Semantic Analysis of Time and Tense in Natural Language: an implementation

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Abstract

In this paper a model for temporal references in natural language (NL) is studied and a Prolog implementation of it is presented. This model is intended to be a common framework for semantic analysis of verb tenses and temporal adverbial phrases. The time model choosen was based on time intervals and temporal relations. The notion of "proposition type" and temporal concepts of tense, aspect, duration, location and iteration were represented as temporal relations between some special time intervals and temporal quantifiers over time intervals. The implementation consisted in extending an existing semantic analyser based on the approach to NL semantics of [Por Fil 84]. Area: Natural Language Understanding

1 Introduction

In this paper a model for temporal references in natural language (NL) is studied and a Prolog implementation of it is presented. This model is intended to be a common framework for semantic analysis of verb tenses and temporal adverbial phrases. The reason for having such a common framework is the well-know fact that the meaning of the temporal expressions in NL sentences, and mainly of verb tenses, is not a one-to-one map from the morphosyntactic forms. The meaning of verb tenses and auxiliaries is different in different NL languages, and even in a given language that meaning relies on several factors: the verb's inherent meaning, the nature of the verb's arguments (definiteness/mass nouns) and adverbials, if present.

This work is part of a research on NL understanding within the Logic Programming paradigm and in particular of a toy project on the construction of a computer-aided translation (CAT) system [Fil84, Fil86, Fil87]. The approach used in the construction of this CAT system is based on the translation of the source language into an abstract language - *interlingua* - from which the target language is subsequently generated. Corresponding to a NL sentence a syntactic analyser produces a functional (relational) structure from which the semantic analyser builds an "intermediate semantic representation" of the sentence: an element of the *interlingua*. The Logic Programming approach to NL semantics put forward in [PorFil84] — to be referred to as *ISR-semantics* — must be seen as defining that language and as prescribing a method for building those representations. [Fil86], [Por88] for some descriptions and [TomFil89] (where a brief description is also made) for some comments and extensions.

Our aim was to develop an extension to the ISR language for the treatment of time and tense, and the following steps were considered:

Morphosyntactic forms → Temporal Concepts → Formal Representation → ISR

The temporal representation scheme was based on previous works on this subject. Among others [Bru72], [BenPar78], [Mou78], [Dow79], [Bac81], were valuable references. A similiar formal model was found in [Eyn87].

2 Background

We assume that a NL sentence describes some situation (or state of affairs) which is valid in some time period (for which it is said to hold or occur). This time period is normally related with other time periods (namely, the so called time of speech) and it can be explicitly or implicitly referred in the sentence. Each NL sentence can be splitted into two components: a basic atemporal component associated with the state of affairs "itself" — which we will call a *proposition type*, following the terminology of formal philosophers [Sho87] — and other associated with the temporal information. In the sentence "John built a house last year" the *proposition type* will be "John build a house" and the temporal component will represent the information conveyed by the simple past and the adverbial of time "last year".

3 Temporal Model

The temporal model is based on the notion of time interval and relations between intervals. Given an isomorphism between time (set of moments) and the set of real numbers ordered by $\leq$, we define time interval and temporal relations in the obvious way. The initial point a_i (end point a_e) of a time interval **A** is the least lower bound (least upper bound) of **A**, if such a bound exists, and then $A = (a_i, a_e)$. If $a_i = a_e$ then **A** is a *moment*. As in [All83, All84], and based on the order relation $\leq$ the following mutually exclusive ordering relations (together with its inverses) are defined between two time intervals, **A** and **B**:

Identity	sim(A,B)	$(a_i = b_i) \wedge (a_e = b_e)$	sim(B,A)
Precedence	pre(A,B)	$a_e < b_i$	pos(B,A)
Contain	inc(A,B)	$(a_i < b_i) \wedge (b_e < a_e)$	dur(B,A)
Overlap	over(A,B)	$(a_i < b_i) \wedge (b_i \leq a_e) \wedge (a_e < b_e)$	over_by(B,A)
Start	ini(A,B)	$(a_i = b_i) \wedge (a_e < b_e)$	ini_by(B,A)
Finish	fin(A,B)	$(b_i < a_i) \wedge (a_e = b_e)$	fin_by(B,A)

The transitive closure of the temporal relations is obtained by computing the possible relations between any two time intervals. For instance, if

$$\begin{aligned} inc(A,B) \wedge pre(B,C) \quad \Rightarrow \quad & pre(A,C) \vee over(A,C) \\ & \vee inc(A,C) \vee fin\_by(A,C) \end{aligned}$$

A time interval **B** is a subinterval of a time interval **A**, iff $inc(A,B) \vee ini(A,B) \vee fin(A,B)$.

These notions of time — totally ordered, dense and unlimited — and time primitives — time periods with some duration — seems to be the ones implicit in the temporal references in NL sentences and close to the common sense, and that is why they were adopted here.

4 Proposition Types and Semantic Representation

The meaning of the temporal references in a NL sentence, and mainly tense forms, depends on the temporal properties of its *proposition type*. For instance, the Portuguese present tense can have different meanings according to the proposition type of the sentence (for each sentence its literal rendering in English is given):

a) A Joana gosta de morangos	Joana likes strawberries
b) A Joana chega a casa às 5 horas	Joana arrives home at five
c) A Joana chega amanhã	Joana arrives tomorrow

While **a)** is only valid in the present, **b)** can be valid in the future or be a habitual present action, and in **c)** the adverbial makes it valid only in the future.

We adopt Vendler's classification of verb phrases (and the so called Aktionsart) but our terminology will be different [Mou78]. According to the kind of state of affairs that they describe — static versus dynamic — we can distinguish *proposition types* which are *states* or *occurrences*. The occurrences can be subdivided in *processes*, *instantaneous events* or *protracted events*.

a) Mary likes strawberries	**state**
b) John ran for an hour	**process**
c) The boy built a boat	**protracted event**
d) The boy found a coin	**punctual event**

This classification is based on the relations between time periods in which the proposition is valid and on its duration. The following definitions could be given:

- *state* – whenever it holds over an interval it holds over all its subintervals:*know, believe, live.*

- *process* – whenever it holds over an interval it holds at least over one of its subintervals:*run, write, wait, walk.*

- *punctual event* – never holds over overlapping intervals or two intervals one of which is a subinterval of the other:*find, arrive, die, notice.*

- *protracted event* – same as *punctual event* but can not occur only in a *momemt:build, paint, grow.*

To obtain a temporal value of a given proposition type we first assign a temporal value to the verb lexical entry according to it, as the above examples show. This value can be overridden during the semantic analysis by the verb's arguments and complements:

"John wrote a long book"	*protracted event*
"John write books"(= John is a writer)	*state*
"The turtle ran a mile"	*protracted event*
"John walked *to* the station"	*punctual event*

Notice that we could have assigned a temporal value to the whole sentence instead of only to the proposition type. In that case we would have different values as we add the temporal information. As an example, consider the sentence"John run for an hour". The temporal value of this sentence is *protracted event*, as we cannot say, for instance, that "John run for an hour at the first half of that hour".

4.1 ISR-semantics

The method for building a ISR for a sentence is a bottom-up rewrite process where each step of the semantic representation is made when the syntactic analyser establishes a syntactic function between two constituents [PorFil84], [TomFil89]. The ISR language is intended to represent individuals of some type, set of individuals, properties of individuals and relations between them. We represent the proposition types as terms of the ISR language. The above sentences would have the following ISRs for the proposition types:

```
for(some(1)-book:B!long(B),write(john,B))
writer(john)
for(the(1)-turtle:T,for(one-mile:M,run(T,M)))
```

```
for(the(1)-station:S,walk_to(john,S))
```

The association of a time interval to a *proposition type* is defined by the relation:

sit(<Type>,<TimeInterval>,<PropositionType>)

The <Type> can be: **state**,**proc** (process), **event** (punctual event) or **pro_event** (protracted event). The <TimeInterval> , to be called the *time of situation* for short, is more difficult to formalise. As the definition of temporal values denote, each state or occurrence does not coincide with a unique, indivisible, and well defined (duration/location) time interval. However a caracterizition of the time interval may be obtained from the temporal value of the proposition type on the one hand and the information conveyed by the temporal references on the other hand. When one says, "I'm leaving tomorrow", it do not mean that "leaving" will take the whole day. In the same way the sentence "I'm reading 'Moby Dick' today", doesn't entail that I must read the whole book today or that I must be reading in all moments of today. Besides if the situation occurs or holds in several disjoint time intervals, several (identical) situations will be considered instead. If we have chosen states and occurrences as time primitives (with some relations of precedence and overlap), [Kam79],[Par84] and then define time instants from them, these problems would be "hidden" but then our system of temporal relations would need to deal with two types of temporal individuals instead of only time intervals.

An arbitrary time interval will be of *type* **time**. The information about its duration or its location can be given by a date system (associated with a system of units of time) or by its temporal relations with other time intervals. Three special types of time intervals were considered corresponding to dates, periods between dates and durations expressed as units of time. This choice is merely a way to improve the calculations of the temporal relations between them. Some examples will be given:

"January 15, 1989"

```
time:I!duration(I,day) & date(I,[year=1989,month=1,day=15])
```

or simplifying

```
date(day,[year=1989,day=15,month=1])
```

"April 5, after 8 o'clock"

```
interval(day,[month=4,day=5,hour=8], [month=4,day=5,hour=24])
```

"Four months and 3 weeks"

```
dur([month=4,week=3])
```

"One day before June"

```
some(1)-date(day):I!pre(I,date(month,[month=6]))
```

It follows from these examples that given the ISRs corresponding to two time intervals and a time relation between them — normally given by a preposition — the system builds the new ISR (corresponding to the total information), after testing its compatibility — in *date* and *duration* — using the transitive rules of the temporal relations and the date system.

5 Temporal Concepts

To build the temporal semantic representation we rely on the following morphosyntactic forms and syntactic functions,

- Verb tense form and auxiliaries
- Temporal complements: adverbs of time and frequency, PP's, NP's and subordinate clauses
- Other information as: subjects singular or plural; objects definite/indefinite; massive/non massive

These elements will be identified in the functional structures by the semantic analyser. Notice that the verbs forms are completed identified by the lexical and syntactic analysers – including auxiliaries – so we can use them directly.

Some linguistic concepts will be introduced:

Tense Temporal ordering of time intervals with respect to the time of speech or other time of evaluation. It expresses whether the situation described in the sentence occurs or holds in the present, the past or the future. This concept (also called "Deixis") is mainly given by the tense form and locational time adverbial. These can be indexical (*this morning, now, yesterday, three days ago*) or not indexical (*on Monday, in June, at 6 o'clock*), and in last case cannot represent the present.

Aspect Expresses whether the sentence describes a situation as a whole (perfective value) or it refers to the beginning (inchoative value), the middle (durative value) or the end of the situation (conclusive value); if the situation is completed or possible left incomplete. Here we distinguish between perfect and simple verb forms; progressive verb forms; some auxiliary verbs like *finish, continue, remain, begin*; temporal adverbials like *for an hour, during the night, since 1999, until the end of the war.* These adverbials explicitly give the duration or the boundaries of the time of situation.

Duration and Location of the time periods referred.

Iteration The situation can hold or occur in several disjoint time periods. Some verb forms can express an habitual action as "He smokes" and iterative situations are given by adverbs of frequency like *always, never, sometime, every day* or noun phrases with plural nouns as *on sundays.*

6 A temporal representation scheme

In order to express the meaning of temporal references in a sentence as temporal relations between time intervals, some *special time intervals* will be defined. The linguistics concepts will be identified as temporal relations between these time intervals and temporal quantifiers over time intervals. A temporal meaning — concerning tense, aspect, duration and iteration — will be assigned to each temporal reference and the temporal representation for the sentence is built by a rewrite process based on compositionality.

6.1 Time of situation, evaluation and reference

This formalization is based on [Rei47], and followed among others, by [Bru72],[Eyn87]. Three time intervals are considered. The first one is the *time of situation* – type **situation:S** –, which was defined above. The second one is the *time of evaluation* – type **eval:N** – which depending on the type of discourse – direct or indirect speech/historical narratives/linear versus non linear discourses – can be the *time of speech* (*now, then*) or some other time interval (considered as a moment) given by the context . Notice that in general the *time of speech* is not explicitly referred to within a text sentence and it is supposed to be a *moment.* The third one is the *time of reference* – type **reference:R** – which connects the time of situation with others time intervals, namely the time of evaluation. It is the temporal view of the situation as described by the NL sentence. As was mentioned above, a sentence can describe - mainly through different verb forms - the whole situation or a particular phase of that situation. The role of this time interval is to capture these differences in the model, as it is implicit in almost all NL sentences. In the sentence "John finishes building a house tomorrow", the proposition type is `build(John,house)` and, as the whole situation is not supposed to be true in the future, our approach should produce the following ISR:

```
inc(tomorrow,R) & pos(R,N) & fin_by(S,R)
              & sit(pro_event,S,build(john,house))
```

where **N** is the time of evaluation, here the time of speech, and **R** is the time of reference and **S** the time of situation. These names will refer to these time intervals henceforth.

6.2 Tense and Aspect

6.2.1 Tense

Tense is defined as the set of the temporal relations between the *time of evaluation* and the *time of reference*. A sentence will have *present* tense if the time of evaluation intersects the time of reference. This would lead to four different hypotheses — $sim(R,N) \vee inc(R,N) \vee fin\_by(R,N) \vee ini\_by(R,N)$ —, but as from a linguistic point of view it seems that there is no difference between them [Eyn87] (the verb forms are the same)[1], only **inc(R,N)** will be considered, standing for an inclusion relation. The tense will be *future* if the time of evaluation is before the time of reference: **pos(R,N)**; and *past* if the time of evaluation is after the time of reference: **pre(R,N)**. The method used to assign the tense meaning can be illustrated by the following examples, where the proposition type is a *process* and its ISR can be `sit(proc,S,work(john))`

a) What is John doing now? He is working.

b) John is working tomorrow

c) John is working on sunday

From these examples it can be noted that the present continuous form can be used to denote present or future tenses. Although, as the proposition type is a process, we have **tense(*pres*cont*) = {inc,pos}**. In **a)** the adverb *now* can only be present, so **tense(*now*) = {inc}**. The intersection of these two sets gives the *tense* of the sentence **a)**: **{inc}**. In **b)** the adverb *tomorrow* can only be future, so **tense(*tomorrow*) = {pos}**, resulting for the *tense* of the sentence **b)**: **{pos}**. Finally for sentence **c)** as the noun phrase is not indexical its tense can be future or past, **tense(*on sunday*) = {pre,pos}**.

Notice that in Portuguese the same analysis holds for the present simple form.

[1]However, we can consider that the proposition type and some temporal adverbials can give some extra information in that regard

6.2.2 Aspect

Aspect is defined as a set of the temporal relations between the *time of situation* and the *time of reference*. According to the linguistic definition of aspect given above, the following values (used also in [Eyn87]) can occur:

perfective	$sim(S,R) \vee dur(S,R)$
durative	$inc(S,R)$
inchoative	$over\_by(S,R) \vee ini\_by(S,R)$
conclusive	$over(S,R) \vee fin\_by(S,R)$
retrospective	$pre(S,R)$
prospective	$pos(S,R)$

The assignment to the aspectual meaning is analogous of the one used for the tense meaning. Considering these two meanings some sentences will be analysed. An exhaustive analysis of all tense forms and adverbials is behind the scope of this paper.

1. "Mary has just arrived"

   ```
   inc(R,N) & pre(S,R) & sit(event,S,arrive(Mary))
   ```

   Notice that the translation to Portuguese would be:" A Maria acaba de chegar", where another tense form - present tense plus an auxiliary, that with *events* denotes a retrospective value - must be used.

2. "Mary arrived yesterday"

   ```
   inc(R,yesterday) & pre(R,N) & sim(S,R) & sit(event,S,arrive(mary))
   ```

   where the simple past was used.

3. "Since 1980 Mary has lived in Porto"

   ```
   ini(1980,S) & inc(R,N) & over(S,R) & sit(state,S,live(mary,porto))
   ```

Once again, in Portuguese another tense form would be used – present simple: "Desde 1980 a Maria *vive* no Porto".

4. "Mary has been sleeping for five hours"

```
sim(dur([hour=5]),S) & inc(R,N) & over(S,R) &
                              sit(proc,S,spleep(mary))
```

5. "John had arrived before yesterday"

```
sim(yesterday,R) & pre(R,N) & pre(S,R) & sit(event,S,arrive(john))
```

The following table summarizes the possible values for the temporal references used in the above examples:

	Prop. Type	Tense	Aspect
pres*perf	event	{inc}	{pre}
pres*perf	state	{inc}	{over,fin_by}
past*simple	event	{pre}	{dur}
past*simple	state	{pre}	{dur,sim}
pres*perf*cont	proc	{inc}	{over}
since...		{inc,pre}	{pre,over,fin_by}
for...		{inc,pre,pos}	{dur,over,fin_by}
just		{inc}	
yesterday		{pre}	

Adverbials refer aslo to a certain time interval and provide information on how this interval is related to either **R** or **S**. The use of this information is not always simple because of its vagueness.

Although each temporal reference can have several values for tense and aspect, at the end only one must remain, otherwise the sentence will be *temporally ambiguous*.

6.3 Iteration

To deal with quantification over situations another special time interval will be introduced. It concerns the time period that contains the several disjoint time periods where the situation is said to hold or occur. This time interval will play the same role as the *time of situation* before, and following [Eyn87a] it will be called *frame time* — type **frame:F**. We must consider two time intervals of reference: one in relation to the time of speech as before, **R** and the other, **Rq** in relation to the time of each individual situation, which will be represented by **S**[2]. It follows that the computation of aspectual values must be different if quantification is present. Notice however that **Rq** will be used only when there is an explicit reference to some "part" of the situation, as "He always finishes eating at midnight". The main changes will then be in the values of the verb forms, but in general it seems not to be the hardest job. We think that in these cases the aspectual value is always "perfective" and **R** may be ignored. However for the time being the general representation will be used.

The quantifiers over temporal intervals will be an extension of the usual ones. The quantification is over some period of time that can be explicitly defined (*every day, once a week*), or not (*always, seldom, never*). Moreover if the number of repetitions for each period of time is given, as (*many times a year, most days of the week*) iteration of quantifiers must be used. When dealing with one single situation it could be — and in the current implementation actually is — associated to each time interval an unary quantifier, for instance

"Mary ate a cake yesterday"

```
for(n(1)-reference:R!(inc(yesterday,R) & pre(R,N)),
   for(n(1)-situation:S!dur(S,R), sit(event,S,eat(mary,cake))))
```

where the properties of each time interval are connected to their definitions. All the examples above should have had this form, which was not given for the sake of simplicity.

Some examples on repeated situations follow

[2]Here our approach differs from the one in [Eyn87a].

1. "Yesterday Mary ate a cake hourly"

```
for(n(1)-reference:R!inc(yesterday,R) & pre(R,N),
   for(n(1)-frame:F!dur(F,R),
      for(each-hour:H!dur(H,F),
      for(n(1)-situation:S!inc(H,S), sit(event,S,eat(mary,cake))))))
```

   The system must know that "yesterday" is one day long in order to produce the correct ISR for the adverb "hourly" (which implies the temporal relation **dur(H,F)** via transitiv rules)[3].

2. " In 1899 John went frequently to London"

```
for(n(1)-reference:R!inc(date([year=1899]),R)&pre(R,N),
   for(n(1)-frame:F!dur(F,R),
      for(many-situation:S!dur(S,F), sit(event,S,go_to(john,london)))))
```

   Here adverb is vague concerning the period of repetition, so that one time interval can be omitted and the quantification be made over the time of situation (or, in other cases, the second time of reference).

3. "John smokes"

```
for(n(1)-reference:R!inc(R,N),
   for(n(1)-frame:F!dur(F,R),
      for(most-situation:S,ev(proc,S,smoke(john)))))
```

   In this case the verb form has a habitual reading and therefore the *most* quantifier is used.

4. "John was reading at 6 o'clock"

[3]For instance if "monthly" was used the system will fail to produce a ISR.

```
for(n(1)-reference:R!pre(R,N) & sim(date([hour=6]),R),
   for(n(1)-situation:S!dur(S,R), sit(proc,S,read(john))))
```

5. “ In June John was frequently reading at 6 o’clock”

```
for(n(1)-reference:R!(pre(R,N) & inc(date([month=6]),R)),
   for(n(1)-frame:F!dur(F,R),
      for(n(1)-reference2:Rq!(dur(Rq,F) & sim(date([hour=6]),Rq)),
         for(n(1)-situation:S!dur(S,R),
         sit(proc,S,read(john)))))
```

The aspectual value of the past continuous is different in the last two sentences: the presence of the adverb of frequency makes the difference.

Finally note that in iterative sentences one time interval must always contain the repeated ones, so that an abreviated denotation can be use, e.g `freq(R,Q-I,Tp)` standing for `for(Q-I!dur(I,R),Tp)`, provided **R** was defined before.

A difficult problem concerns the scope of quantifiers (including the ones introduced by frequency adverbials) and the occurrence of locational temporal adverbials. We used the linear order of occurrence in the sentence and some inclusion properties (as a month has several time intervals named “6 o’clock”) to solve it, although our method does not work in all cases.

7 Some implementation details

The semantic analysis of functional structures of sentences with a main verb must produce the *proposition type* and the temporal information. For the latter we use the same rewrite method of *ISR-semantics*. Some considerations on it and on the basic information needed follows.

Concerning verb forms we have seen that some can be used with adverbials of frequency and others can not, and that some may express habitual situations with some proposition type. Morover, the meaning of the temporal concepts were changed with these facts. So, this information must be available for each tense form and for each language. In Prolog this is defined by a predicate whose arguments are the verb form, the value of the proposition type, the sets of temporal relations for tense and aspect and the information on quantification. Some clauses for some English verb forms would be:

```
tai(pres*cont,event,[pos,inc],[dur,sim],n(1)).
tai(pres*cont,event,[inc],[dur,sim],some).
tai(pres*cont,pro_event,[pos,inc],[inc],n(1)).
tai(pres*cont,proc,[inc],[inc],n(1)).
tai(pres*simple,event,[inc],[inc],most).
tai(pres*simple,state,[inc],[inc],n(1)).
tai(past*simple,event,[pre],[dur],n(I))
tai(past*cont,proc,[pre],[inc],n(1)).
tai(past*cont,proc,[pre],[dur],some).
```

where

n(I)	all quantifiers are allowed
some	if quantifiers present
n(1)	neither habitual nor iterative
most	habitual

Beginning with the value of the proposition type this information is used to build a first ISR concerning the temporal information. As there are many possible choices, a "practical ISR" carrying along all the pertinent information is produced which in each step can be transformed in the final ISR. This transformation is done when the proposition type is added. This point may be reviewed in future implementations and is related to the criticism made to the Principle of Compositionality as used in *ISR-semantics* in [TomFil89]. In what concerns temporal prepositional phrases, the situation quantification is analysed at first (taking into account the noun determiner and the preposition)[4]. The single cases are treated differently from plural ones. Then the preposition is considered in order to produce new values for tense and aspect and the special time interval is chosen. The preposition and the noun are used to produce an ISR which is added to the old ISR of that special time interval, producing a new ISR. Adverbs are treated in an analogous way, beginning by the analysis of whether they are frequency adverbs, then the temporal values are determined and a new ISR for the special time interval is produced. More details can be found in [Mor88], for a first implementation.

8 Temporal subordinate clauses

As a first step to the temporal treatment of complex phrases and texts temporal subordinate clauses were analysed. The main role of these sentences is to locate the time of reference of the main clause. Essentially the method used is: the subordinate clause is analysed and its time of reference is related, by means of the temporal connective, to the time of reference or situation of the main clause. To each connective is possible to associate a unique temporal relation (*after*/**pos**, *while*/**inc**,*when*/**sim**, etc) provided that some deterministic transformations of tense forms were performed and modality is not considered. A first requirement is that the two clauses has the same *tense*. However if the verb form of the subordinate clause is tenseless, its *tense* will be taken as the one of the main clause. Some deterministic syntactic patterns concerning *proposition types, tense forms* and *connectives* can be used to simplify the semantic analysis. In Portuguese, for instance, some uses of the subjunctive forms can be ignored. Another example, both in English and Portuguese, is the use of *when* with events in the simple past, where the connective can be changed to *after*, as the sentence describe successive events. An example taken from [Hei74] is:

"When John pushed the button, the bomb exploded"

[4]Prepositions can entail iteration in some contexts; for instance, in Portuguese the use of "desde"(/since) with events

A detailed analysis of these clauses, in Portuguese, can be found in [Mor88][5]. The main issue here was that the use of *times of reference* allowed a correct temporal relation between the two situations to be find. One example is

"The boat arrived when John was eating"

```
for(n(1) - reference:R!(pre(R,N) &
      for(n(1)-reference:Rs!(pre(Rs,N) & sim(R,Rs)),
             for(n(1)-situation:Ss!inc(Ss,Rs),
               sit(proc,Ss,eat(john))))),
   for(n(1)-situation:S!dur(S,R),
      sit(event,S,arrive(boat))))
```

9 Conclusions

We described the main points leading to an implementation of a semantic analyser dealing with temporal references in NL sentences based on time intervals and relations between them.The notion of *proposition type* and temporal concepts were introduced and its representation described. As only single sentences with temporal complements and some types of complex sentences were considered, one line for future work is to test and to extend the scheme used - and the extensions to ISR-language proposed - for dealing with discourse.

10 Acknowledgements

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[5]Partially based on an English exhaustive analysis made in [Hei74] in a somehow different context

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