

On Representing the Temporal Structure of a Natural Language Text*

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Abstract

A proposal to deal with tenses in the framework of Discourse Representation Theory is presented, as it has been implemented for a fragment at the IMS for the project LILOG. It is based on the theory of tenses of H. Kamp and Ch. Rohrer. The system uses the tense and aspect information, the information about the temporal discourse structure of the preceding text stored in a specific list of possible reference times, and background knowledge. These types of information interact in order to choose a suited temporal anchor for the event of a new sentence.

With respect to extended texts, choosing the right reference time for a new event is a problem which has been largely neglected in the literature.

1 Introduction

In Reichenbach (1947) the tenses are analyzed into different orderings of the relevant temporal parameters which are: the *time of the event* talked about, the *speech time* (time of utterance) and the *reference time*. Simple past, for instance, identifies event- and reference-time, which are both before the speech time. In the case of past perfect the event time precedes the reference time which precedes the speech time.

Kamp and Rohrer (1983,1985) were led by text-phenomena to split up the Reichenbachian reference time into two contextually given coordinates: the *reference time* (in the narrow sense) and the *temporal perspective time*.

(1) *Harry handed the book about giraffes to Jane (e_1). Two hours ago he had discovered it in Alfred's bookshop (e_2). He had bought it (e_3), had inserted a dedication (e_4) and had it wrapped up (e_5). Jane took the book with a smile (e_6)*

In (1), the events $e_2 - e_5$ are ordered consecutively,

*This research has been done in the context of LILOG. Thanks on this way to the members of the LILOG-research group of IBM for helpful comments and especially for having made the integration of the suggested system in the LILOG-prototype possible.

each taking its predecessor as reference time, with the exception that the context does not provide an event which precedes e_2 and which, therefore, could play the role of reference time with respect to e_2 . The whole sequence $e_2 - e_5$ is seen from a vantage point in the past, e_1 , which, therefore, plays the role of perspective time with regard to the structural integration of $e_2 - e_5$. The perspective from which e_1 and e_6 are seen is the speech time. e_1 serves as reference time for e_6 . In the approach of Kamp and Rohrer the role that the reference time plays in Reichenbach's system is taken over by the perspective time with respect to the meaning of the tenses in single sentence discourses: The meaning (one of the meanings) of past perfect is that the event time precedes the perspective time which precedes the speech time. The meaning of simple past is that the event time precedes the speech time which coincides with the perspective time. However, in addition to a system like Reichenbach's there is another parameter which comes exclusively from the text, the reference time proper, which is part of the impact of the tenses on the temporal reconstruction of a narrative, thus completing the sentential meaning of the tenses by a textual aspect. Here, the idea, that we take over from Kamp and Rohrer, is that in a sequence of simple past sentences introducing events (not states) normally the event of a new sentence follows the reference time which is provided by the event of the preceding sentence within the sequence. By transposition the same should hold for sequences of past perfect sentences. Here, the perspective is shifted from the speech time to a (contextually given) point in the past. There is an additional feature however with respect to temporal parameters. Adverbials can provide a *location time* for events and states. For instance, in (1), the *location time* of e_2 is the time pointed to by *two hours ago*.

On the basis of the Reichenbachian approach using three temporal parameters the problem of integrating a new event in the event structure of the preceding text has been attacked by Hinrichs (1986), Partee(1984) and others. More independent of this approach are suggestions made by Moens and Steedman (1988) and by Webber(1988).

Since we think that a correct analysis of narratives cannot do without a fine grained distinction between the roles played by temporal anchors, our approach uses the coordinates suggested by Kamp and Rohrer. Such coordinates are stored in a structured list, called *T-list*, which reflects the discourse structure of the preceding text. The problem of choosing the right anchor for the new event from the preceding text is largely neglected in the literature. Very often there, the preceding text consists of only one sentence or the problem is restricted to the intra-sentential one presented by temporal conjunctions. How do we decide in (1) that the reference time for e_3 is not the earlier introduced e_1 , but e_2 and that the reference time for e_6 is not the most recent reference time e_5 , but e_1 ? In our system we use the structure of the T-list among other things to get a hierarchy of the topicality of the reference times. This is very close to the idea of accessibility in Discourse Representation Theory (Kamp (1981)) and to the notion of focus in the work of Grosz and Sidner (1985). In order to tackle the task of event-integration, which we call "temporal resolution" - making allusion to the very similar problem of the NP-resolution, where anaphoric links for the case of nominals have to be established - we structure the T-list along the lines of different discourse relations such as *continuation*, *elaboration*, *flashback* etc. Flashback, for instance, holds in the example above between e_1 and e_2 and between e_1 and e_3 . The relation between e_2 and e_3 is continuation. As we will see in the section after next, often, from the purely linguistic point of view there are alternatives with respect to the decision about the discourse relation which directs the integration of a new event or state.

In our system, the criteria to decide about the relevant discourse relation are provided by the tense forms of the reference event(s) and of the new event respectively, by the existence and the characteristics of temporal adverbials, by the aspect of the events - is it an event proper or a state - and by internal semantic properties of the events which are made explicit by means of rules stored in the background knowledge. Of course, in addition, the hierarchically structured T-list influences the choice and helps to update the system correctly, where updating means adding a new temporal condition to the representation of the text and adding a new reference time to the T-list at a specific place.

In the next section we will briefly introduce the kind of discourse representation structures that we use. Then we will say something about the discourse relations dealt with and we present the syntax of the T-list. After that we sketch the relevant background knowledge and finally, we give some of the resolution rules of the system.

The structuring of the T-list extends a suggestion of Eberle and Kasper (1989) and comprises elements of a proposal by Reyle (1986).

The algorithm suggested is part of the LILOG-prototype which is used for text understanding. In

particular it uses knowledge provided by the knowledge base and the inference component of the prototype.

2 DRT and Events

Within the framework of *Discourse Representation Theory* (DRT) (Kamp(1981)) a *Discourse Representation Structure* (DRS) is a pair $\langle U, K \rangle$ consisting of a set U of *discourse referents* (DRFs) and a set K of conditions. DRSs are interpreted modeltheoretically. DRT uses a variant of the Davidsonian method of talking about events: they are treated as a kind of objects.

In LILOG we use DRSs for text representations. But we deviate from the classical DRT-style in using one-place event predicates and thematic roles instead of n-place event predicates. A second difference is given by the fact that in LILOG DRSs come with an index. The index is the list of reference times available with respect to the DRS in question. For a simple sentence it will be a list consisting only of one element - the DRF of the event introduced - for a text it will be a complex list, the T-list.

So, for instance, the LILOG-DRS for *coming of x* can be illustrated as follows:

$$\langle [e], \begin{array}{|l} e, x \\ \hline \text{come}(e) \\ \text{agent}(e) = x \end{array} \rangle$$

For the DRS to be valid there must exist an embedding function which maps e onto an event of the model structure such that e satisfies the conditions as described in the DRS.

3 Discourse Relations

It is clear that the idea about the order of events introduced by sequences of sentences that we have sketched in the introduction is an oversimplification.

In the following we will restrict ourselves to the tenses prevailing in narratives, simple past and past perfect, and to only some of the text phenomena related to these tenses (as we have done in the LILOG implementation with respect to the German counterparts of these tenses).

Besides the discourse relations used in example (1), i.e. flashback and continuation, there are at least two more, which we call *elaboration* and *background*.

Compare the two following examples:

(2) *Monday Hans went to Paris. Tuesday he met Gabi.*

(3) *Monday Hans went to Paris. At the border he had some trouble.*

(2) describes a continuation. This can be deduced from the characteristics of the location times.

In contrast to that, (3) describes an elaboration. We call the relation between a new event e_2 and its reference event e_1 an elaboration, if e_2 describes e_1 on a more fine-grained level (which gives rise to the temporal condition of inclusion (\subseteq) between the new event and the reference event within the representation of the text).

In (3) the relation of elaboration can be deduced only if there is some input from the knowledge base equipping the resolution component with facts about journeys to foreign countries. Notice that, here, the temporal inclusion is due to the homomorphic local inclusion of the border into the path of the travel. This illustrates that an intelligent temporal resolution component cannot do without having access to local reasoning.

Now compare the following pair of examples, taken from Dowty (1986) and from Hinrichs (1986) respectively:

(4) *John entered the president's office. The clock on the wall ticked loudly.*

(5) *Jameson entered the room, shut the door carefully and switched off the light. It was pitch-dark around him because the venetian blinds were closed.*

In both (4) and (5) the last sentence introduces not an event proper, but a state. As widely accepted, the normal case of relating a new state e_2 to an existing reference event e_1 seems to be that of inclusion ($e_1 \subseteq e_2$).¹

However, as examples like (5) make clear, this default can be overwritten. Here too, it seems that background knowledge gives the decisive indication about when the default has to be upset.

We call the discourse relation of (4) *background* and that of (5) *causally introduced background*. For cases like (5) we introduce the new state e_2 as following the actual reference event e_1 ($e_1 \prec e_2$) and as including a dummy reference time t ($t \subseteq e_2$) with respect to which e_2 introduces a background. In the further course of processing the text, t has to be instantiated by a new event which is understood as following e_1 .

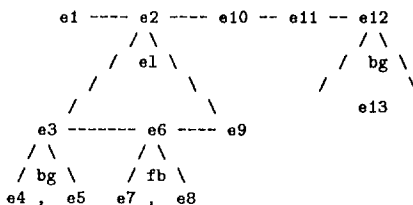
The T-list makes use of these discourse relations as structuring elements. For instance, processing the sample text (6), which integrates the text phenomena reflected by the examples (1) - (4), should result in a representation which has as index the T-list (7):

(6) *John left Paris by the Porte de St Cloud late in the evening (e_1). He went to Frankfort (e_2). At the border he was stopped (e_3). It was pretty dark (e_4). Only a few lights were burning (e_5). He had to open his boot (e_6). In Paris he had bought five cartons of cigarettes (e_7) and had hidden them in the car (e_8). The customs officers missed them (e_9).*

¹This parallels, for instance, the insights of Partee(1984), Hinrichs(1986), Kamp and Rohrer(1985) and others.

Early in the morning John entered a bar near the mess tower in Frankfort (e_{10}), ordered a beer (e_{11}) and lighted a cigarette (e_{12}). He was happy (e_{13}).

(7)



In (7) the structure of (6) is stored in the following way: $e_1, e_2, e_{10}, e_{11}, e_{12}$ (the leaving of Paris, the going to Frankfort, the entering the bar, the ordering of beer and the lighting the cigarette) on the one hand and e_3, e_6, e_9 (the stopping, the opening of the boot, the failure of the officers) on the other form continuation chains (tied up in the picture by —). The second of these chains elaborates an event of the first, e_2 , the transition to Frankfort (e_1/\backslash). e_4 and e_5 serve as background to e_3 , e_{13} is the background of e_{12} (bg/\backslash). Finally, the continuation chain $e_7 - e_8$ is a flashback seen from the perspective e_6 .

We define the accessibility of an event as reference event in such a way that, having processed the whole text, the only accessible event will be e_{12} , whereas, in the case of having processed the text till the integration of e_8 , the accessible events will be e_8, e_6 and e_2 (with decreasing prominence). In this situation e_8 is the so called *actual* reference event. When integrating a new sentence, one will try to expand the node represented by the actual referent first. But, finally, what level has to be chosen and what kind of anchoring has to be stored in the next step is decided by the system rules. So, for instance, in the case of (6), by purely linguistic reasons, e_9 cannot be related to the actual reference event e_8 , because there is a tense switch from past perfect to simple past between e_8 and e_9 which indicates the termination of the flashback. This results in the re-initialization of the level the flashback started from as the level providing the new actual referent. In the case of (6) this is e_6 which is a member of an elaboration. Actual elaborations may be terminated by knowledge indicating that expanding the structure at the actual level is not plausible or even not possible. In this case the system will try to relate the new event with respect to the (accessible) events of higher levels of the elaboration hierarchy. Since, with respect to (6), e_9 is compatible with e_2 the system has no reason to terminate the level marked by e_6 . We think that the data confirm the concept of a hierarchy of reference events as used in the system. The exact definition of the accessible reference events of a T-list resides in the definition of the specific access-functions for T-lists that we sketch

in section 5.²

In fact, in the LILOG implementation, the items of the index, i.e. of the T-list, do not consist of the pure events. They are terms with different slots filled by the relevant temporal information such as the tense form which introduces the corresponding event, the aspect, the actual speech time etc. Skipping such technical details, the simplified syntax of the T-list is the following:

T-list := [] ;
 [E(D-list)|T-List]
 where
 E(D-List): list item
 with
 E: the discourse referent for the event, and
 D-List: the list of the items depending on the event,
 where
 D-List := [];
 [bg([E()|T'-List])|D-List];
 [fb([E(D-List)|T-List])|D-List];
 [el([E(D-List)|T-List])|D-List];

Here, of course, embeddings which are given by the dimensions *bg*, *fb*, *el* in turn stand for background, flash-back and elaboration. T'-List is a T-list where each D-list is the empty list. We use T'-List for the items in *bg*-lists, because we do not think that a background give rise to further embeddings. The neighborhood of T-list items of the same level signifies *continuation*, except the case where such a list is fronted by *bg*. In this case, in the corresponding DRS the elements of the list include the same event and, therefore, overlap each other. Continuation is reflected in the reversed order, because we use T-list as a stack. For (6), according to (7), we write (8). Here and in the following we abbreviate E([]) by E:

(8) [e12([bg([e13])),
 e11,
 e10,
 e2([el([e9,e6([fb([e8,e7]))],e3([bg([e5,e4]))])),
 e1]

Of course, there are other discourse relations as those mentioned. Especially, if one tries to analyse the structure of texts on a more fine-grained level than the purely temporal one, the relations described above are not sufficient, others like *explanation*, *contrast* etc. are needed.³ For lack of space, here, we can nothing say about these. The relations described are those

²Anchoring new events to non-accessible reference events clearly is possible, provided there is additional information to motivate this choice, such as, for instance, definite descriptions using event nominalizations in order to establish co-referentiality. But, at present, such possibilities are not implemented.

³Partly for other purposes discourse or rhetorical relations are used, for instance, in Grosz and Sidner(1985), Thompson and Mann (1987).

dealt with in the LILOG system.

4 Background Knowledge

The LILOG knowledge base provides us with a sort hierarchy for discourse referents which is related with respect to events to the classification given in Vendler(1967). This sort hierarchy is used as one of several information packages within the temporal resolution. With respect to the hierarchy we mainly use calendar knowledge and incompatibility-statements about event types. For instance, an event introduced with the location time 1987 (or with subintervals of 1987) cannot overlap with an event with location time 1988. Exactly the same is true when the new event has an event type which is incompatible with the type of the reference event. A SWIMMING-event is incompatible with a WRITING-event if the relevant thematic roles are the same, i.e., here, the agent-role. Of course, when formulating such incompatibilities one tries to make use of the sort hierarchy. One will define the incompatibility for very general sorts (if possible) so that it is inherited by subsorts.

Knowledge of this kind is hard information so to speak. In addition to this, the system uses default knowledge about event types which is similar to what is called *event frames* (cf. Minsky (1975), Schank and Abelson (1977), Bartsch (1987) and others). Typical (simplified) examples of the two kinds of knowledge are (9) and (10):

(9) $\forall E_1 \in MOVE, L \in LOC$
 $(L \subseteq path(E_1) \rightarrow \exists E_2 \in PLACED-AT$
 $(theme(E_1) = theme(E_2) \wedge E_2 \subseteq E_1))$

(10) $\forall E_1 \in TURN, E_2 \in BEING-LIGHTED$
 $(object(E_1) \in LIGHT-SWITCH \wedge E_2 meets E_1 \rightarrow_D$
 $\exists E_3 \in BEING-DARK (E_1 meets E_3))$

(9) regulates the localization of the theme of a movement. From this rule we infer the existence of different *PLACED-AT*-states for the theme within the movement. (10) predicts that normally (*D* for default) turning a switch when it is lighted results in darkness.

5 Temporal Resolution

The construction of the semantic representation for a discourse proceeds in several stages. I shall skip here the steps leading to the DRS of a sentence. But it has to be stressed that the result of sentence processing is not a completed DRS. There may be variables which have to be instantiated in the process of integrating the sentence-DRS into the text-DRS.

The sentence-DRS is understood as the input of the aspect-calculus of the prototype which has to compute the aspect of the events of the DRS. Therefore it uses the information provided by the thematic roles. The starting point is the aspect-entry for the

verb in the lexicon. It can be overwritten by specific role information and morphological information with regard to aspect. For the sake of simplicity in the following we assume that there are just two contrasting aspects corresponding to the main sorts of the upper structure of the event sort hierarchy, the heterogeneous events proper (*ev*) and the homogeneous states (*st*). The aspect calculus used is based on ideas from Krifka (1987).⁴ So, for *Peter wrote a book* we will get the aspect value *ev*, whereas for *Peter wrote books* we will get *st*. For the example (6) we get that $e_4, e_5, e_1, 3$ are states, the rest will be analyzed as events proper. After the computation of the aspect we come up with an indexed DRS as described in the second and third section with the value of the aspect feature instantiated.

Within the process of anchoring we use several access-functions with respect to the T-list. Among other things these are *act-ref(T-list)* which gives us the most topicalized item in the list, the actual referent, *el-embedder(T-list, E)*, *fb-embedder(T-list, E)* which give us the points elaborations and flashbacks containing *E* start from. It has to be stressed that reference events have to be events proper. They cannot be states. The actual referent is the first element of the stack, provided that this element does not contain flashback- or elaboration-embeddings. If it does we start the recursive call of the search procedure with respect to the first of these embedded lists. *tense(E)*, *aspect(E)*, and *tp(E)* give us the values of the tense and aspect features (*sp*, *ppf*, *ev*, *st*: simple past, past perfect, event and state) and the temporal perspective from which *E* is seen.

In order to decide the anchoring of new events, the rules of the system make use of three filters:

- (F1) the tense/aspect filter which decides whether a particular discourse relation is possible with respect to tense and aspect,
- (F2) the "consistency" filter, which decides whether the choice of a particular discourse relation is logically compatible with the information of the preceding text against the background of the information from the inference component (this consists mainly of testing sort subsumptions in the context of temporal incompatibilities between calendar units and event sorts), and
- (F3) the evidence filter which tries to support the relation tested by means of rules like (9) and (10).

To illustrate the system we restrict ourselves to some simple cases (compare figure 1). We suppose that the new sentence introduces just one event and we only sketch simplified versions of the rules for continuation, 1.), for elaboration, 2.), for flashback,

3.), for causally introduced background, 4.), for background, 5.), for termination of elaborations, 6.), and for the termination of flashbacks, 7.). We skip rules which deal with specific subcases of these relations. For instance, we skip rules which deal with dummy referents *t* introduced by the causal background and rules which allow for more precise temporal localizations of the new events. We use rewrite rules which depict the amalgamation of a sentence DRS with a text DRS.

In rule 1.) of figure 1, (*) reflects the particular case where e_{ref} is member of an elaboration. If it is not, the corresponding condition in K_{n+1} is omitted.

In the cases 1.) - 3.) (F1) requires that e_S is heterogeneous ($aspect(e_S) = ev$). The tense forms of reference- and new event have to be identical ($tense(e_S) = tense(e_{ref})$). In addition, (F1) accepts 3.), if $tense(e_{ref}) = sp$ and $tense(e_S) = ppf$. This arrangement allows also for continuation and elaboration on flashback levels and for iteration of flashbacks. For 4.) and 5.) the tense forms must be identical. In contrast to 1.) - 3.), it is required that $aspect(e_S) = st$.

(F2) should be clear in all cases. For acceptance, the tested solutions have to be consistent.

With respect to the cases 1.) - 4.), (F3) accepts the relation tested, if some evidence for this relation can be inferred from the representation of the preceding text on the basis of the background knowledge. In addition, in the cases 1.) - 3.) (F3) also accepts the relation, if evidence for the competing relations cannot be entailed. In the case of $tense(e_S) = tense(e_{ref}) = ppf$, flashback, elaboration and continuation are pairwise competing relations. In the case of $tense(e_S) = tense(e_{ref}) = sp$, flashback is ruled out as competing relation with respect to elaboration and continuation. In the case of 5.), background, and 3.) with $tense(e_S) \neq tense(e_{ref})$ (F3) is empty.

Evidence for a particular relation *X* can be inferred, if there exists an event sort *P* which is more general than the event description from DRS_S with respect to the event sort hierarchy, such that the knowledge base (KB) together with the representation of the preceding text (DRS_n) predicts an event *e* auf type *P* temporally related to e_{ref} in a way significant for *X*, and that KB, DRS_n do not entail the corresponding statement with respect to the competing relations of *X*. Formally, for instance with respect to $X = \text{"continuation"}$, *X* is evident, if for *P* with $\forall e (DRS_S[e_S/e] \rightarrow P(e))$, we can infer that $\exists e (P(e) \wedge e_{ref} \prec e)$, but neither that $\exists e (P(e) \wedge e \subseteq e_{ref})$ nor $\exists e (P(e) \wedge e \prec e_{ref})$.

The whole system is implemented in Prolog. So the order of the rules is important. Thus, we get a preference relation over the allowed readings. Continuation is preferred to elaboration which is preferred to flashback (in the case that all alternatives seem possible and that they are supported by (F3)). With respect to 6.) and 7.), we see that local level expansion is preferred to the anchoring of the new event at

⁴For a detailed description of the calculus refer to Eberle (1991).

Text_{n+1} $\langle T_{n+1}, \text{DRS}_{n+1} \rangle$	\Rightarrow	Text_n $\langle T_n, \text{DRS}_n \rangle$	Sentence_{n+1} $\langle T_S, \text{DRS}_S \rangle$
1. Continuation:			
$U_{n+1} = U_n \cup U_S$ $K_{n+1} = K_n \cup K_S$ $\bigcup \begin{cases} e_{ref} \prec e_S \\ e_S \prec e_{tp} \\ e_S \subseteq e_{elref}(\ast) \end{cases}$ $T_{n+1} = \dots [\dots e_S, e_{ref}, \dots] \dots$	(F1) (F2) (F3)	$akt-ref(T_n) = e_{ref}$ $tp(e_{ref}) = e_{tp}$ $el-embedder(T_n, e_{ref}) = e_{elref}(\ast)$	$T_S = [e_S]$
2. Elaboration:			
$U_{n+1} = U_n \cup U_S$ $K_{n+1} = K_n \cup K_S \cup \boxed{e_S \subseteq e_{ref}}$ $T_{n+1} = \dots [e_{ref}(\langle el(\langle e_S \rangle), \cdot \rangle), \cdot] \dots$	(F1) (F2) (F3)	$akt-ref(T_n) = e_{ref}$	$T_S = [e_S]$
3. Flashback:			
$U_{n+1} = U_n \cup U_S$ $K_{n+1} = K_n \cup K_S \cup \boxed{e_S \prec e_{ref}}$ $T_{n+1} = \dots [e_{ref}(\langle fb(\langle e_S \rangle), \cdot \rangle), \cdot] \dots$	(F1) (F2) (F3)	$akt-ref(T_n) = e_{ref}$	$T_S = [e_S]$
4. Causally introduced Background:			
$U_{n+1} = U_n \cup U_S$ $K_{n+1} = K_n \cup K_S$ $\bigcup \begin{cases} e_{ref} \prec t \\ e_{ref} \prec e_S \\ t \subseteq e_S \end{cases}$ $T_{n+1} = \dots [t(\langle bg(\langle e_S \rangle), e_{ref}, \cdot \rangle), \cdot] \dots$	(F1) (F2) (F3)	$akt-ref(T_n) = e_{ref}$	$T_S = [e_S]$
5. Background:			
$U_{n+1} = U_n \cup U_S$ $K_{n+1} = K_n \cup K_S \cup \boxed{e_{ref} \subseteq e_S}$ $T_{n+1} = \dots [e_{ref}(\langle bg(\langle e_S \rangle), \cdot \rangle), \cdot] \dots$	(F1) (F2) (F3)	$akt-ref(T_n) = e_{ref}$	$T_S = [e_S]$
6./7. Return from elaborations/flashbacks:			
restart the system with e_{ref} instead of e_{ref}	(F1) (F2) (F3)	$akt-ref(T_n) = e_{ref}$ 6.) $el-embedder(T_n, e_{ref}) = e_{ref}$ 7.) $fb-embedder(T_n, e_{ref}) = e_{ref}$	$T_S = [e_S]$

Figure 1: resolution rules

higher levels of the hierarchy. This strategy seems to be validated by the text phenomena.

For illustration, we briefly sketch the effects of the rules when applied to the sample text (6). *Leaving Paris-* and *Going to Frankfurt-*events cannot overlap. Therefore, (F2) rules out the alternative “elaboration” for e_2 with respect to e_1 and the remaining competing “continuation” is chosen. Further support by (F3) is not needed in this case. For travels e to foreign countries we can infer the existence of *PLACED-AT*-states e' for the agent or theme of the travelling event and for the borders contained in the path of the travelling such that $e' \subseteq e$ (compare the KB rule (9)). Since the description of e_3 , the stop at the border, is subsumed by the more general *PLACED-AT*-sort, (F3) - in the absence of corresponding evidences for the competing relation of continuation - supports “elaboration”. Since for the states e_4, e_5, e_{13} the alternative of “causally introduced background” is not evident, they are anchored by means of the rule 5.). In the case of e_6 and e_9 , the fact that evidence for “elaboration” is missing selects for “continuation”. e_{10} which is situated in Frankfurt cannot be part of the travel. For this reason anchoring e_{10} with respect

to the level of e_{ref} , which actually is e_9 , is not possible. Therefore, with rule 6.), we have to climb up the elaboration hierarchy. The anchoring of e_7, e_8, e_{11} and e_{12} should be clear on the basis of what we have said so far.

In order to arrive at alternative readings of a text we use a specific backtracking routine which can suppress the impact of (F3) for the resolution.

6 Conclusion

The described system computes the event structure of a discourse. Since we think that the semantics of tense and aspect is not sufficient to establish the temporal discourse meaning, we use background knowledge to disambiguate between different readings.

The system is incomplete at present. The fragment it deals with doesn't allow for relative clauses. In addition the interaction between NP-resolution and temporal resolution is not available. Some temporally relevant discourse relations are not treated. The logic underlying the preference relation is only rudimentary sketched. The approach to temporal resolution

presented here is a condensed version of that suggested in Eberle (1991). The corresponding implementation for the LILOG prototype dates back to 1989. Meanwhile, independent of this approach, similar suggestions have been made (cf. Asher and Lascarides (1991)). In the work of Asher and Lascarides the underlying theory of non-monotonic reasoning is MASH (cf. Asher and Morreau (1991)). It is projected to extract a suited proof theory from MASH for the purpose of refining the temporal resolution component suggested.⁵

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⁵Since M. Morreau is member of our institute and N. Asher visiting professor in Stuttgart, this can be done in close connection with the authors of MASH.