

Prétexte: A Generator for the expression of temporal information

Michel Gagnon¹ and Guy Lapalme¹

Département d'informatique et de recherche
opérationnelle, Université de Montréal
C.P. 6128, Succursale "A", Montréal, Québec,
Canada, H3C 3J7,
e-mail: {gagnonm,lapalme}@iro.umontreal.ca

Abstract. In this paper we present a method for generating French texts conveying temporal information. This method integrates the Discourse Representation Theory (DRT) and the Systemic Grammar Theory. First, we show how the DRT is used to represent temporal information. We then show how this formalism is used to represent the temporal localization expressed by temporal adverbial phrases. Finally, we give a description of how this representation of adverbial phrases can be translated into a syntactic form, using Systemic Grammar Theory. Prétexte, our implementation of this method, is able to generate a great variety of temporal adverbial phrases.

Keywords: text generation, systemic grammar, DRT, expression of time.

1 Introduction

Until now, few generators have been developed to solve satisfactorily the problem of the expression of time. Furthermore, the ones which address this problem focus on the production of verb tenses, without offering a convincing solution to the choice of temporal adverbs. In [15], a method is proposed for integrating the expression of temporal concepts in the process of text generation. In particular, it shows how to produce different types of text in French from a single representation of events. But there are many problems with the method proposed. Mainly, the method governing the planning process is too much determined by the temporal concepts. Thus, the planning process appears too much ad hoc, compared with other promising frameworks like the schema of McKeown [16] or the RST [12, 8]. Also, this proposal is not really successful in integrating in the generator all the expressive potential of a language like French for the expression of time.

Here a different perspective is adopted. We believe it is easier to establish a method for discourse planning if we have a better understanding of the way temporal information can be expressed by the adverbs and verb tenses. We thus focus on the surface generation process, more specifically on the problem of generating the great variety of syntactic markers, such as adverbial phrases and verb tense. To achieve this we started from the work of [3]. She proposes a

method to extract the temporal structure of a text, according to the Discourse Representation Theory (DRT) proposed by Kamp in [9]. Her work relies on an analysis of temporal adverbial phrases made by Molines [17]. Of course, it is not possible to develop a method for surface generation without considering the higher levels, at least partially. Therefore, in this paper, we will present not only a surface generator, but the solutions that are suggested by our method at the deep level process.

To implement the production of temporal adverbs and verb tenses, we have chosen the systemic grammar of Halliday. The advantage of this framework is the possibility of expressing the syntactic aspect of a sentence as resulting from a sequence of semantic choices. We developed a grammar interpreter inspired from Nigel (cf. [14]). But we depart from Nigel on many aspects, especially on the way of representing the production of verb tenses and adverbs.

Prétexte, the system we developed in Prolog, has many resources for the expression of time. The French discourse (D1), which is an adaptation of an example taken from [3], has been produced by Prétexte (an English translation is given on the right).

| | |
|--|--|
| <p>Hier l'avion a effectué un vol (o_1). À 8h10 il a quitté Paris (o_2). Quand il a survolé Barcelone (o_3), le réacteur fonctionnait (o_4). À 10h15, un voyant a clignoté (o_7). Auparavant, il s'était allumé (o_5). Puis il s'était éteint (o_6). Pendant 35 minutes, l'avion a survolé la mer (o_8). Puis il a atteint la côte (o_9). Jusqu'à 10h50, il a survolé l'Algérie (o_{10}). À 11h30 il était sur la piste (o_{11}). À ce moment-là le réacteur a explosé (o_{12}).</p> | <p><i>Yesterday the plane made a flight. At 8h10 it left Paris. when it flew over Barcelone, the engine was working. At 10h15, a warning light flashed. Previously it had come on. Then it had gone out. For 35 minutes the plane flew over the sea. Then it reached the coast. Until 10h50 it flew over Algeria. At 11h30 it was on the landing runway. At this moment the engine exploded.</i></p> |
|--|--|

Discourse (D1)

To produce such a text, we must start from a conceptual representation which embodies objectively the facts that must be reported in the text, with their disposition in time. The information at the conceptual level must be translated into a semantic representation where the facts are presented according to a subjective perspective. The semantic representation is then used to produce the text. In the next section we will see how the temporal information can be represented at the first two levels. We then show how temporal adverbial phrases can be produced from the semantic representation.

2 The representation of time

Although our work focused on the second translation process which produces the temporal markers in the text, we cannot ignore the issue of the conceptual representation. It is because the nature of the semantic representation is determined not only by the syntactic potentiality of the language, but also by the type of temporal concepts that can be formed.

2.1 The conceptual representation

To represent temporal concepts in Prétexte, we chose the principles of Discourse Representation Theory (DRT). The DRT offers one of the most interesting explanation for the way temporal notions are conveyed by a text.

According to DRT, we associate to a text a Discourse Representation Structure (DRS). This DRS is updated incrementally by the processing of each sentence. A DRS is a structure containing a set of entities and a set of conditions on these entities. We can find in a DRS different types of entities. A temporal fact can be presented either as a punctual event or as a situation obtaining at a certain moment in time. Another type of entities are the *temporal constants* which designate a segment of the temporal axis. Finally, there are the entities that participate in the events or situations.

In Prétexte, the conceptual knowledge is represented as a DRS. We made little change in the formalism, in order to adapt it with the context of text generation. We do not make the distinction between events and situations in the conceptual representation, because we want it to be independent of the language. We think that this distinction regarding the temporal aspect must not appear at the conceptual level. The fact that something is presented as a situation of an event in the discourse is not relevant at the conceptual level. In a generation we should let the system choose among these possibilities. Therefore, at the conceptual level we prefer to use the unique concept of *occurrence*, for every fact that takes place in time, may it be an event or a situation.

Among the motivations for choosing DRT as a framework for our conceptual representation is that it has already shown its suitability for dealing with temporal information in discourse analysis. Also, we believe that the use of occurrences as primitive concepts (which means that the notion of time ensues from the occurrences) is in accordance with the intuition. We have considered the other possibilities, that is to take the point or the interval as primitive, but found them less interesting for natural language applications.

In particular, [1] proposes a system for temporal reasoning, which uses a set of all possible relations that can exist between two intervals. But we believe it is not well suited for natural language generation. The main reason is that temporal relations in this framework must be expressed with precision, whereas it is in the nature of language to often express temporal concepts approximately.

In fact, the aspect of DRT that really convinced us to use it is that it offers the possibility of considering the occurrences and time periods as being equivalent in regard with their external behavior. That is, if we consider only the temporal relations expressed in the conceptual representation, occurrences and times are not distinguishable. This facilitates the expression of temporal localization in many different ways, which is an important issue in text generation. In [6] we present an ontology of time that take advantage of this important characteristic of DRT.

In the conceptual representation we find four types of information:

- The description of occurrences.

| | n | ct_1 | ct_2 | ct_3 | ct_4 | o_1 | o_2 | o_3 | o_4 | a | l | p | b | r |
|-------------------------|-----|--------|--------|--------|--|-------|-------|-------|-------|---|---|---|---|---|
| plane(a) | | | | | $ct_1 = \text{Sept. 10 1992}$ | | | | | | | | | |
| flight(l) | | | | | $ct_2 = \text{Sept. 10 1992 at 8:10 am}$ | | | | | | | | | |
| engine(r) | | | | | $ct_3 = \text{Sept. 11 1992}$ | | | | | | | | | |
| city(p) | | | | | $ct_4 = \text{Sept. 10 1992 at 9:00 am}$ | | | | | | | | | |
| Paris(p) | | | | | $o_2 < n$ | | | | | | | | | |
| city(b) | | | | | $o_2 \circ ct_2$ | | | | | | | | | |
| Barcelona(b) | | | | | $o_1 < n$ | | | | | | | | | |
| o_1 : make(a,l) | | | | | $o_3 < n$ | | | | | | | | | |
| o_2 : leave(a,p) | | | | | $o_1 \subset ct_1$ | | | | | | | | | |
| o_3 : flightover(a,b) | | | | | $o_4 < n$ | | | | | | | | | |
| o_4 : work(r) | | | | | $o_3 \subset o_4$ | | | | | | | | | |
| $n \subset ct_3$ | | | | | $o_3 \circ ct_4$ | | | | | | | | | |

Fig. 1. Conceptual representation for the first three sentences of (D1)

- The description of participants in the occurrences.
- The description of the temporal localizers, which are called *temporal constants*. They usually refer to time periods in the calendar.
- Some temporal relations between the occurrences and the temporal localizers. The relation $<$ is used to represent temporal precedence. To state that two temporal objects are somehow simultaneous, we use the overlap relation \circ . Thus, in our representation, “Y happens at time X” is represented by “Y temporally overlaps X”. Finally, we use the relation \subset to express the fact that the temporal extent of a temporal object is a subset of the temporal extent of another object.

Figure 1 shows the part of the DRS used to generate the first three sentences of (D1). It contains five temporal constants: n , ct_1 , ct_2 , ct_3 and ct_4 . We have developed a formalism to express the variety of possibilities to designate temporal segments represented by these constants. Due to space limitations this formalism is not presented here (for more detail see [5]). In the illustrated DRS we give for these constants an English description. The constant n represents the speech time. In the representation, we specify that it is included in a time represented by ct_3 , which is the day corresponding to *September 11 1992*. Four occurrences are represented in the DRS: o_1 , o_2 , o_3 and o_4 . We see, from the relations, that all these occurrences take place before the time n .

Note that not all temporal relations in the DRS must be given as input: some can be deduced. Many relations can be inferred from the ones given as input. To achieve this, three kinds of knowledge may be used. One is the representation of conventional time that is used by everyone for identifying a specific period in time. Such a representation implies a structure of the conventional

time, together with reasoning mechanisms to deduce temporal relations¹. For example, this knowledge informs us that *September 10* must be before *September 11*, which implies the relations $ct_1 < ct_3$ in our representation. Similarly, we can deduce $ct_2 \subset ct_1$, $ct_4 \subset ct_1$ and $ct_2 < ct_4$.

The second kind of information is the world knowledge about the occurrences. Knowing that occurrences o_2, o_3 and o_4 are part of the occurrence o_1 implies that they are all temporally included in it.

The last kind of knowledge that can be used is a reasoning mechanism on the temporal relations. Such mechanism will rely on a set of axioms. Suppose, for example the existence of these axioms:

$$\forall x, y(x \circ y \wedge x < y \wedge y < x) \quad \forall u, v, x, y(u \circ x \wedge v \circ y \wedge x < y \Rightarrow u \circ v \vee u < v)$$

From world knowledge we can infer that occurrences o_2 and o_3 cannot overlap (the leaving of Paris cannot overlap the flying over Barcelona). Thus, according to the axioms, we can infer $o_2 < o_3$ from the relations $o_2 \circ ct_2$, $o_3 \circ ct_4$ and $ct_2 < ct_4$.

2.2 The translation into a semantic representation

To generate a text with an input such as the one illustrated at figure 1, where many occurrences are given, we must first choose one discourse structure among all the possibilities. It is the discourse structure that specifies the segmentation of the message into sentences.

Figure 2 illustrates such a discourse representation, inspired from the Segmented Discourse Representation Theory (SDRT) proposed by Asher in [2], which extends the DRT by adding to it the notions of rhetorical relations such as the one proposed in the RST [13]. We call SDRS such a discourse structure. It contains the same information as in the DRS of figure 1 except that it has been segmented. We see that the top-level DRS contains three small DRSs which are related by *rhetorical relations*: each DRS corresponds to a sentence. Beside these three small DRSs, the top-level DRS contains the information that is global to the text: the description of participants and the description of speech time. At this moment, we do not know how to produce this discourse structure, but we are planning to work on this problem. In particular, we will try to use the results of the work done by other researchers who tried to apply the SDRT to the analysis process [10, 4]. In the discourse structure of our example, we have one sentence that is to be elaborated by two other sentences. These two sentences constitute a narration.

Once the discourse structure has been established, it must be translated into a semantic representation of the form (S_1, S_2, \dots, S_n) . For now on, we will use the convention S_i to designate the i^{th} element of a semantic representation S . To achieve the translation of the SDRS, we effectuate a depth-first traversal of the DRSs in the discourse structure. For each DRS visited, we establish its corresponding feature structure in the semantic representation.

¹ In [6] we propose an implementation of such a structure

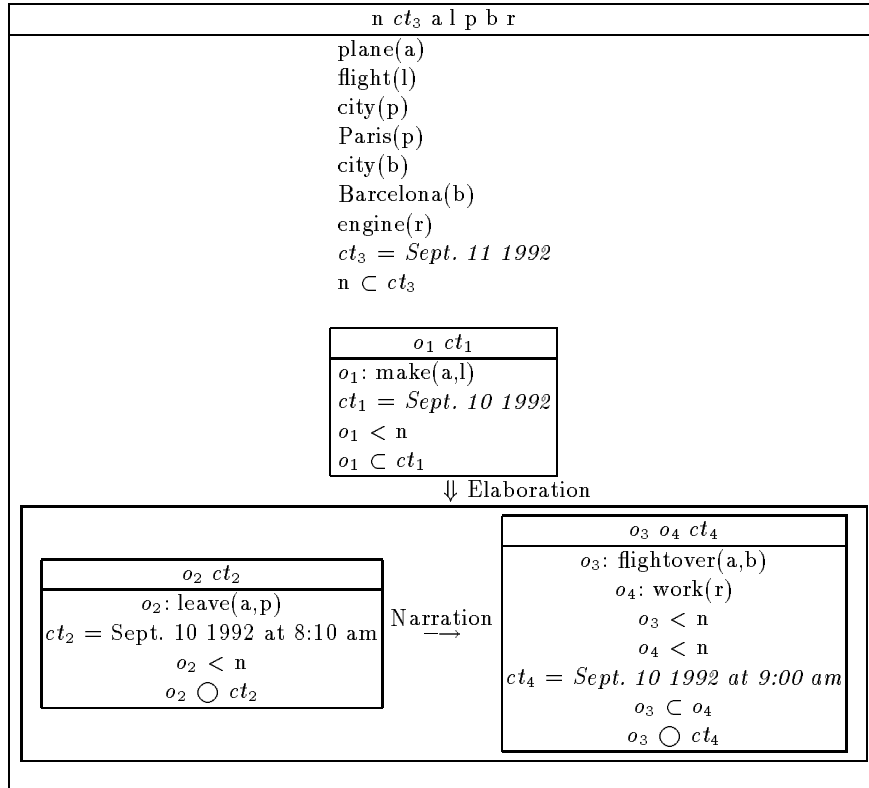


Fig. 2. Discourse representation for the first three sentences of (D1)

Figure 3 is an illustration of a semantic representation that can be produced from the SDRS of figure 2.

We see that each structure contains five features. The feature *Message* refers to the occurrence that must be reported by the sentence, and specifies the aspect that must be used to present it. We distinguish, as Kamp does, two aspects that can be used to present an occurrence, as an event or as a situation, with a further specification for the last case. Two types of situations are recognized by Prétexte: *open situations* and *resulting situations*. An open situation is obtained when we locate ourselves at a time where an occurrence is in progress. A resulting situation is the state that follows the termination of an occurrence. Usually, in French, the event aspect for a past occurrence would result in the use of verb tense *passé composé* (simple past in English). To open and resulting situations would correspond the *imparfait* and the *plus-que-parfait* respectively (the closest tenses in english for these last two tenses are the past progressive and the past

$$\left(\begin{array}{l} \left[\begin{array}{l} Message = event(o_1) \\ N = n \\ R = nil \\ P = n \\ L = ct_1 \end{array} \right], \left[\begin{array}{l} Message = event(o_2) \\ N = n \\ R = o_1 \\ P = n \\ L = ct_2 \end{array} \right], \left[\begin{array}{l} Message = \\ open_situation(o_4) \\ N = n \\ R = o_2 \\ P = n \\ L = o_3 \end{array} \right] \end{array} \right)$$

Fig. 3. Semantic representation for the first three sentences of (D1)

perfect). In the first two elements of the semantic representation of figure 3, the occurrence is presented as an event, whereas in the last one it is presented as an open situation. We see that among the four occurrences contained in the DRS, only three constitutes the main “message” of the text: o_1 , o_2 and o_4 .

The four other features in a structure S_i give the value of four temporal markers which express the localization of the occurrence. These markers correspond essentially to the four markers proposed by Kamp and Rohrer (as presented in [3]) for the analysis of texts, which we have adapted to the problem of generation. We can consider them as an extension of Reichenbach’s markers [18]. To identify the value of these four features, at least two information have to be considered:

- The other DRSs to which the visited DRS is attached in the discourse structure
- The rhetorical relations

The marker N represents the time of speech. The utility of this marker may not be clear, considering the fact that it is constant in our example. The reason for having such a feature in every semantic structure S_i is that the value of N could be locally altered in the discourse, in indirect speech for example. We have not studies such cases, but we think that the existence of the marker N would be necessary to deal with them.

The perspective point P refers to an instant from which the occurrence must be considered. Usually it points to the speech time. In some cases, when a flashback is expressed, for example, it will have a different value. In discourse (D1), there is such a case. The fifth and sixth sentences constitute a flashback, the perspective point being the occurrence of the fourth sentence. In the discourse structure, the flashback is represented by using a rhetorical structure. Consider for example the discourse structure for the first seven sentences of (D1) as sketched at figure 4. For the translation of the two DRSs containing o_5 and o_6 , the value given to P will be the occurrence o_7 since the DRS containing this occurrence dominates the two other ones with the relation *flashback*. For the next DRS visited, the one containing o_8 , the perspective point will be reset to the value it had before entering the flashback, that is, the value when the DRS of o_5 was considered.

The value of P is used to determine the choice of verb tense. In discourse (D1) we see that the flashback results in the choice of the *plus-que-parfait*.

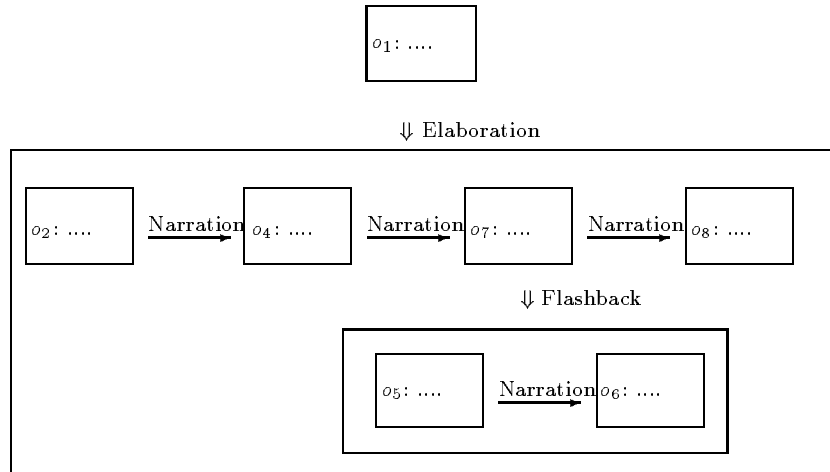


Fig. 4. Discourse representation for the first seven sentences of (D1)

L represents the temporal location of the occurrence reported. If this occurrence overlaps another temporal object, this object could be used as value for L. In our example, the values of L show that the constants ct_1 and ct_2 are used to localize the first two occurrences. In the third sentence, the situation corresponding to o_4 is presented at the instant where the occurrence o_3 takes place. If no other temporal object overlaps the one that constitutes the message, the temporal region represented by L can be defined in relation with another temporal object. We will see examples of this in the next section. L represents the information that will be expressed by an adverbial phrase in the sentence. It is not necessary to give a value to it. A sentence may not contain an adverbial phrase of temporal localization.

Sometimes a localization is performed in relation to a reference in the context, which is represented by the marker R. This reference is used to represent the progression of time in the discourse. Only events and temporal constants have the capacity of stating a new reference. Put simply, the rule for identifying the value of R is the following one:

1. First identify the DRS to which the visited DRS is attached in the discourse structure. We call *S-antecedent* this DRS, and S_a the feature structure that is associated to this DRS in the semantic representation.
2. If the occurrence reported as Message in S_a is present as a situation, it cannot be used as a reference point, since a situation cannot state a progression in time.

3. If L has a value which is temporally more precise than the occurrence in the Message, R will take it as a value. In the reverse case, R is bound to the occurrence in the Message, if this occurrence is not presented as a situation.
4. If L has no value and the occurrence in the Message is a situation, it means that the antecedent sentence does not state a progress in time. Therefore, R will be given the same value it has in S_4 .

In the semantic representation of figure 3 we see that the context for the first sentence is empty, so there are no value for R. For the second and third sentences, the value of R is the event presented in the preceding sentence. Note that the occurrence in the third sentence is expressed as a situation. So, it cannot be the reference for the next sentence. Consequently, the marker R for the next sentence will have the value of L in the structure of third sentence, that is the constant ct_4 . We will see in the next section how the value of R is considered to produce the temporal adverb.

It is easy to see that the choice of the aspect is not an easy task in the building of the semantic structure. Not only the pragmatic information must be used to select one aspect, but also we must take into account the interaction with other choices such as the type of temporal localizer used. At this moment, we consider that the localizer is first identified and that the selection of aspect is constrained by this choice. But we must admit that more study have to be done to clarify this interaction between aspect and temporal localizer.

If an occurrence is presented as a situation, the temporal localizer must be a time included in it. On the contrary, the event aspect cannot be combined with a localizer included in the occurrence. In our example, the occurrence of S_1 must be presented as an event, since the localizer ct_1 includes the occurrence. In S_2 , the localizer overlaps the occurrence. In this case, we must be careful, because the overlapping relation does not prevent the existence of an inclusion relation. If this inclusion relation between ct_2 and o_2 can be deduced, than the situation aspect should be chosen. Here we suppose that this inclusion relation cannot be deduced, thus resulting in the choice of the event aspect. Finally, in S_3 , the localizer is included in the occurrence of the Message. Consequently, the situation aspect is selected.

Note that the semantic representation given in figure 3 is not unique. Figure 3 shows another semantic representation that could be built from de DRS of figure 1. It contains a fourth sentence. In fact, the main difference with the other representation is that the occurrence o_3 , instead of acting as a localizer for the occurrence o_4 , constitutes by itself the message of a sentence.

Once the semantic representation is produced, the temporal adverbial phrase and the verb phrase can be generated independently. The syntactic form of the verb phrase is determined by the combination of the following information:

- Temporal relation between localizer L and speech time N.
- Temporal relation between localizer L and perspective point P.
- Aspect of the occurrence.

$$\left(\begin{array}{l} \left[\begin{array}{l} Message = \\ event(o_1) \\ N = n \\ R = nil \\ P = n \\ L = ct_1 \end{array} \right], \left[\begin{array}{l} Message = \\ event(o_2) \\ N = n \\ R = o_1 \\ P = n \\ L = ct_2 \end{array} \right], \left[\begin{array}{l} Message = \\ event(o_3) \\ N = n \\ R = o_2 \\ P = n \\ L = ct_4 \end{array} \right], \left[\begin{array}{l} Message = \\ open_situation(o_4) \\ N = n \\ R = o_3 \\ P = n \\ L = ct_4 \end{array} \right] \end{array} \right)$$

Fig. 5. Alternative semantic representation

The temporal adverb is mainly determined by the value of L. The choice of its syntactic structure will be affected if the value of L refers to the speech point N or the reference R. The interaction of temporal information conveyed by verb tense and adverbs is taken into account in the translation process from conceptual level to semantic level.

As we said earlier, we have not solved entirely the problem of choosing among all the semantic representations that can be built from a DRS. We are planning to focus our attention on this issue in the future.

Due to space limitation, we will not discuss the generation of verb phrases. We will describe in detail only the production of temporal adverbs. We made this choice because adverbial phrases have not received much attention until now and, as we will see, it has many implications that makes the generation process complicated.

3 The production of temporal adverb

In the previous section, we said that the marker L, called the *localizer* in the semantic structure of a sentence, is to be generated as an adverbial phrase. In the example at figure 3, the value for L is always an object of the conceptual, either a temporal constant or an occurrence. But it needs not to be so. The localization can be expressed indirectly.

In the discourse (D1), we see that the temporal localization expressed by the temporal adverb can be achieved in many different ways: in relation to the time of speech (*hier/yesterday*), by designating a temporal reference (*à 8h10/at 8h10*), in relation with another fact (*puis/then, à ce moment-là/at this moment*, *quand il a survolé Barcelone/when it flew over Barcelone*), etc. To this variety in the semantic of localization we must add the variety of syntactic forms. The localization can be expressed by an adverb (*puis/then*), a prepositional phrase (*jusqu'à 10h50/until 10h50*), a nominal phrase (*le lendemain/the day after*) or a subordinate clause (*quand il a survolé Barcelone/when it flew over Barcelone*). We are thus confronted with two levels of representation where each one has its own diversified potential for the expression of temporal localization.

3.1 The grammar

Our problem is now this one: on which of these two representations will be hinged the translation process? We have chosen the semantic representation because it permits an integrated solution for the expression of time. By analysing all the possible forms of localizer that can be made up, we find that their semantic can be represented by the following recursive structure:

$$\text{Localizer} = \text{Temporal object} \mid \text{Positioner}(\text{Localizer})$$

That is, a localizer can identify directly the temporal zone of an occurrence, by using another temporal object that overlaps, or express it in relation with another localizer. The localizer for the occurrence o_6 in (D1), translated into the adverb *puis* (then), would be represented by the term *after(o₅)*. As an example of more complex structure we can take the representation of *jusqu'à deux jours avant le départ de Robert* (until two days before Robert's departure), which would be represented by a term like *term(before(o₂₃, 2 days))*, where o_{23} represents the departure occurrence and the relation *term(X)* represent a temporal segment terminated by X. We will call *secondary localizer* a localizer embedded in a term of the form *positioner(localizer)*.

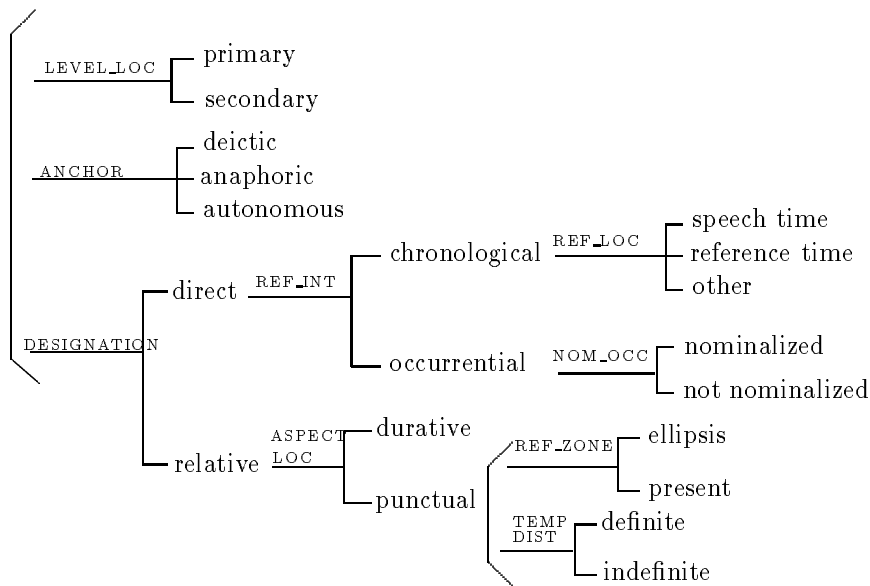


Fig. 6. Systemic network for the production of adverbials

Figure 6 shows a simplified version of the systemic network implemented in Prétexte. To represent the sequence of choices that must be performed in order to produce the adverbial phrase corresponding to the semantics of the localizer. This network is composed of *systems*, each one declaring a list of features. The network is processed from left to right and when a system is entered, a choice must be made among the listed features. The feature selected may lead to another system (note that two features could lead to the same system). Brackets identify systems that must be processed concurrently. The syntactic structure of the adverbial phrase is determined by a set of constraints entailed by features selected in a complete traversal of the network. To implement the selection of features, we use a method inspired by the *inquiries* of Nigel [11].

We will now give an overview of how the network can be used to produce an adverbial phrase.

If the localizer has a simple structure, as it is the case when it is not expressed in relation with another localizer using a positioner, its translation into the syntactic form will be achieved by a unique traversal of the network. Otherwise, there are two possibilities. It could happen, depending on the choices made in the systems, that only the positioner is expressed in the resulting phrase. In the text (D1) this is the case for the occurrence o_5 , where the semantics of its localizer, *before*(o_7), has been translated in the phrase *auparavant* (previously). The secondary localizer refers to the event expressed in the preceding sentence: thus it is the value of the reference R. Consequently this secondary localizer is not expressed because it is present in the context. In the case where the secondary localizer must be expressed, it will be done by re-entering recursively in the network. Suppose, for example, that the occurrence o_7 in the localizer *before*(o_7) is not the value of R. This means that o_7 is not given in the context and, consequently, must be expressed. A first traversal of the network establishes that the phrase must contain a positioner, which will be translated into *avant* (before), and a secondary localizer expressing o_7 . To translate this secondary localizer, the network is re-entered, which results in the production of the phrase *le clignotement d'un voyant* (the flashing of a warning light). We thus obtain the adverbial phrase *avant le clignotement d'un voyant* (before the flashing of a warning light).

When the grammar is used to generate a localizer, three parallel systems must first be entered: LOC_LEVEL, ANCHOR and DESIGNATION. The role of the system LOC_LEVEL is to indicate in which level of embedding we are in the generation of the adverbial. The first time we enter the network to generate an adverbial, the feature *primary* is selected. If other traversals are required to generate embedded localizers, the feature *secondary* will be selected for each new traversal. The reason for having this system is that the syntactic structure of a localizer may differ whether it is embedded or not in another one, as we will later.

The system ANCHOR offers three ways to localize the occurrence that constitutes the message. The localization is deictic if it is in relation with the time of speech, anaphoric if made in relation to the reference point indicated by the

marker R, and autonomous if made according to a dating convention. In the system DESIGNATION, we must decide if the temporal zone occupied by the occurrence is designated directly, by selecting the feature *direct*, or in relation with another, by selecting the feature *relational*. In the first case, we then have to determine if the localization is made by a temporal constant (feature *chronological*) or another occurrence (feature *occurential*). In the case of a temporal constant, we must determine if the localizer refers to speech time, reference time, or other. Examples of phrases corresponding to these three types are, respectively: *maintenant* (now), *à ce moment-là* (at this moment) and *à 8h10* (at 8h10). If the feature *occurential* is selected, the localization will be expressed by a nominal phrase or a subordinate clause, depending on the choice made in the following system. It will be nominalized if it is a secondary localizer, as in the phrase *two days after his departure*, which contains a positioner expressed by *two days after* and a nominalized secondary localizer, *his departure*. If the occurrence is used as a simple localizer, a subordinate clause is produced, as in the third sentence of (D1)².

Let's now consider what happens if the feature *relative* is chosen. Prétexte will add syntactic constraints indicating that the phrase must contain a positioner. In the subsequent systems, the syntactic form of the positioner will be established, and a decision will be made about the expression of the embedded localizer in the resulting phrase. In the system ASPECT_LOC, we establish if the temporal zone identified by the localizer must be perceived as being punctual or as having a duration. In the second case, the generated phrase will express the secondary localizer. For example, we see in (D1) that the localization of the occurrence o_{10} has been rendered by a durative localizer expressed by the phrase *jusqu'à 11h30* (until 11h30). When the *punctual* feature is selected, we must then consider two systems concurrently. First, in REF_ZONE, we determine if we will express the embedded localizer, or only express the positioner. Depending on this decision, the localizer of occurrence o_{10} in (D1), *after(o₉)*, will be translated into *puis* (then), composed of a positioner without a secondary localizer, or *après avoir survolé la mer* (after having flown over the sea), containing a positioner and a secondary localizer. In TEMP_DIST, we determine if the relative localization indicates a temporal distance from the embedded localizer. If it is the case, the feature *definite* is selected.

Thus, there are two stages in the generation of the sentence. First there is the selection of features in the grammar, which is achieved by considering the information contained in the semantic structure of the sentence. Second, the constraints associated with the selected features must be taken into account in order to determine the syntactic structure of the sentence. This second stage is called the *syntactic realization*.

We will present in detail how the features can be selected using the informa-

² Note that this way of dealing of nominalization is oversimplified. More study is needed on this problem. The important thing to note here is that the choice must be constrained by the fact of being an embedded localizer or not. A *when*-clause cannot be generated for an embedded localizer.

tion in the semantic representation.

3.2 The selection mechanism

To select features in the systems, the semantic structure of the sentence and the conceptual information pointed by the semantic structure are consulted. Sometimes, a feature is *pre-selected*, that is, its selection is determined by features already selected.

In table 1 we give the rules that are applied to achieve the selection in each system. In the rules we designate L_i the most embedded localizer in the expression associated to L in the semantic structure.

| SYSTEM | CONDITIONS | SELECTION |
|-------------|---|----------------------|
| LOC_LEVEL | The network is entered for the first time | primary |
| | Otherwise | secondary |
| ANCHOR | $L_i = N$ | deictic |
| | $L_i = R$ | anaphoric |
| | Otherwise | autonomous |
| DESIGNATION | The value of L is an occurrence | direct |
| | The value of L is a temporal constant | direct |
| | Otherwise | relative |
| REF_INT | The value of L is a temporal constant | chronological |
| | The value of L is an occurrence | occurrential |
| REF_LOC | <i>deictic</i> has been selected in ANCHOR | speech time |
| | <i>anaphoric</i> has been selected in ANCHOR | reference time |
| | <i>autonomous</i> has been selected in ANCHOR | other |
| NOM_OCC | <i>primary</i> has been selected in LOC_LEVEL | not nominalized |
| | <i>secondary</i> has been selected in LOC_LEVEL | nominalized |
| ASPECT_LOC | L has the form <i>term(...)</i> or <i>beg(...)</i> | <i>durative(...)</i> |
| | L has the form <i>before(...)</i> or <i>after(...)</i> | punctual |
| TEMP_DIST | A metric is specified in the relation | definite |
| | Otherwise | indefinite |
| REF_ZONE | L has the form <i>before(...)</i> or <i>after(...)</i> and <i>anaphoric</i> or <i>deictic</i> has been selected in ANCHOR | ellipsis |
| | Otherwise | present |

Table 1. The selection rules

To select the type of localization, Pr etexte considers the most embedded object in the localizer identified by L. If this object is the same as the one pointed by the reference R, the feature *anaphoric* is selected; if it corresponds to the speech time N, the feature *deictic* is selected; otherwise the feature *autonomous* is selected. The choice between the features *relative* and *direct* in DESIGNATION

reflects the structure of the localizer. If it has the form *positioner(localizer)*, the feature *relative* is selected. For ASPECT_LOC, we see that the selection depends on the nature of the positioner. In REF_ZONE, the conditions for the selection of *ellipsis* represent the cases where the temporal localization conveyed by the embedded localizer is already available in the context: either it is the speech time (feature *deictic*), or it is a time introduced before in the discourse (feature *anaphoric*).

To see more clearly the selection mechanism, let's take the semantic representation of the last four sentences of (D1), which is illustrated in figure 7. Note that for all structures except the last one, the value of the reference R is the occurrence of the preceding structure. This because in these cases, the occurrence is temporally more (or as much) precise as the localizer. Only for the last structure we had to take the value of L in the preceding structure, since the occurrence o_{11} is presented as a situation.

$$\left(\left[\begin{array}{l} \text{Message} = \\ \text{event}(o_9) \\ N = n \\ R = o_8 \\ P = n \\ L = \text{after}(o_8) \end{array} \right], \left[\begin{array}{l} \text{Message} = \\ \text{event}(o_{10}) \\ N = n \\ R = o_9 \\ P = n \\ L = \text{term}(ct_6) \end{array} \right], \left[\begin{array}{l} \text{Message} = \\ \text{open_situation}(o_{11}) \\ N = n \\ R = o_{10} \\ P = n \\ L = ct_7 \end{array} \right], \left[\begin{array}{l} \text{Message} = \\ \text{event}(o_{12}) \\ N = n \\ R = ct_7 \\ P = n \\ L = ct_7 \end{array} \right] \right)$$

Fig. 7. Semantic representation of the last four sentences of (D1)

For the following discussion, we will denote S_1 , S_2 , S_3 and S_4 the four elements of the representation of figure 7.

In S_1 and S_4 , the L's most embedded object and R have the same value, thus entailing the selection of *anaphoric* in ANCHOR. For S_2 and S_3 we can see that we are in a situation where the feature *autonomous* will be chosen.

In S_1 and S_2 , the localizer L has a complex form using a positioner. Therefore, the feature *relative* must be selected in this case. In the two other cases, since we have two temporal constants, the feature *direct* is selected.

Let's first consider the elements S_3 and S_4 , for which the system REF_INT must now be considered. Since the objects associated to L are temporal constants in both cases, the feature *chronological* is selected. Up to now we are not surprised that the same choices have been made for S_3 and S_4 , since in both cases L has the same value. But different selections are made in the next system, because the feature *autonomous* has been selected previously for S_3 , whereas *anaphoric* has been selected for S_4 . Therefore, the feature *reference* is selected for S_4 , whereas *other* is selected for S_3 . This explains why we obtained *à ce moment-là* (at this moment) for S_4 , rather than a repetition of the phrase *à 11h30* obtained for S_3 .

For S_1 , the semantics of the localizer L requires the choice of the feature *punctual* in ASPECT_LOC. Then, considering the fact that the feature *anaphoric* has been previously selected, we have all the condition for selecting *ellipsis* in REF_ZONE. We thus avoid the production of the phrase *après avoir survolé la mer* (after having flown over the sea) which would be repetitive with the preceding sentence. Finally, for S_2 , the feature *durative* has been selected because of the semantics of the positioner *term*. For S_2 , the semantics of the localizer requires the selection of *durati* in ASPECT_LOC.

3.3 Syntactic realization

In Sytemic Grammar Theory the syntactic realization relies on a functional analysis of the sentence, as explained by Halliday in [7]. He consider that sentences have many meanings: logical, thematic and interpersonal meanings. Each phrase in the sentence has a function for each of these sentence meanings.

The construction of the syntactic structure results from the solving constraints of different type. A constraint may:

- specify the existence of a function in the sentence;
- specify the ordering of some function in the sentence;
- for a specific function, which requires that the network must be re-entrer to realize it, preselect some of the feature that will be selected ;
- for a specific function, specify a syntactic feature that will determine its lexicalization.

In our implementation, a sentence contains a function which is called the Localizer. To generate the Localizer, the network given at figure 6 is traversed in order to generate a temporal adverbial phrase. An temporal adverbial phrase is itself decomposed into subphrases having different functions. These are the functions we may find in a temporal adverbial phrase:

TempLocSpec (Temporal location specifier) It is the component of the phrase that express the location in time, such as *8:00 am* and *april 1992*.

TempDet (Temporal determiner) It is the component that specify a relation to the temporal location specifier, such as *after* in the phrase *after 8:00 am* and *when* in *when John left Paris*.

TempDistSpec (Temporal distance specifier) It is a component which specify a temporal distance from another localizer, such as *two days* in *two days after Jonh's departure*.

Note that it is not necessary that all features in the grammar specify a constraints. Some features, as the ones in systems LEVEL_LOC, ANCHOR, serves for determining choices in other systems. Other features has the role of leading us to a subpart of the network. For example, the feature *chronological* in REF_INT leads us to system REF_LOC, whereas the feature *occurential* leads us to NOM_OCC.

| SYSTEM | FEATURE | REALIZATION CONSTRAINTS |
|-------------|-----------------|---|
| LEVEL_LOC | | <i>no realization constraint</i> |
| ANCHOR | | <i>no realization constraint</i> |
| DESIGNATION | direct | +TempLocSpec +TempDet [...,TempDet,TempLocSpec,...] lex(TempDet, temporal prepositional phrase) |
| | relative | +TempDet |
| REF_INT | | <i>no realization constraint</i> |
| REF_LOC | speech time | lex(TempLocSpec, adverb) |
| | reference time | lex(TempLocSpec, noun) |
| | other | lex(TempLocSpec, temporal noun) |
| NOM_OCC | nominalized | TempLocSpec → nominal phrase lex(TempDet, preposition) |
| | not nominalized | TempLocSpec → clause lex(TempDet, preposition) |
| REF_ZONE | ellipsis | [...,TempDet,...] |
| | present | +TempLocSpec [...,TempDet,TempLocSpec] TempLocSpec → temporal adverbial phrase |
| ASPECT_LOC | | <i>no realization constraint</i> |
| TEMP_DIST | definite | +TempDistSpec TempDistSpec → temporal nominal phrase lex(TempDet, temporal preposition) IF ANCHOR = <i>deictic</i> : [TempDet,TempDistSpec] OTHERWISE: [TempDistSpec,TempDet,...] |
| | indefinite | IF REF_ZONE = <i>ellipsis</i> : lex(TempDet, adverb) OTHERWISE: lex(TempDet, temporal preposition) |

Table 2. Realization constraints

In table 2, we enumerate the realization constraints that are associated with features in the grammar. *+Function* means that the function *Function* must be present in the structure generated. The ordering of functions is specified by a list expression like $[F1, \dots, F2, F3, \dots]$, where \dots means that any sublist of functions could be present in this place and “,” is used to specify that two functions must be contiguous. We write *Function* → *Cat* to indicate that the function *Function* must be realized by re-entering the grammar. Since the grammar is divided in many subsection, one for each syntactic category of phrase, we indicate in *Cat* which subpart must be entered. We write *lex(Function, Cat)* to indicate that the function *Function* must be lexicalized. *Cat* indicates category of the lexical item that must be extracted from the lexicon. It would be too long to present here how lexicalization is achieved. Suffice it to say that lexical item is identified by using the category specified, the list of features selected in the grammar, and

the semantic form of the structure generated. Finally, we write *Syst = Feature* to mean that the feature *Feature* has been selected in system *Syst*.

Note that with the simplified version of our grammar given in this paper, we cannot explain all the forms of temporal adverbial phrases that can be generated by Prétéxte. For example, to generate *hier* (yesterday) we need more systems than what is contained in the grammar at figure 6. Also, we have not introduced all the systems that are needed to generate the durative forms of localizer. For an exhaustive description, see [5].

To illustrate the realization process, we will see how a few forms of temporal adverbial phrases can be generated.

À 8h10 (*at 8:00 am*) To obtain this form the following features must be selected in the grammar: *primary, autonomous, direct, chronological* and *other*. Consulting table 2, we see that we thus obtain the following realization constraints:

```
+TempLocSpec
+TempDet
[...TempDet,TempLocSpec,...]
lex(TempDet, preposition)
lex(TempLocSpec, temporal noun)
```

The syntactic structure will contain two functions in this order: TempDet TempLocSpec (since no other ordering constraints are given, the ... are replaced by nothing). Both must be lexicalized using the lexicon. We obtain *à* for the first one and *8h10* for the second one.

Quand il a survolé Barcelone (*When it flew over Barcelona*) Selected features: *primary, autonomous, direct, occurrential* and *not nominalized*. Realization constraints:

```
+TempLocSpec
+TempDet
[...TempDet,TempLocSpec,...]
lex(TempDet, prepositional phrase)
TempLocSpec → clause
```

The only difference with the preceding example is the last constraint. In this case, to identify the syntactic structure of the TempLocSpec we must re-enter the grammar to generate the clause *il a survolé Barcelone*.

Puis (*Then*) Selected features: *primary, autonomous, relative, punctual, ellipsis* and *indefinite*. Realization constraints:

```
+TempDet
[...TempDet,...]
lex(TempDet, adverb)
```

Note that the third constraint has been added because the feature *ellipsis* has been selected. Here the constraints imply a structure which contain only one function which must be lexicalized as an adverb.

Il y a 3 jours (*Three days ago*) Selected features: *primary, deictic, relative, punctual, ellipsis* and *definite*. Realization constraints:

```
+TempDet
[...TempDet,...]
+TempDistSpec
TempDistSpec → temporal nominal phrase
lex(TempDet, temporal preposition)
[TempDet,TempDistSpec]
```

Here the structure contains the two function TempDet and TempDistSpec. Two ordering specifications must be solved. The first one says that the TempDet may be preceded or followed by any other function sublist. The second says that it must be immediately followed by the TempDistSpec. The final result is a structure with two functions in this order: TempDet TempDistSpec. Note that the second ordering constraint has been added because of the selection of *deictic* in ANCHOR. A constraint specifies that the TempDet must be lexicalized as the temporal preposition *il y a*. Finally, the TempDistSpec must be generated by re-entering the grammar, and consider the systems pertaining to the generation of temporal nominal phrases.

3 jours après le départ de Jean (*Three days after Jean's departure*) Here we have a case where the section of the grammar for the generation of temporal adverbial phrase (illustrated at figure 6) must be entered twice. The first time, the selected features are: *primary, autonomous, relative, punctual, present* and *definite*. The result is the posting of the following constraints:

```
+TempDet
+TempLocSpec
[...TempDet,TempLocSpec]
TempLocSpec → temporal adverbial phrase
+TempDistSpec
TempDistSpec → temporal nominal phrase
lex(TempDet, temporal preposition)
[TempDistSpec,TempDet,...]
```

Here we have the maximal form, that is, all three possible functions are present. Solving the ordering constraints we get the following structure: TempDistSpec TempDet TempLocSpec. The first one is generated by re-entering the grammar in order to produce the nominal phrase *3 jours*. The second one is lexicalized as the temporal preposition *après*. For the last one, the grammar must also be re-entered to produce another temporal adverbial phrase. This time the features selected will be: *secondary, autonomous, direct, occurrential, nominalized*. Note that *nominalized* is selected because *secondary* is also selected. We get the following constraints:

```

+TempLocSpec
+TempDet
[...TempDet,TempLocSpec,...]
lex(TempDet, preposition)
TempLocSpec → nominal phrase

```

In the lexicalization process, because of the presence of the feature *secondary* the function TempDet will be realized as an empty item. The realization of this example is illustrated at figure 8

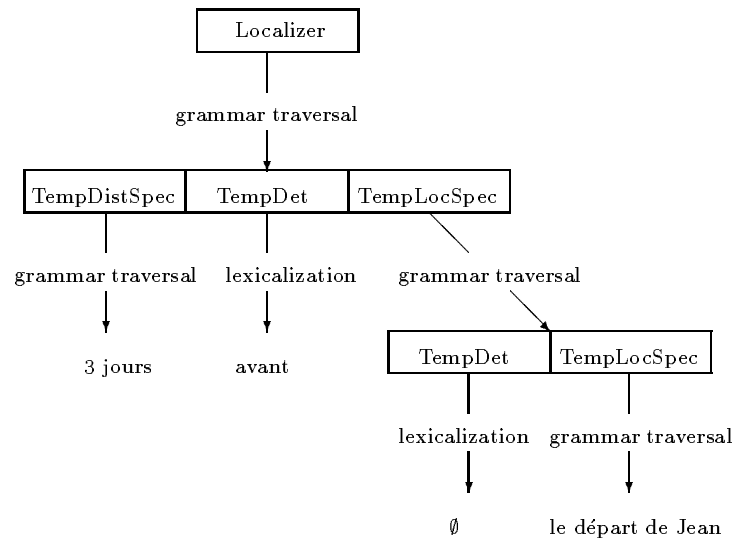


Fig. 8. Realization of *3 jours après le départ de Jean*S

3.4 Summary

What we have explained in this section is how temporal adverbial phrases, despite their variety of syntactic forms, can all be considered as temporal localizers composed of a positioner and, possibly, a secondary localizer. With this unified semantics we have shown how our semantic network determines the syntactic form of the phrase. But we have not said a lot about how the information in the semantic representation are used to make the selections in the system.

For most of the systems in the network, the information contained in the semantic representation is sufficient to make a selection. With the four markers

N, R, P and L, this combined with the great expressive power of the semantics used to represent the localizer L, we are able to generate most of the patterns identified by [17] for temporal adverbs. Thus, the generation of the temporal adverbs, once the semantic structure has been established, can be considered independent of the domain. However, at the level of the translation process from the conceptual level into the semantic one, the situation is different. At the current stage of our research, we cannot say how the domain influences the generation of temporal adverbs at this level.

4 Related work

We have been given the opportunity to examine at length the system Nigel. As far as the expression of temporal information is concerned, *Prétexte* covers more possibilities than Nigel. Moreover, we are not aware of any other systems that displays the same expressive power for the expression of temporal localization. Also, in *Prétexte*, we propose a unified explanation for the expression of the temporal localization, which is dispersed in many part of the network in Nigel.

5 Conclusion

In this paper, we have presented a method that has been successfully used to produce text conveying temporal information. Our method combines the principles of two theories: the DRT of Kamp and the Systemic Functional Grammar of Halliday. The first one guides us in the expression of temporal information. The second provides a generation process controlled by a set of semantic choices, with the syntactic form resulting from these choices. With these tools we showed how our generator could cover a large number of the possible forms of temporal adverbial phrases. But there still remains a great amount of work to accomplish on this aspect. The biggest task that must be tackled is the identification of a mechanism to choose one semantic representation among all the ones be built from a conceptual representation.

6 Acknowledgements

We would like to thank John Bateman of the Komet Project, who gave us the opportunity to meet his team and with whom we shared many fruitful discussions. We are also indebted to Myriam Bras, from the IRIT at Toulouse, who helped us to deal with the DRT and allowed us to use her examples in our experimentations with *Prétexte*. Special thanks to Leila Kosseim who accepted to revise this paper. This research is financially supported by the Natural Sciences and Engineering Research Council of Canada.

References

1. J. Allen. Maintaining knowledge about temporal intervals. *Communications of the ACM*, 26(11):832–843, 1983.
2. Nicholas Asher. *Reference to Abstract Objects in Discourse*. Kluwer Academics, Dordrecht, 1993.
3. M. Bras. *Calcul des structures temporelles du discours*. Thèse de doctorat, Université Paul-Sabatier, 1990.
4. Myriam Bras and Nicholas Asher. Le raisonnement non monotone dans la construction de la structure temporelle de textes en français. In *9ème congrès AFCET-RFIA*. Paris, 1994.
5. Michel Gagnon. *Expression de la localisation temporelle dans un générateur de texte*. Thèse de Doctorat, Publication #888, Département d’informatique et de recherche opérationnelle, Université de Montréal, 1993.
6. Michel Gagnon and Myriam Bras. Discourse interpretation and time representation. *Technical Report*, 1995.
7. M. Halliday. *An Introduction to Functional Grammar*. Edward Arnold, London, 1985.
8. E. Hovy. Approaches to planning of coherent text. In W. Swartout and Mann W., editors, *Natural Language Generation in Artificial Intelligence and Computational Linguistics*, pages 83–102. Kluwer Academics Publishers, Boston, 1991.
9. H. Kamp. Événements, représentations discursives et référence temporelle. *Langages*, 64:34–64, 1981.
10. Alex Lascarides and Nicholas Asher. Temporal interpretation, discourse relations and commonsense entailment. *Linguistics and Philosophy*, 16:437–493, 1993.
11. W. Mann. An Overview of the Nigel Generation Grammar. Technical report, USC/ISI, 1983.
12. W. Mann. Discourse structures for text generation. In *10th International Conference on Computational Linguistics*, Stanford, 1991.
13. W. Mann and S. Thompson. Rhetorical structure theory: Description and construction of text structure. In Gerard Kempen, editor, *Natural Language Generation*, pages 85–95. Martinus Nijhoff, Dordrecht, 1987.
14. C. Matthiessen and J. Bateman. *Text Generation and Systemic-Functional Linguistics*. Pinter, London, 1991.
15. M. Gagnon and G. Lapalme. A text generator for the expression of temporal relations. In *Proceeding of the Third European Workshop on Natural Language Generation*, Judenstein/Innsbruck, 1990b.
16. Kathleen R. McKeown. Discourse strategies for generating natural language text. *Artificial Intelligence*, 27(1):1–41, 1985.
17. F. Molinès. *Acceptabilité et interprétation des adverbiaux de localisation temporelle*. Mémoire de D.E.A., Université de Toulouse - Le Mirail, 1990.
18. H. Reichenbach. *Elements of Symbolic Logic*. McMillan, New York, 1947.