa 1988) (Sowa 1984).

Concepts are the representations of objects of the application domain. A concept is characterized by two elements : a type which represents the set of all the occurrences of a given class (i.e. human, animal etc.); a referent which represents a given occurrence of the class which is associated with the concept (i.e. John,Mary, Kiko etc.).
Using a graphical notation, a concept is represented by a rectangular box. Using a linear notation, we specify it between square brackets : [TYPE-NAME : referent].

Concept types are organized in a hierarchy which supports the abstraction operations on concepts : generalization and specialization. An abstraction relation between two types c_i and c_j is indicated by $c_i \geq c_j$ if c_i is a generalization of c_j. For instance HUMAN ≥ WOMAN, ANIMAL ≥ MONKEY, ACT ≥ EAT etc. Sowa has transformed the type hierarchy in a lattice structure, by adding a "universal type" UNIV which is the most generalized concept, and a type ABSURD which is the most specialized concept.

An elementary link between two concepts is called a **conceptual relation.** A conceptual relation is always associated with a "sink concept" (by means of an output arrow) and zero, one or several "source concepts" (by means of input arrows). Using a graphical notation the conceptual relation is represented by an oval box from which exits only one arrow and to which may enter several arrows. Using a linear notation the conceptual relation is represented between brackets and is associated with concepts by means of arrows. Conceptual relations are usually binary. They correspond often to "semantic cases" (Fillmore 1968) such as "agent" (AGNT), "object"(OBJ), "instrument"(INST), "patient"(PTNT), "characteristic" (CHRC), "point in time" (PTIM), "beneficiary" (BENF), "duration" (DUR)...

Conceptual graphs (C.G.) are finite, connected and bipartite graphs, whose nodes are either concepts or conceptual relations : in the graph an edge can only relate two nodes whose categories are different. In figure 1 we find an example of C.G. in both linear and graphical notations. C.G. are also organized according to a **generalization hierarchy**. Conceptual graphs are used to represent knowledge structures at a semantic level. Hence, they support the abstraction operation which is most important when it comes to processing and organizing knowledge. The abstraction operation allows us to represent various types of conceptual structures, namely type definition, prototype specification, schema definition, individual definition and conceptual relation specification (Sowa 1984).

The conceptual graph theory enables us to specify embedded CG by the use of a concept of type PROPOSITION. For instance "Mary thinks that John eats an apple" is expressed by :

[Mary] <- (AGNT) <- [THINK] -> (OBJ)->
    [PROPOSITION : [John] <- (AGNT) <- [EAT] ->
     (OBJ) -> [APPLE]].

Sowa defined a "context" as a set of propositions, and a situation as "a state of affair that occurs at a single place and time (Sowa 1988). For instance we can indicate the situation : "John eats an apple" by :

[SITUATION : [John] <- (AGNT) <- [EAT] -> (OBJ) -> [APPLE]].

To relate the tense with a conceptual graph, Sowa introduced monadic relations such as PAST, FUTR (future). For instance "John arrived on Monday" can be expressed by :

(PAST) -> [SITUATION : [John] <- (AGNT) <- [ARRIVE] -> (PTIM) -> [MONDAY]].

Sowa (1988) indicates also that various relation types can be used to relate different sentences such as : SUCC (successor), BFOR (before), AFTR (after). "John buys an apple before going to school" is expressed by :

[[John] <- (AGNT) <- [BUY] -> (OBJ) -> [APPLE]]
    -> (BFOR) ->
[[John] <- (AGNT) <- [GO] -> (DEST) -> [SCHOOL]].

2.2 Some difficulties arise with the use of the CG approach

When we tried to use the CG approach for NLG, the main difficulty that we have encountered was related with the way temporal knowledge is expressed in conceptual graphs.

Pb1. In Sowa's approach temporal knowledge is not specified in a uniform way since there are three different kinds of temporal relations : the monadic relations to indicate verb tenses; dyadic relations related to concepts or propositions (PTIM, DUR) and dyadic relations related to propositions (SUCC, BFOR, AFTR).

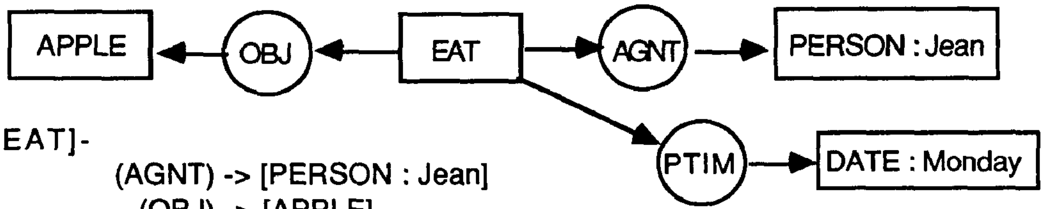
A problem arises when we want to differentiate sentences such as "John bought an apple and went to school" :

(PAST) -> [[John] <- (AGNT) <- [BUY] -> (OBJ) -> [APPLE]]
    -> (AND) ->
[[John] <- (AGNT) <- [GO] -> (DEST) -> [SCHOOL]] <- (PAST)

and "John bought an apple before going to school" :

(PAST) -> [[John] <- (AGNT) <- [BUY] -> (OBJ) -> [APPLE]]
    -> (BFOR) ->
[[John] <- (AGNT) <- [GO] -> (DEST) -> [SCHOOL]].

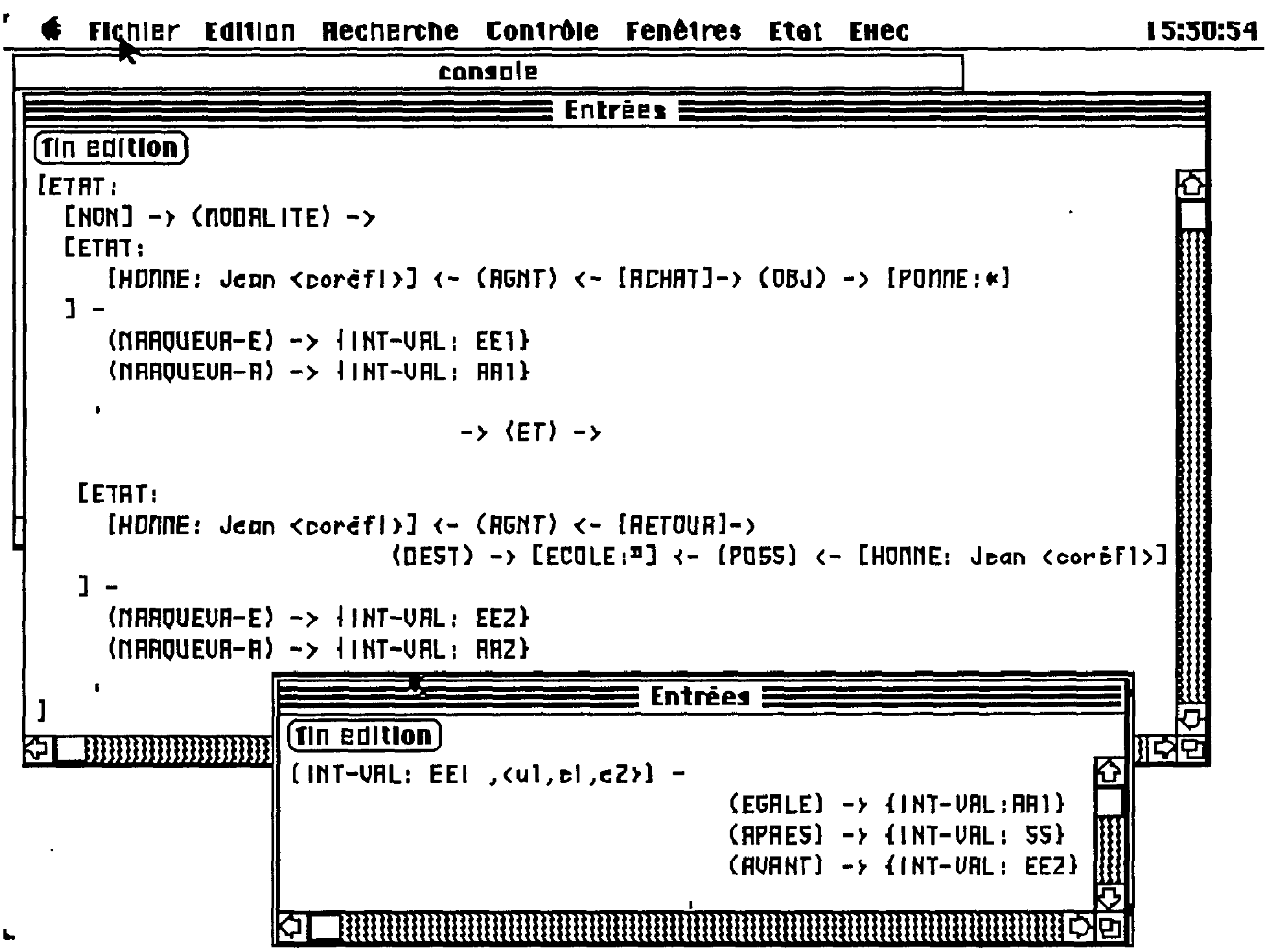
We claim that tense relations are properties of sentences at the surface level of language expression and should not be expressed at the same level as the relations which indicate properties of points in time (PTIM) or time intervals (DUR, BFOR etc.). As we will see, temporal markers can be used to deduce tense



[EAT]-
(AGNT) -> [PERSON : Jean]
(OBJ) -> [APPLE]
(PTIM) -> [DATE : Monday].

Figure 1 : graphical and linear presentations of a conceptual grap

Figure 3 : the linear form of conceptual graphs



cHaracteristics from temporal relations related to point in time and intervals.

Pb2. Monadic relations (i.e. PAST, FUTR) are not precise enough for expressing verb tenses in languages such as French, Spanish, German or Italian in which different tenses can indicate past or future activities. For instance in French, a past activity can be indicated by the following tenses : imparfait, passé composé, passé simple, plus que parfait. Neither can we express tense concordance in related sentences using monadic tense relations. K. Dorfmüller-Karpusa (1988) indicates that "an understanding of the temporal relations cannot be separated from the complete semantic analysis of a text". B. Comrie (1985) provides a interesting study about temporal and aspectual relations.

Pb3. Sowa never mentioned any process which would enable us to check the coherence of temporal knowledge in conceptual graphs. Such a process is an important one for a NLG system since it is necessary to verify that the input knowledge structures are coherent before trying to generate sentences.

3. An extended CG model differentiating temporal and non-temporal knowledge

In (Moulin 1987) we suggested the idea of separating the temporal structures from non-temporal knowledge which are currently merged in Sowa's approach. In our model we use conceptual graphs for describing non-temporal knowledge structures which are called "states". For instance
[STATE : [John] <- (AGNT) <- [EAT] -> (OBJ) -> [APPLE]].

Temporal knowledge is expressed by a temporal label which is related to a state by a "period" relation (PER). A temporal label is specified by a triplet [unit, lwr-bnd, upp-bnd], where unit indicates the precision of the observations (second, minute, hour, day etc.), the lower-bound lwr-bnd corresponds to the point in time when the state was first observed, the upper-bound upp-bnd corresponds to the point in time when the state was last observed. The lower and upper bounds can be either instantiated or variable.
Using temporal labels we can specify information about points in time as well as time intervals. We can define relations between temporal labels similar to the relations that Allen introduced between intervals (before, equal, meets, overlaps, during, starts, finishes) (Allen 1983).

For instance "John buys an apple before going to school" is expressed in our model by :
[STATE : [John] <- (AGNT) <- [BUY] -> (OBJ) -> [APPLE]] -> (PER) -> [u1, b1, b2]
[STATE : [John] <- (AGNT) <- [RETURN] -> (DEST) -> [SCHOOL]] -> (PER) -> [u1, b3, b4]
[u1, b1, b2] -> (BEFORE) -> [u1, b3, b4].

In order to specify verb tenses, we use an approach which was first proposed by Reichenbach (1947) and extended by Borillo et al. (1988). This approach distinguishes for every statement three temporal markers : S, E and R.
S is the time at which the statement is produced (time of locutor);
E is the time at which occurred the event represented by the statement;
R is the time of the temporal reference according to which are situated the locutor and the event.
These markers are needed to express semantically verb tenses (see Pb2 in section

2.2). These markers are situated differently on a temporal axis according to the verb tense :

I saw John   E,R   S
————————> t
I have seen John   E   R,S
————————> t
I will see John   S   E,R
————————> t

If we use the concomitance relation (noted ",") and the precedence relation (noted "_") between these markers, we have the following representations for verb tenses :

Passé simple (perfect) (E,R _ S)
Je vis (I saw)
Passé composé (present perfect) (E _ R,S)
J'ai vu (I have seen)
Plus que parfait (E _ R _ S)
J'avais vu
Présent (E,R, S)
Je vois (I see)
Futur (S _ R, E)
Je verrai (I will see)
Futur antérieur (S _ E _ R)
J'aurai vu (I will have seen)

Reichenbach model can be used to represent semantically verb tenses, but it cannot be used to differentiate aspectual differences between imperfect and perfect. We can express these differences if we represent the markers by time intervals instead of points in time (Dorfmüller-Karpusa 1988) :

[E [R]]   [R] [E]   [E]   [R]
———>   ————>   ————>
Imperfective   Perfective   Perfective

Borillo et al. (1988) extended Reichenbach's approach by considering the three temporal markers as time intervals and using Allen's temporal logic to reason on their relationships. These authors demonstrated that their approach can be used to represent verb tenses at the indicative mode, as well as temporal adverbs ("yesterday", "today", "tomorrow") and temporal conjunctions ("when"). Algorithms can be implemented in order to check automatically the proper use of tenses, temporal adverbs and conjunctions in sentences. Hence we have a way for solving the problem of tense concordance.

In our model the temporal markers S, E, R are considered as temporal labels, where E corresponds to the temporal label which is associated with the conceptual graph representing the sentence. We can relate the temporal markers using our relations on temporal labels, which are compatible with Borillo's approach. It is worth remarking that these markers enable us to introduce pragmatic knowledge in our model since we take in account the context in which sentences are formulated.

For instance the semantic representation in figure 2 corresponds to the sentence "John will not buy an apple before he will return to his school" *("Jean n'achètera pas une pomme avant qu'il retourne à son école")*.
The complete sentence represents a state 0 in which are embedded two states 1 and 2. State 1 is associated with the marker intervals E1 = (u1,e1,e2) and R1 = (u1,r1,r2);
State 2 is associated with the marker intervals E1 = (u1,e3,e4) and R1 = (u1,r3,r4);
(units and bounds of the temporal labels are undefined and represented by variables).

The temporal relations indicate that (S _ E1,R1) and (S _ E2,R2) : both sentences are

Figure 2 : the graphical form of conceptual graphs

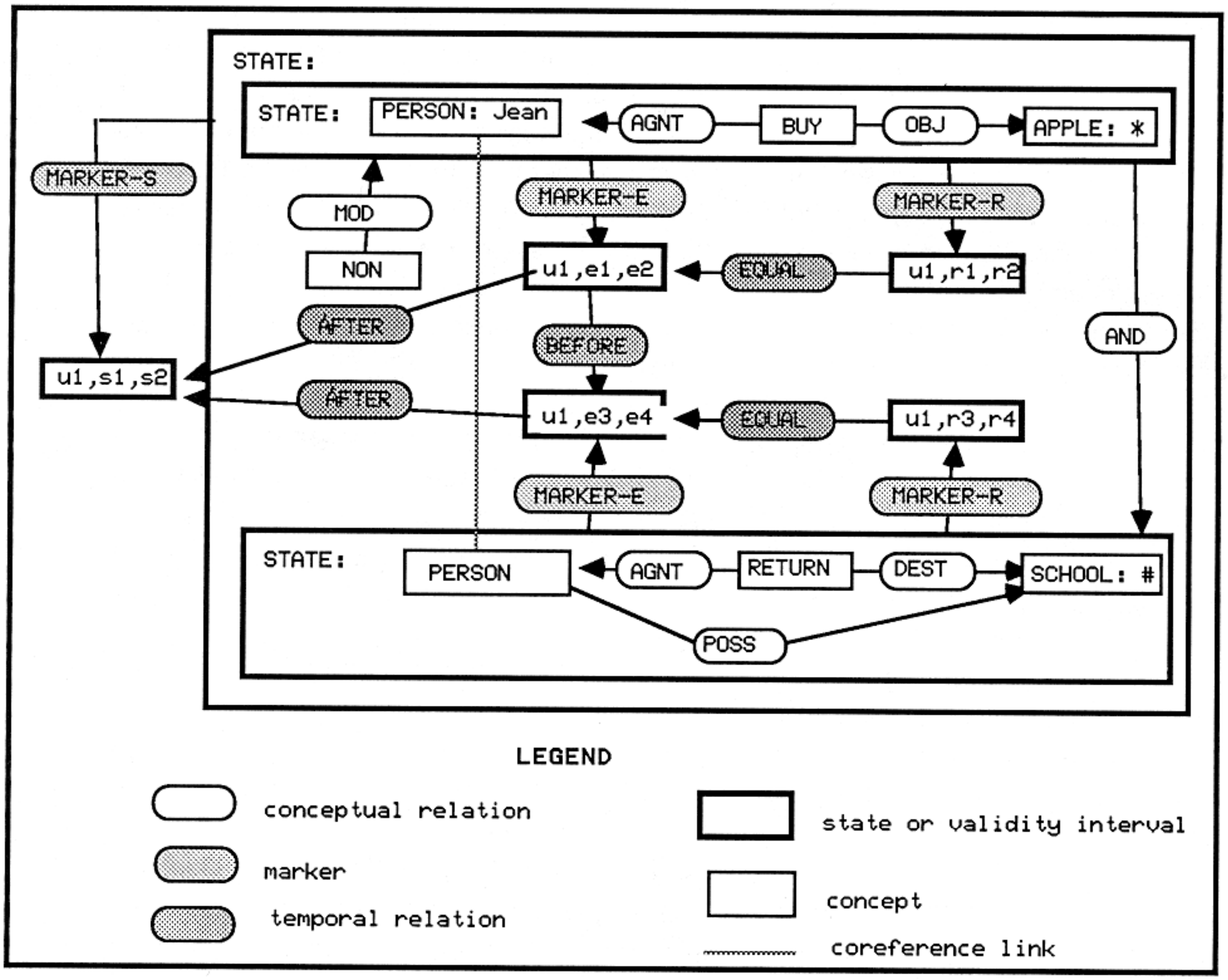
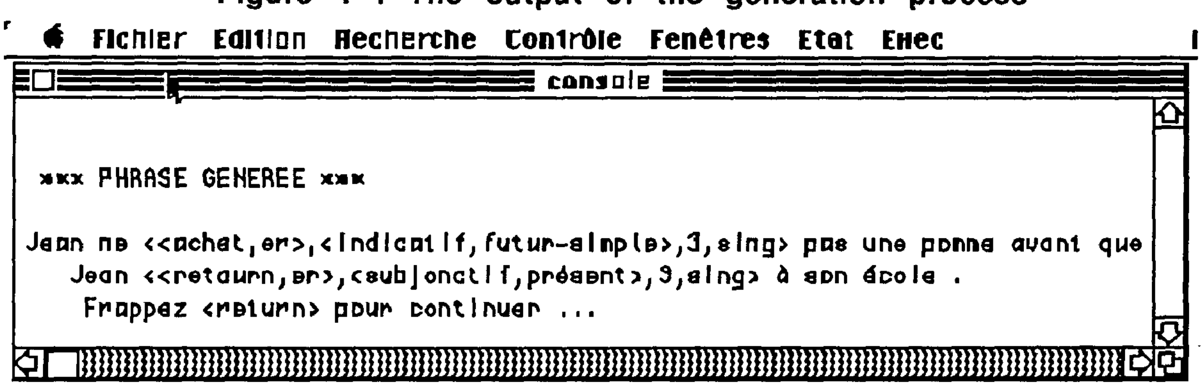


Figure 4 : The output of the generation process



expressed using future tense. The relation [E1] -> (BEFORE) -> [E2] enables us to express the precedence order of the two sentences. Note that Sowa's theory enables us to express anaphoric references by the use of coreference links (the dashed line between John and person in figure 1).

We have developed an algorithm which enables the system to propagate temporal constraints along the network of temporal labels. Hence the system is able to check the validity of the temporal labels and to detect inconsistencies which are reported to the knowledge engineer.

4. An overview of the text generation system

We have developped a text generation system which derives from our extended conceptual graphs a text written in French. This system which has been programmed in Prolog has two main components : a sub-system for managing the knowledge structures which are used as input for the second sub-system which is the text generator.

The first sub-system enables us to specify knowledge structures in the form of extended conceptual graphs (including temporal labels). Figure 3 shows the graph specification in linear form. The system checks temporal constraints using the propagation algorithm. It checks as well semantic constraints according to definitions of concepts and conceptual relations available in a semantic lexicon. If any inconsistency is detected, the system asks the knowledge engineer to correct them.

The second sub-system uses extended conceptual graphs to direct the generation process. The different states are considered according to the precedence of their temporal labels. The approach that is used for generating the text corresponds to an extension of the guidelines proposed by Sowa (1984) for generating sentences from conceptual graphs, using an "augmented phrase structure grammar". This extension stems mainly from our use of conceptual graphs augmented with time labels. Figure 4 presents the sentence which is generated in French : verbs have not been conjugated in order to show tense characteristics. In French the second verb tense is conjugated with the present of subjunctive, because it follows the conjunction "avant que".

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