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Transfer I: Tense and Aspect

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Contents

1 Introduction

In the machine translation Project Verbmobil the University of Tübingen has undertaken the semantic evaluation and translation of tense and aspectual phenomena (project areas 11 and 12).

For the first phase of the project the domain of investigation consists of spoken dialogs whose object is the scheduling of appointments. As most of the utterances are formulated in the present tense, and as the nature of the dialogs encourages the use of temporal adverbials, we have concentrated primarily on the German present tense, and its interaction with temporal adverbials for the first phase (the Demonstrator). We have also investigated the interaction of quantification, negation, and Aktionsart with tense, and have implemented a basic strategy for dealing with the relevant phenomena in the dialogs.

The treatment of tense and aspect presented here has most in common with the approach taken within Eurotra (Allegranza et al. 1991) in the sense that an interlingua representation based on Reichenbachian temporal relations (Reichenbach 1947) is constructed. That is, we consider it to be given that the semantics of tense and aspect can be formulated within the same semantic representations for all languages, but that identical semantic representations may be realized by differing morphological and syntactic devices in natural language.

Within Verbmobil, syntactic analyses and representations are modeled in the framework provided by Head-Driven Phrase Structure Grammar (HPSG) (Pollard and Sag 1994), while the semantics are based on Discourse Representation Theory (DRT) (Kamp and Reyle 1993). The two theories have been integrated within Verbmobil by instantiating the *sem*(antics) feature of an HPSG sign through a lambda-DRS (see Bos et al. 1994). The semantics of an expression is constructed by traversing the syntactic sign and building up corresponding lambda-DRSes. As part of the semantic construction a tense condition is instantiated within the DRS. The tense morphology of the verbs provides the crucial clues towards constructing the relevant Reichenbachian temporal relations between E (event time), R (reference time) and S (speech time). Furthermore, the presence of temporal adverbials, negation, and quantification is registered and represented within the tense condition.

The evaluation and simultaneous disambiguation of the information collected in the tense condition results in the instantiation of a *sur(face)_tense* feature within the tense condition. This is undertaken as the last step of the semantically-based recursive transfer (VM12 Stuttgart 1994).

The temporal semantics is built up compositionally during the construction of the overall semantics of the expression. It is generally recognized that tense cannot be translated in isolation, but must be sensitive to other information, such as that carried by temporal adverbials in the expression. Differing strategies may be pursued in compositional construction of temporal information.

In the approach taken within the Rosetta system (Apello 1986), for example, translation is achieved through *attuning* the grammars of two languages to one another. Taking a semantic derivation tree (which corresponds to the syntactic D-structure tree) as a starting point, rules are formulated which rely on Aktionsarten information, a perfective/imperfective/retrospective, and a past/present/future contrast. These rules derive a complete tree based on information specified initially for the clause and additional information coming from adverbials. Two trees are considered to be translational equivalents when the history of their derivation is equivalent.

Here the overt syntactic realization of tense and aspect is built into the rules for temporal expressions, which help to derive a particular tree. For example, given the same kind of information with regard to the perfectivity of an expression, an English rule will introduce an auxiliary, while a Dutch rule will not. However, since the derivational step is considered to be one and the same (equivalent rules are triggered), the expressions are translational equivalents.

Within the Verbmobil approach to tense, a compact invariant representation for temporal relations is provided. This representation is independent of the particular syntactic realizations in the source or target languages. Additionally, the surface tense feature contains the result of the "transfer" of tense, i.e., the evaluation of the temporal and aspectual information in light of the English tense system.

This surface tense feature provides a clue to the generation component. In priniciple, however, the generation component is not restricted to the information provided in the surface tense feature, but can also work with the interlingua representation contained in the tense condition. Thus, the generation component is given an interesting degree of freedom: for example, if another verb were chosen as being subtly more appropriate within the given context than one produced by the transfer component, and if that verb changed the Aktionsart of the expression, then the generation component would still have access to the interlingua representation, and be able to generate a more appropriate surface tense.

There are several other distinct advantages that the approach to tense and aspect taken within Verbmobil has to offer. One distinct advantage is that it allows for the ambiguity of certain tenses. The German present tense, for example, can be used to denote both present and future eventualities (Bach 1986).[1] Disambiguation may occur through the presence of temporal adverbials like *morgen* ('tomorrow'), or through context, or not at all. Given that the general approach to disambiguation in Verbmobil is that it should only occur when needed for translation, the possibility of allowing an ambiguous encoding of particular tense morpheme provides a desirable degree of flexibility.

[1]It can also be used for the *historical present*, which is ignored for the purposes of this report.

The treatment presented here is based on an already existing, coherent and internally consistent framework, namely DRT, in which the phenomena under investigation have been thoroughly explored and modeled from a linguistic point of view. For an analysis of the German tense system, we base ourselves primarily on the work by Ehrich (1992). The analysis of the English temporal system is based mainly on Kamp and Reyle (1993). The fact that a solid linguistic base for tense and aspect can be assumed allows an immediate treatment of the better known phenomena, and leaves more room for an investigation and innovative treatment of phenomena that have not been discussed as intensely in the literature, but do occur in the Verbmobil dialogs.

Finally, the implementation presented here is completely monotonic, and yet exceeds the original goals as formulated in our grant proposal by far. For the Demonstrator, we had planned to provide only the prototypical implementation of a tense module. Instead, an approach which provides a broad coverage of the phenomena encountered in the dialogs was implemented.

In what follows, the general approach to the representation and subsequent translation of tense is presented, then the various tenses and the interaction of tense with temporal adverbials, quantification, negation and Aktionsarten is discussed in some detail. Throughout, we also present the problems which we intend to work on intensely for second phase of the project, the Prototype.

2 Basic Approach

2.1 Temporal Relations

Ehrich (1992) presents the attractively simple, and yet sufficiently powerful schema in (1) as the basis for an analysis of the German tense system. The distinction she makes between *contextually* and *intrinsically* determined relations is also sometimes viewed as the difference between tense (relation between R and S) and aspect (relation between E and R) (e.g., Apello 1986, Allegranza et al. 1991).

(1)

		Contextually Determined	
		S, R	R < S
Intrinsic	E, R	Present	Past
Relations	E < R	Perfect	Past Perfect
	E > R	—	—

The notation "S,R" signifies that these times stand in some sort of relation to one another, though whether this relation is one of overlap or temporal precedence is underspecified and is further determined by the context (temporal adverbials or discourse context).[2]

[2]The future tense is not included in Table (1) as Ehrich follows Vater (1975) in treating the German future auxiliary *werden* as a modal.

Within Verbmobil, morphological and syntactic temporal information are mapped to interlingua representations according to the correlations presented in Table (2). For all verbs an E, R, and S is introduced. For infinitives and participles the relation between these times is initially underspecified: the information contributed by the auxiliaries serves to specify the relations in a monotonic fashion.[3] For the simple tenses, the past tense is unambiguously represented as denoting an event which occurs before the speech time. The present tense, on the other hand, is initially realized with an ambiguous specification: either the speech time coincides with the reference time, in which case a "true" present is realized; or the reference time is after the speech time, in which case a futurate interpretation is called for.

(2)			
	Present Tense Verbs	$E \bigcirc R$,	$R > S$ or $S \subseteq R$
	Past Tense Verbs	$E \bigcirc R$	$R < S$
	Infinitives/Participles	E,R	R,S
	Future Auxiliary		$R > S$
	Present Perfect Auxiliary	$E < R$	$R \bigcirc S$
	Past Perfect Auxiliary	$E < R$	$R < S$

2.2 Tense within the Semantic Formalism

Concretely, the above information is integrated into the Semantic Formalism in form of a tense condition. The tense condition is a complex condition within the *conds* slot of a DRS. The reader is referred to Figure 1 in Section 2.4 for a complete semantic representation of a simple sentence, in which the tense condition is included. The internal structure of the tense condition is given here.

```
tense_condition   ::   e_rel_r             : tense_rel,
                       r_rel_s             : tense_rel,
                       tense_inst          : marker,
                       e_time              : marker,
                       r_time              : marker,
                       s_time              : marker,
                       tloc                : tloc_type,
                       sur_tense           : etense_val.
```

The types e_time, r_time, and s_time and the encoding of the relations between them is as described above. The s_time is coindexed with a (contextual)

[3] Note that no provision is made for future perfects. This will be discussed later on.

time anchor, whose value is "now". The e_time is coindexed with the instantiation of the verb. Both are thus bound by existential closure.[4]

As it is as yet not possible to evaluate anaphoric relations, or to evaluate temporal adverbials with respect to a calendar model, it is not possible to instantiate an evaluation procedure which would take an temporal adverbial, place it in relation to the speech time, and determine the reference time for the event. The temporal relations as they stand are thus not *inferred* from calendar and contextual information, but are specified lexically. A hierarchical modeling of the set of temporal relations, which are based on the proposals in Allen (1983), further ensures that the various lexical specifications can be combined compositionally and yet monotonically.

In the *tloc* slot information about the presence and particular nature of temporal adverbials is gathered. For example, when *im April* is processed, a value of *st_dist* (distributed around the speech time) is introduced. This is then evaluated as a part of the determination of surface tense, and is simultaneously used to disambiguate the German present. The *tloc* thus in effect situates the event, and would seem to play exactly the role of the reference time (r_time). However, the temporal adverbial which introduces the *tloc* specifications is not explicitly identified with the r_time. This is because they are not always identical. In the case of quantification, for example, there may be a temporal adverb (and, hence, a *tloc*), but when it is contained within the scope of the quantiifier, it may not serve as the r_time for the expression. Furthermore, when there is no explicit temporal adverb in an expression, a reference time which situates the event must still be assumed. This is represented by the r_time, underspecified though it may be.

The issue of reference times in general and their role with regard to temporal anaphora (Partee 1973) in particular will be taken up again in a later section. However, it should be emphasized at this stage that despite the lack of a resolution/inference component in the Demonstrator, quite an impressive amount of the phenomena Verbmobil is confronted with are dealt with successfully.

The feature *tense_inst* serves to identify the tense condition uniquely. In most cases, the value of the tense_inst is exactly that of the e_time, but under quantification and negation the tense_inst is flagged with sortal information in order to be able to identify the tense condition as having been introduced by negation or quantification. The details of the treatment and implementation of quantification with regard to tense are described in the section on quantification.

Finally, the *sur_tense* is instantiated as a last step of transfer and contains the English surface tense that the expression should be generated with.

[4] The label e_time applies to both states and dynamic events – no crucial distinctions are lost with regard to this simplification of terminology since the precise nature of the eventuality is encoded both in terms of sortal information, and in terms of Aktionsarten.

2.3 Aktionsart

One very fundamental component of tense/aspect analyses that has so far not been mentioned is the Aktionsart of a predicate (Vendler 1967). Unlike tense and the information contributed by temporal adverbials, the Aktionsart of a predicate cannot be seen as a condition on a DRS, but must rather be realized as a *perspective* on the entire situation. As such, Aktionsarten information is encoded in a *persp* feature outside of the DRS. The modeling of Aktionsarten information and the compositional "calculation" Aktionsart has been undertaken by IBM-Heidelberg, as described in Egg and Herweg (1994) and Egg (1994a). Unfortunately, the *persp* feature has not been implemented fully for the Demonstrator. As such, the following discussion reflects the scenario as it is visualized with respect to the *persp* feature, not its current realization.

Semantic Evaluation, under which the evaluation of tense and aspect falls, was originally envisioned as "triggered" by the Transfer component only when disambiguation became necessary for translation. This strategy was proposed in order to avoid the costly drawing of inferences necessary for many of the phenomena within Semantic Evaluation. However, the case of tense and aspect is slightly different. In the approach presented here, no inferences need to be drawn. Furthermore, since each and every sentence containing a predicate will contain temporal and aspectual information, and since the intention at Tübingen was to provide a surface tense for all of the expressions handled by the Demonstrator, it seemed that the evaluation of temporal and aspectual information could not be treated as being triggered optionally.

Both the information in the tense condition and the *persp* feature must be arrived at compositionally, so the collection and instantiation of the relevant information most logically should take place parallel to the Semantic Construction. The evaluation of the temporal and Aktionsart information needed for the realization of the English surface tense, however, should clearly be situated within the Transfer component. As the Semantic Construction, Semantic Evaluation (in the form of the BACK/FLEX system (Quantz et al. (1994))), and the Transfer components have in practice all been integrated into a single module, the Minidemosystem (MDS), this division of labor in terms of tense and aspect is in fact supported by the underlying architecture.

The above scenario for the treatment of tense and aspect was agreed upon by the Tense/Aspect partners and representatives from the Semantic Construction in various meetings.[5] In order to keep the amount of management required from the Semantic Construction group to a minimum, the tense condition and the *persp* feature are instantiated according to the specifications provided by the concerned groups: the tense condition is the responsibility of Tübingen, the *persp* feature that of IBM.

[5]The groups working on diverse tense and aspect phenomena are IBM-Heidelberg, IMS-Stuttgart and Universität Tübingen.

In theory, the tense condition and the *persp* feature can be viewed as a separate tense/aspect module within the Semantic Construction, as they are of no immediate concern to the remainder of the Semantic Construction, and are put together entirely according to the specifications of the Semantic Evaluation partners.

In the remainder of the paper the treatment of tense as it is actually implemented for the Demonstrator is described, i.e., without recourse to Aktionsart. The only differentiation possible is thus that of the sortal distinction between stative and dynamic predicates. While we will therefore only refer to differences between states and events in most of the discussion, some space is devoted further on to instances where Aktionsart information is crucial, and what role we see it as playing for the Prototype.

2.4 Sample Analyses

Before going on to a more detailed description of the analyses and corresponding implementation, two sample analyses of the simple sentence in (3) are shown in order to illustrate the situation of the tense condition (and the *persp* feature) within the overal semantic representation, and to provide an initial idea of the kind of information that is contained within the tense condition, for both the source and the target language representations.

(3) Wir machen übermorgen einen Termin aus.
We'll arrange an appointment day after tomorrow.

FIGURE 1: Source Language Semantic Representation

```
sem
[ LAMBDA: ⟨ ⟩
  DRS: [ DOM: ⟨ [ IDENT: [A]
                   SORT: dynamisch_c ],
                 [ IDENT: [C]
                   SNUMBER: individual
                   SORT: zper_zpunkt_veranst_c ] ⟩
         CONDS: ⟨
           alfa_condition
           [ ALFA_ARG: [ IDENT: [B]
                         SNUMBER: collective
                         SORT: person_c ]
             ALFA_TYPE: std
             ALFA_RESTR [ DOM: [B]
                          CONDS: ⟨ ⟩ ] ]
           basic_condition
           [ PRED: ausmachen
             INST: [A]
             ARGS: [ ARG: [B]
                     ROLE: agent_rel ] [ ARG: [C]
                                         ROLE: theme_rel ] ]
           tense_condition
           [ E_REL_R: assoc
             R_REL_S: follow_eq
             E_TIME: [A]
             TENSE_INST: [A]
             R_TIME: [ SORT: temporal_c ]
             S_TIME: [ IDENT: [E]
                       SORT: temporal_c ]
             TLOC: st_dist ]
           basic_condition
           [ PRED: timeloc
             INST: [A]
             ARGS: [ ARG: [D]
                     ROLE: temporal_inclusion_rel ] ]
           basic_condition
           [ PRED: uebermorgen
             INST: [D]
             ARGS: [ ARG: [E]
                     ROLE: temporal_point_anterior_rel ] ]
           basic_condition
           [ PRED: termin
             INST: [C]
             ARGS: ⟨ ⟩ ]
         ⟩ ]
  QUANTS: ⟨ ⟩
  PERSP: [ P_INST: [A] ]
  ANCHORS: ⟨ disc_anchor [ PARAM: [B]
                           DISCOURSE_ROLE speaker_hearer ],
             time_anchor [ TIME_PARAM: [E]
                           TIME_ROLE: now ] ⟩
  PRAG: [ IMP: no
          KEY_WDS: ⟨ ⟩
          PROSODY: prosody_val
          VERB_POSITION: verb2
          WHQ:NO ] ]
```

FIGURE 2: Target Language Semantic Representation

$$
{}_{sem}\left[\begin{array}{ll}
\text{LAMBDA:} & \langle\ \rangle \\
\text{DRS:} & \left[\begin{array}{ll}
\text{DOM:} & \left\langle \begin{bmatrix}\text{IDENT:} & \boxed{A}\\ \text{SORT:} & \textit{dynamisch\_c}\end{bmatrix}, \begin{bmatrix}\text{IDENT:} & \boxed{C}\\ \text{SNUMBER:} & \textit{individual}\\ \text{SORT:} & \textit{veranstaltung\_c}\end{bmatrix}\right\rangle \\
\text{CONDS:} & \left\langle \begin{array}{l}
{}_{\textit{alfa\_condition}}\begin{bmatrix}
\text{ALFA\_ARG:} & \begin{bmatrix}\text{IDENT:} & \boxed{B}\\ \text{SNUMBER:} & \textit{collective}\\ \text{SORT:} & \textit{person\_c}\end{bmatrix}\\
\text{ALFA\_TYPE:} & \textit{std}\\
\text{ALFA\_RESTR} & \begin{bmatrix}\text{DOM:} & \boxed{B}\\ \text{CONDS:} & \langle\ \rangle\end{bmatrix}
\end{bmatrix} \\
{}_{\textit{basic\_condition}}\begin{bmatrix}
\text{PRED:} & \textit{arrange}\\
\text{INST:} & \boxed{A}\\
\text{ARGS:} & \begin{bmatrix}\text{ARG:} & \boxed{B}\\ \text{ROLE:} & \textit{agent\_rel}\end{bmatrix}\begin{bmatrix}\text{ARG:} & \boxed{C}\\ \text{ROLE:} & \textit{theme\_rel}\end{bmatrix}
\end{bmatrix} \\
{}_{\textit{tense\_condition}}\begin{bmatrix}
\text{E\_REL\_R:} & \textit{overlap\_rel}\\
\text{R\_REL\_S:} & \textit{follow}\\
\text{E\_TIME:} & \boxed{A}\\
\text{TENSE\_INST:} & \boxed{A}\\
\text{R\_TIME:} & \begin{bmatrix}\text{SORT:} & \textit{temporal\_c}\end{bmatrix}\\
\text{S\_TIME:} & \begin{bmatrix}\text{IDENT:} & \boxed{E}\\ \text{SORT:} & \textit{temporal\_c}\end{bmatrix}\\
\text{TLOC:} & \textit{st\_dist}\\
\text{SUR\_TENSE:} & \textit{fut}
\end{bmatrix} \\
{}_{\textit{basic\_condition}}\begin{bmatrix}
\text{PRED:} & \textit{timeloc}\\
\text{INST:} & \boxed{A}\\
\text{ARGS:} & \begin{bmatrix}\text{ARG:} & \boxed{D}\\ \text{ROLE:} & \textit{temporal\_inclusion\_rel}\end{bmatrix}
\end{bmatrix} \\
{}_{\textit{basic\_condition}}\begin{bmatrix}
\text{PRED:} & \textit{day\_after\_tomorrow}\\
\text{INST:} & \boxed{D}\\
\text{ARGS:} & \begin{bmatrix}\text{ARG:} & \boxed{E}\\ \text{ROLE:} & \textit{temporal\_point\_anterior\_rel}\end{bmatrix}
\end{bmatrix} \\
{}_{\textit{basic\_condition}}\begin{bmatrix}
\text{PRED:} & \textit{appointment}\\
\text{INST:} & \boxed{C}\\
\text{ARGS:} & \langle\ \rangle
\end{bmatrix}
\end{array}\right\rangle
\end{array}\right] \\
\text{QUANTS:} & \langle\ \rangle \\
\text{PERSP:} & \begin{bmatrix}\text{P\_INST:} & \boxed{A}\end{bmatrix} \\
\text{ANCHORS:} & \left\langle {}_{\textit{disc\_anchor}}\begin{bmatrix}\text{PARAM:} & \boxed{B}\\ \text{DISCOURSE\_ROLE} & \textit{speaker\_hearer}\end{bmatrix}, {}_{\textit{time\_anchor}}\begin{bmatrix}\text{TIME\_PARAM:} & \boxed{E}\\ \text{TIME\_ROLE:} & \textit{now}\end{bmatrix}\right\rangle \\
\text{PRAG:} & \begin{bmatrix}\text{IMP:} & \textit{no}\\ \text{KEY\_WDS:} & \langle\ \rangle\\ \text{PROSODY:} & \textit{prosody\_val}\\ \text{VERB\_POSITION:} & \textit{verb2}\\ \text{WHQ:NO} & \end{bmatrix}
\end{array}\right]
$$

The semantics of the German sentence and its English translational equivalent in (3) does not differ notably. This is convenient, because it allows a clear look at the realization of surface tense and the translation of adverbs. As mentioned before, the tense condition is represented as a complex condition within a DRS. That is, all of the temporal information usually represented as separate conditions within the corresponding standard DRS representation in (4) is bundled within the tense condition, including a flag in the *tloc* that a temporal adverbial is present, and that it is of the type *st_dist* (not equal to the speech time).

(4)

$$\boxed{\begin{array}{c} \text{x,y,t,t}',\text{n,e} \\ \\ \text{Wir(x)} \\ \text{Termin(y)} \\ \text{übermorgen(t}'\text{)} \\ \text{e} \subseteq \text{t} \\ \text{t} > \text{n} \\ \text{t}' = \text{t} \\ \text{e: } \boxed{\text{x ausmachen y}} \end{array}}$$

The only type that finds no equivalent in a standard DRS representation is the surface tense (sur_tense) instantiated in the target language semantics. This feature could be argued to be purely syntactic, and to have no place within the semantics of the expression. However, if this feature is viewed as language particular shorthand for the collection of information represented in the tense condition, then its position within the tense condition is justified: it provides a convenient abbreviation for the "deep" temporal semantics of the expression in light of the English temporal and aspectual system.

The German present tense verb *ausmachen* is represented as ambiguous in the source language: the relation between R and S (r_rel_s) is given as *follow_eq*, which indicates that the reference time may either follow the speech time, or coincide with it. The relation between E and R (e_rel_r) has been left underspecified, since no further information is as yet available.

In the target language (English) representation, the ambiguous specification for the relation between R and S has been disambiguated to *follow* by taking the nature of the temporal adverbial into account (if the adverb had been *heute*, the result of disambiguation would have been *equal*). The surface tense feature has been instantiated as a part of transfer, indicating that the English expression must be realized in the future.

Due to the constraints placed on the nature of basic conditions within the Semantic Formalism, the temporal adverbials *übermorgen* and *day_after_tomorrow* are represented in a rather complicated manner, in terms of two basic conditions. As already mentioned, a more detailed description of the treatment of temporal adverbials is provided in a later section. For the moment, what is relevant is that *übermorgen* is represented as an adverbial which locates the event denoted by *ausmachen* within the time it introduces, and which is at a point after the speech time (temporal_point_anterior_rel). The speech time is represented as discourse conditioned, hence in the *anchors*, where it provides a temporal anchoring point for the evaluation of event and reference times. However, since no method of evaluating times with respect to one another is available for the Demonstrator, the speech time is always represented as an invariant *now*.

Further differences between the standard DRT representation in (4) and the analyses within Verbmobil are clearly evident in the treatment of arguments. The argument *wir* of the verb is represented as an *alfa_condition*, a complex condition, in the above structures, while the argument *Termin* is represented as a basic condition. This captures the fact that *wir* is a pronoun which is subject to anaphoric resolution, while *Termin* is not. Since the subject of this paper is not the description of the Semantic Formalism, but an overview of the phenomena treated in Tübingen with respect to tense and temporal adverbs, the reader is refered to Bos et al. (1994) and Bos and McGlashan (1994) for a detailed description of the formalism.

3 Tense

3.1 The German Present Tense

The German present tense is analysed as fundamentally ambiguous: it can refer to past, present, or future occurences (e.g., Ehrich 1992). Within the scope of Verbmobil, we ignore the historical present, and model the present as being ambiguous between a present and a future reading (Hinrichs 1994). The present tense must be disambiguated by means of temporal adverbials or context. As contextual information is not yet available for the Demonstrator, in the absence of an overt temporal adverbial, the German present tense is realized as either English present or present progressive, depending on whether the verb describes a stative or a dynamic event.

Representative examples from various Verbmobil dialogs in the simple present are shown in (5)–(7).[6]

[6]The labeling of the examples is as follows: DRF and ERF refer to German and English sentences, respectively, from the *Referenzdialog*. D7, E7, etc., refer to utterances from the Blaubeuren Dialogs, which are considered to be the core corpora for the Demonstrator. The numbering here is according to a standardized version agreed upon by the syntax, semantics, transfer, and generation partners. Examples labeled "Bonn", etc., stem from further Verbmobil dialogs which are not included in the core corpora, but which have been tagged, translated, and investigated in Tübingen. Examples not labeled at all have been made up.

Dynamic predicates (events) usually occur with a temporal adverb. Examples like (6), in which a dynamic predicate occurs on its own are extremely rare in the dialogs. As (5) shows, when an event predicate occurs with a temporal adverb, then it must be realized in the future in English. When an event predicate occurs on its own, it must be realized with the present progressive.

Event in combination with a Temporal Adverb

(5) DRF:28: genau, wir **treffen** uns **dann** in der Eingangshalle des Czerczinsky mit den Unterlagen
ERF:29: we **will meet** in the lobby of the Czerczinsky with the papers.

Unmodified Event

(6) wir **treffen** uns in der eingangshalle.
we **are meeting** in the lobby

Statives, on the other hand, are always realized in the present tense in English: whether or not a temporal adverb is present is irrelevant.

Statives

(7) a. D7:08 Dienstag **ist** etwas ungünstig.
E7:08 Tuesday **is** a bit inconvenient.

b. D7:14 **Meinen** Sie das **reicht** uns?
E7:14 Do you **think** that **is** enough for us?

c. D7:07 Da **habe** ich noch Zeit.
E7:07 I still **have** time then.

d. BonnD1:89 und **am siebenundzwangisten**, da **ist** leider der Kongress in Berlin wieder
BonnE1:89 and **on the twenty-seventh** there **is** the conference in Berlin again

The examples presented here exclude cases which contain modals, subjunctives, quantification, or negation, as they are discussed separately later on. The basic factors which must be taken into account for the simple German present tense are presented here. The tense condition intially introduced by a verb with present tense morphology is as follows.

The German Present Tense

e_rel_r:	assoc	(underspecified)
r_rel_s:	follow_eq	(ambiguous)
r_time :	sort: temporal_c	(underspecified)
s_time :		(specified as "now" in anchors)
e_time :		(coindexed with the verb)
tense_inst:		(same as the e_time)

The rules which disambiguate underspecified temporal relations and instantiate the English surface tense follow the general schema shown below. The information contained in a tense condition which is relevant for a calculation of the surface tense is checked: the type of the *tense_inst* (temporal vs. non-temporal for quantification), the type of the temporal adverb (*tloc*), whether the event is dynamic or stative (the sort of the e_time), and the nature of the specification for the temporal relations between E and R, and R and S, which are also simultaneously specified further.

General Format for the Instantiation of Surface Tense

```
saturate_tense =>  (e_rel_r:#ER & r_rel_s:#RS & tense_inst:sort:#TIS &
     e_time:sort:#ES & tloc:#TL) &
     saturate_tense1(#ER,#RS,#TIS,#ES,#TL).
```

The *saturate_tense* rules are instantiated through *surface_tense* in the recursive transfer statement below. The definition of *trs* allows the recursive traversal of a sign, and the translation of lexical items and passing along of interlingua representations through *tau* (VM12 Stuttgart 1994).

Recursive Transfer and Surface Tense

```
trs([#F&prag:#P|#R]) =>
    [sem:(saturate_sem(tau(#F,[]))&surface_tense)&prag:#P|trs(#R)].
```

At each stage, *surface_tense* looks for a tense condition, checks whether an English surface tense value has been provided yet, and instantiates an appropriate value for the English surface tense where necessary through the specific *saturate_tense* rules (e.g., 1–4 below).[7]

[7]The integration of the tense module into the overall transfer component was undertaken by the Transfer group at IMS-Stuttgart (in particular, K. Eberle, C.J. Rupp, M. Dorna, and M. Emele). The relatively complicated sign-traversal macros needed for the identification of tense conditions and satisfaction of the *sur_tense* value, as well as general technical support at all stages were also provided by the IMS group.

As was illustrated in the above source and target language semantic representations, the *tloc* slot is filled by the introduction of a temporal adverb into the semantic representation. For a treatment of the simple German present tense, two factors need to be taken into account.

- If the verb is dynamic (an event), and there is a temporal adverb (st_dist), then the English tense is future (see 1).[8]
- If the verb is dynamic, and there is no temporal adverb, then the English tense is present progressive. (see 2)
- If the verb is stative, the presence of a temporal adverb has no influence: the English tense is always present (see 3 and 4).

In 1–4, the *saturate_tense* statements needed for a treatment of simple German present tense sentences are shown.

1. Present Disambiguated to Future by Temporal Adverbial → Future

```
saturate_tense1(~precede,follow_eq,temporal_c,dynamisch_c,st_dist) =>
      e_rel_r: overlap_rel &
      r_rel_s: follow &
      sur_tense: fut.
```

2. Present of Dynamic Verbs → Present Progressive

```
saturate_tense1(~precede,follow_eq,temporal_c,dynamisch_c,~st_dist &
                         ~st_perf&~st_prec) =>
     e_rel_r: overlap_rel &
     r_rel_s: equal &
     sur_tense: presprog.
```

3. Present of Stative Verbs → Present

```
saturate_tense1(~precede,follow_eq,temporal_c,statisch_c,
                         ~st_dist & ~st_perf & ~st_prec) =>
     e_rel_r: overlap_rel  &
     r_rel_s: equal &
     sur_tense: present.
```

[8] Various kinds of temporal adverbs are defined in terms of what intervals around the speech time they describe – for a disambiguation of the German present tense, only the type *st_dist* is relevant.

4. Present of Stative Verbs with Temporal Adverb → Present

```
saturate_tense1(~precede,follow_eq,temporal_c,statisch_c,st_dist) =>
      e_rel_r: overlap_rel &
      r_rel_s: follow &
      sur_tense: present.
```

The above rules are part of the transfer component, but, as already mentioned, also simultaneously disambiguate or further specify the information about the relations between E, R and S.[9] In all of the rules, the underspecified *assoc(iated)* value for E and R is specified to be *overlap_rel.*[10] In 1. and 4. the presence of a temporal adverb serves to disambiguate the relation between R and S. However, while this disambiguation has an effect on the English tense in 1., it does not do so in 4. The Rules in 3 and 4 also illustrate that the temporal relations are not identical with the information in *sur_tense*.

If no temporal adverb specifies the relation of the reference time to the speech time, then the reference time is assumed to be equal to the speech time. If contextual information were available, the German present could also be disambiguated according to contextual information.

(8) Wir haben morgen einen Termin mit den Schweizern. Wir **treffen** sie in der Eingangshalle des Hotels.
We have an appointment with the Swiss tomorrow. We**'ll meet** them in the lobby of the hotel.

In addition to the issue of disambiguation by contextual information, there are also some other issues which we have not been able to tackle for the Demonstrator, but which are planned for the Prototype. However, the rules presented above, in combination with a special treatment of quantification and negation, allow a successful and semantically well motivated treatment of the phenomena associated with the German present tense within the Verbmobil scenario. The handful of exceptions, namely imperatives and performatives, which are not captured straightforwardly under the basic approach are described in the next sections, after a brief look at possible "futurate" uses of the English present tense.

[9] For ease of presentation, we have abstracted away from implementational details here — in a non-procedural language like STUF further conditions need to be added to ensure that not more than one solution per expression is instantiated. For the rules as they actually appear see Appendix A.

[10] The underspecified value *assoc* is introduced in order to allow a compositional treatment of the periphrastic tenses, as will be seen in the next section.

3.1.1 The English Futurate

A intriguing difference in translation possibilities is found with some copula constructions. Notice that while the sentence in (9) could be translated either with the English future or present, this is not possible for (10).

(9) D2:03 am dreizehnten April **bin** ich noch im Urlaub
E2:03 on the thirteenth of April I **will** still be on vacation
on the thirteenth of April I **am** still on vacation

(10) BonnD1:89 und am siebenundzwangisten, da **ist** leider der Kongress in Berlin wieder
BonnE1:89 and on the twenty-seventh there ***will be/is** the conference in Berlin again

The factor that appears to be relevant here, as far as can be concluded from the Verbmobil dialogs, is the whether or not the subject is human. While this factor appears to be consistent throughout the dialogs, the difference has not been realized within the tense component for two reasons: 1) both present and future translations are indeed possible for examples like (9); 2) the semantic factors conditioning this behavior are not quite clear yet and need to be investigated further, beyond the scope provided by the Verbmobil scenario.

In fact, the examples in (9) and (10) appear to be instances of the more general question of the English "futurate" (Moens and Steedman 1988, Smith 1990). Some relevant examples, based on Smith, are shown in (11).

(11) a. The gardener waters the flowers tomorrow.

b. Christine rehearses next Wednesday.

c. We paint the house tomorrow.

d. We are painting the house tomorrow.

As can be seen in (11), both simple present tense forms and present progressives in English can be used to express events in the future without being restricted to special contexts. This use of the English present and present progressive is quite reminiscent of the German facts. However, the English "futurate" usage is not as wide-spread as the German. For example, the English present and present progressive cannot receive a futurate interpretation on their own – a temporal adverb must always be present in order to trigger this reading.

(12) a. The gardener waters the flowers.

b. Christine rehearses.

c. We paint the house.

d. We are painting the house.

We hope to undertake a more global investigation of the possibilities for expressing future events with the English present/present progressive in the second phase of the project, and to integrate our findings into the Prototype.

3.1.2 Performatives

As mentioned above, a certain class of predicates, namely performatives make a regular exception to the rules for surface tense instantiation formulated above. Predicates like *danken*, for example, describe a dynamic event, but cannot be realized with the present progressive in the translation shown in (13). The example in (14) provides a basis for comparison with an activity (event) predicate that is not a performative.[11]

(13) Ich danke Ihnen.
I thank you.
*I am thanking you.
??*I'll thank you.

(14) Wir machen einen Termin aus.
*We decide on a date.
We are deciding on a date.
We'll decide on a date.

Other verbs which display the same pattern as *danken* within the Verbmobil corpora are *vorschlagen*, *erklären*, and *sagen*.

The difference between (13) and (14) cannot be modeled in terms of the Aktionsart hierarchy proposed for Verbmobil (Egg, p.c.), since performatives are simply intergressives (albeit punctual ones) from the point of view of Aktionsart modeling (see Egg and Herweg 1994, Egg 1994a) and are thus indistinguishable from other intergressive predicates.

The difference between (13) and (14) can, however, be represented in the Domainmodel (BACK/FLEX). A treatment of performatives with recourse to the Domainmodel is thus planned for the Prototype.

3.1.3 Imperatives

Imperative constructions as shown in (15) cannot as yet receive an adequate treatment.

[11]The '*' here indicates an inappropriate translation rather than an ungrammatical expression.

(15) D2:20 gut machen Sie einen Vorschlag
E2:20 okay, make a suggestion

The information that an expression is imperative is not as yet coded consistently within the semantic representation (the appropriate slot is located within the *prag(matic)* feature, which is currently not fully instantiated). Once the information that a construction is an imperative is consistently made available to the transfer component, a treatment of imperatives will not pose a problem for the post-Demonstrator tense module, which will be able to take information outside of the tense condition into account.

3.2 The German Past Tense

Occurences of the German past tense within the Verbmobil dialogs are rare and fairly uninteresting. They always correspond to the English past or past progressive, depending on whether or not the predicate in question is a state or an event. Typical examples are shown in (16) and (17).

(16) D1:19 nein halt das **war** jetzt Mai
E1:19 no wait, that **was** May now

(17) D1:07 oh, ich **dachte** eigentlich an den fünfzehnten April
E1:07 oh, I **was** actually **thinking** of the fifteenth of April, a week later

The tense condition as initially introduced by a verb with past tense morphology is as follows.

Past Tense		
e_rel_r:	assoc	(underspecified)
r_rel_s:	precede	(unambiguously past)
r_time :	sort: temporal_c	(underspecified)
s_time :		(specified as “now” in anchors)
e_time :		(coindexed with the verb)
tense_inst:		(same as the e_time)

The transfer rules for the English surface tense are shown in 5 and 6.

5. German Past of Dynamic Verbs → Past Progressive

```
saturate_tense1(~precede,precede,##,dynamisch_c,##) =>
     e_rel_r: overlap_rel &
     sur_tense: pastprog.
```

6. German Past of Stative Verbs → Simple Past.

```
saturate_tense1(~precede,precede,##,statisch_c,##) =>
     e_rel_r: overlap_rel &
     sur_tense:spast.
```

As with the present tense, the rules simultaneously instantiate the appropriate English surface tense, and provide a more informative specification for the relation between E and R: since no other specifications with regard to E and R occured in the expression (as would be the case in the perfect tenses, for example), the relation between E and R is concluded to be one of temporal overlap.

3.3 Progressives

One question that has so far not been addressed directly is the question of the PROG(ressive) operator (c.f., Dowty 1979, Hinrichs 1983, Parsons 1990, Landmann 1992), and how it relates to the implementation presented here, where the English progressive is instantiated without recourse to a PROG. In fact, as the PROG operator is crucial for the evaluation truth conditions, i.e., for the *understanding* of natural language, but is not centrally relevant to a modeling of the temporal relations without an evaluation component, this is not surprising.

The PROG operator was postulated originally to account for the Imperfective Paradox illustrated in (18) and (19). Despite the fact that the predicate in both cases is an accomplishment, (18) does not entail (19). Although the precise semantics for the PROG operator are formulated differently in the various approaches mentioned above, the essence of the PROG operator can be described as applying to an accomplishment predicate, and allowing one to ignore its telic implication.

(18) Mary was crossing the street.

(19) Mary crossed the street.

In both the (possibly) atelic reading in (18) and the telic reading in (19), however, the event in question is located solidly before the speech time. The progressive thus has no effect on the relation between E, R and S. In fact, a crosslinguistic investigation of inceptives, resultatives, and progressives in various languages (Smith 1990) indicates that the central function of progressives is to *focus* on the duration of an event, just as inceptives and resultatives focus on the points of inception and completion of an event (Butt 1994).

A side effect of the progressive in English is the Imperfective Paradox, which must still be explained. However, we would like to suggest that the Imperfective Paradox is actually an instance of a more general problem that the evaluation of truth conditions with respect to Aktionsart poses. For example, similar problems are found with expressions in the future (which are generally treated modally), and with German present tense sentences like (20), in which there is no overt progressive morpheme.[12]

(20) John überquert die Straße.

The PROG operator must therefore be viewed as representative of a much broader issue, an issue whose complete resolution still remains to be undertaken, despite the very insightful work that has already been done.

3.4 The Periphrastic Tenses

3.4.1 The Future

Utterances in the future also occur very rarely in the Verbmobil dialogs. When they do occur, they can always be translated straightforwardly with the English future. Some typical examples are shown in (21) and (22).

(21) Karls5:12 und dann **werden** wir uns am Mittwoch **sehen**
Karls4:12 and then we**'ll meet** on Wednesday

(22) Karls5:16 auf jeden Fall **werde** ich am Donnerstag **kommen**
Karls5:16 in any case, **I'll come** on Thursday

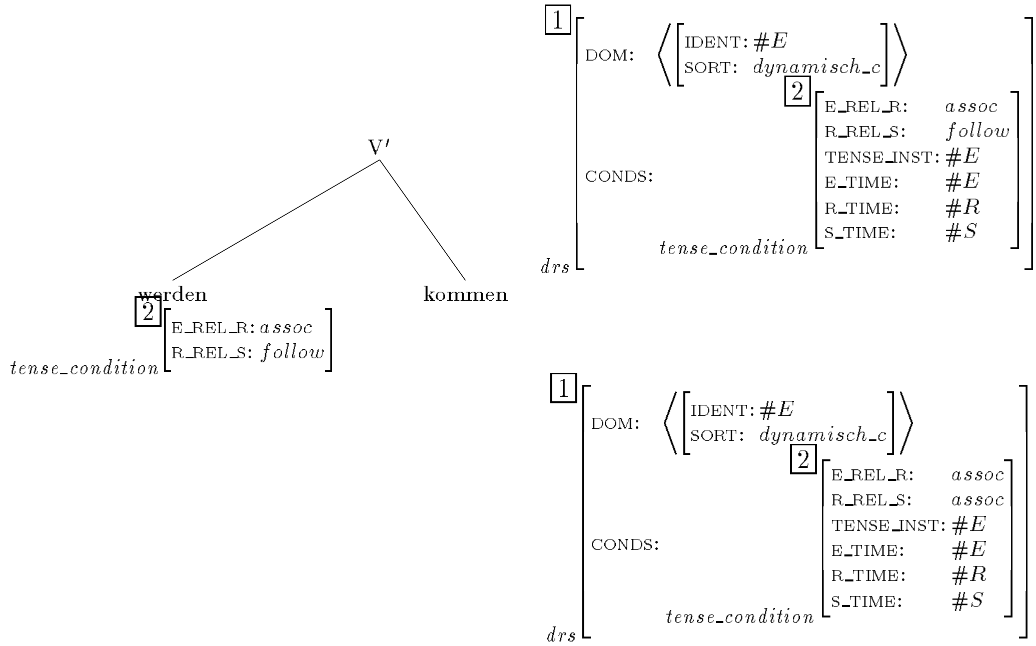
The tense information here must be determined compositionally from the future auxiliary *werden*, and the main verb of the sentence. As can be seen in the following example, where the compositional construction of the tense condition is illustrated,[13] the infinitive main verb introduces completely underspecified values with regard to the temporal relations that hold between E, R and S. The auxiliary *werden* then serves to provide more specific values for the relations: the reference time must be located after (follow) the speech time.

(23) Wir werden kommen.

[12] Although we do have a suggestion for the treatment of progressives of position and location verbs like *The picture is hanging on the wall*, we present no discussion of the issue here, as it would lead us too far afield.

[13] For ease of presentation, only the tense condition is shown.

FIGURE 3: Source Language (German) Representation



Although future perfects never occur in the Verbmobil dialogs, the simple model here can easily be extended to allow for any possible occurences: in a sentence like (24) the reference time is after the speech time (r_rel_s: follow), but the event time must precede the reference time (e_rel_r: precede).

(24) Ich **werde** einen Termin **ausgemacht haben**.
I **will have made** an appointment.

The transfer rule for the simple German future is given in 7.

7. German Future → English Future

```
saturate_tense1(~precede,follow,temporal_c,##,##) =>
      e_rel_r: equal &
      sur_tense:fut.
```

3.4.2 The Perfect Tenses

Current Treatment

Occurences of the perfect are also very rare in the dialogs, and always correspond to the English simple past. Since our primary aim was to implement a broad treatment of the German present tense for the Demonstrator, we have concentrated on not more than the occurences in the Verbmobil dialogs, and have translated all German present perfects as English simple past. An example is shown in (25).

(25) D3:01 der Termin den wir neulich **abgesprochen haben** ...
E3:01 the appointment that we **decided on** the other day ...

Utterances in the German past perfect are even rarer, and always correspond to the English past perfect.

(26) BonnD1:02 das **hatten** wir ja **vorgesehen**
BonneE1:02 we **had planned** on that

The tense condition for the perfect and the past perfect is constructed compositionally, in analogy to the future.[14] The perfect auxiliaries *sein* and *haben* introduce the condition that the event time must lie before the reference time. The relation between the speech time and the reference time is determined by the morphological tense of the auxiliary: if the auxiliary carries present tense morphology, the relation between R and S will be one of coincidence. If the auxiliary carries past tense morphology, the reference time will precede the speech time. The tense conditions resulting from the combination of the underspecified participle and the auxiliary are shown below for each of the tenses.

The Perfect

e_rel_r:	precede	(introduced by auxiliary)
r_rel_s:	equal	(present tense morphology)
r_time :	sort: temporal_c	(underspecified)
s_time :		(specified as "now" in anchors)
e_time :		(coindexed with the verb)
tense_inst:		(same as the e_time)

The Past Perfect

e_rel_r:	precede	(introduced by auxiliary)
r_rel_s:	precede	(past tense morphology)
r_time :	sort: temporal_c	(underspecified)
s_time :		(specified as "now" in anchors)
e_time :		(coindexed with the verb)
tense_inst:		(same as the e_time)

[14] The realization of this approach is due to C.J. Rupp, who coordinated the specification of the *mtv* (mood-tense-voice) access predicate in close cooperation with the syntax (S. Schachtl).

The transfer rules for the English surface tense are shown in 8 and 9.

8. German Present Perfect → English Simple Past

```
saturate_tense1(precede,equal,##,##,##) =>
      sur_tense:spast.
```

9. German past perfect → English past perfect

```
saturate_tense1(precede,precede,##,##,##) =>
      sur_tense:pastperf.
```

Perspectives for the Prototype

In the treatment presented above, there are, of course, many issues which are disregarded with respect to the perfect tenses. Within standard DRT, the perfect auxiliary is analysed as describing a state which embeds an event within it. For example, (27) is analyzed as describing a state in which a letter exists.

(27) Mary has written a letter.

This state presupposes that an event of letter-writing has occured in the past. The state in which we are in now is considered to begin right at the time that the event of letter-writing ended (described as the *abut* '$\supset\!\subset$' relation). A standard DRT analysis of (27) is given in (28).

(28)

$$\boxed{\begin{array}{c} x,y,t,n,e,s \\ \hline \text{Mary}(x) \\ \text{letter}(y) \\ t = n \\ t \subseteq s \\ e \supset\!\subset s \\ e\text{: } \boxed{\text{x write y}} \end{array}}$$

While the standard DRT analysis does capture the English intuitions for the perfect, it cannot be applied to the German in the way that it is stated. As already mentioned above, the German present perfect is most often used to express the equivalent of the English past tense. The English past tense is modeled in terms of a single past event, rather than a past event which results in a current state, so the standard DRT analysis for perfects does not carry over straightforwardly to the German perfect.

Moreover,the German perfect is not restricted to the simple past tense use, as (29) illustrates.

(29) a. Ich **habe** nun einen Fußball **mitgebracht**. Können wir jetzt spielen?

b. I **have brought** a soccer ball this time. Can we play now?

c. #I **brought** a soccer ball this time. Can we play now?

In a context where I showed up without a soccer ball previously, with the result that we could not play, but have brought one with me this time, the translation in (29b) is clearly better than the translation in (29c).

For the second phase of the project, we hope to undertake a comprehensive look at the German perfect and possible corresponding English realizations, and to present an analysis which clearly identifies and separates out the Aktionsart from the temporal information expressed by perfects. The necessity for this is illustrated by examples like (30) in contrast with (27).

While examples like (27) would seem to indicate that in "true" perfects, the perfect auxiliary indeed serves to introduce a state which immediately follows (and is the result of) a completed event, this cannot be true for all perfects even within English, since not all events necessarily result in a change of state, even when completed (see Krifka (1992), Verkuyl (1992), Egg (1994b) for extensive discussions). Furthermore, examples like (30) show (taken from Smith 1990:244) that, irrespective of the nature of the "embedded" event, the standard DRT analysis cannot hold.

(30) a. Mary has been drawing a circle.

b. Bill has been swimming for five minutes.

Here the perfect describes an event in the past that has not been completed, and that is continuing in the present. In fact, the sentences in (30) are reminiscent of the interpretation that expressions containing "perfectivizing" items *seit* and *seitdem*. Consider the present tense German sentence in (31), which can only be interpreted as refering to a state which began to hold in the past, and still continues to hold. Like the sentences in (30), the English equivalent of (31) must be realized in the perfect.

(31) Ich **bin** schon seit Montag in London.
I **have been/*am** in London since Monday.

Given that *seitdem* and the adverbial *bisher*, which displays similar effects, occur in the Verbmobil core dialogs, a rudimentary analysis of these items has been provided. These lexical items are marked as a special kind of temporal adverbial, an *st_perf*, which triggers a perfect interpretation in the transfer component. The relevant rule is shown in 10.

10. Perfect Reading Introduced by *seitdem* and Similar Adverbials → Perfect

```
saturate_tense1(assoc,follow_eq,temporal_c,##,st_perf) =>
      e_rel_r: precede &
      r_rel_s: equal &
      sur_tense:presperf.
```

However, it is clear that a more complete analysis of the phenomena associated with the perfect is in order. The one common denominator between the perfect examples so far has been that they refer to an event or state whose inception is located firmly in the past, i.e, before the speech time. Whether or not the event has been completed, or whether we can truthfully consider this event to have resulted in a state which holds for the present seems to be able to vary. A complete analysis of the perfect will entail: 1) a broad survey of perfectual usages in both German and English; 2) the clear identification of the contribution Aktionsart makes (change of state event vs. activities); 3) a clear representation of temporal relations (event is located in the past, but seems to be able to overlap with the speech time); 4) a modeling of relevant contextual information in terms of temporal anaphora.

4 Temporal Anaphora

The treatment of tense presented here has had no recourse to contextual information in terms of temporal anaphora. That is, within the scope of the Demonstrator, it has not been possible to situate a given sentence within the structure of the discourse. For the German present tense, for example, it is not possible to reconstruct the fact that the second sentence must refer to an event in the future, since the first sentence clearly locates the reference time in the future.

(32) Wir haben morgen einen Termin mit den Schweizern. Wir **treffen** sie in der Eingangshalle des Hotels.
We have an appointment with the Swiss tomorrow. We**'ll meet** them in the lobby of the hotel.

It has long been noticed that in the standard Reichenbachian formulation of temporal relations between E, S, and R times, the R time is used for too many differing purposes, so that a clear account of temporal anaphora and phenomena like the past perfect cannot be stated within just these parameters. In fact, at least two differing notions of reference times are needed.

In the course of presenting the standard DRT analysis of the past perfect Kamp and Reyle (1993) introduce the notion of a *Tpt* (Temporal Perspective

Point) in addition to the notion of reference point. The former is used for tenses which require the reader or listener to project him or herself to a point in either the past (past perfect), or the future (future perfect) and to view the event from that perspective. The *Tpt* is argued to differ from reference points, and both concepts are clearly needed, as the following discourse illustrates (Kamp and Reyle 1993:594).

(33) Fred arrived at 10. He had got up at 5; he had taken a long shower, ...

Here the temporal perspective point is the time that Fred arrived at. However, each of the following clauses also introduces a reference time which situates the event particular to the clause. Kamp and Reyle's *Tpt* represents the notion which is closest to Reichenbach's original formulation of R, but, as already mentioned, Reichenbach also uses R for the contribution made by tense morphology and temporal adverbs.

Since the treatment of tense presented here had no recourse to discourse structure, but could only apply to single utterances, the question of the precise interpretation of the R modeled in the tense condition has so far not been crucial. For a treatment of temporal anaphora, however, the question of reference times and their role in connecting sequences of utterances to one another will become crucial.

In fact, a third notion of reference point is implicitly assumed in the discourse processing algorithms formulated in Hinrichs (1986) and Kamp and Reyle (1993). As a narrative progresses, the reference point in relation to which the following clause is interpreted must be continuously updated. Due to this notion of temporal update, there must actually always be two reference times available: the current one, and the one introduced by the preceding clause, with respect to which the current reference time must evaluated. Kamp and Reyle (1993) represent by this introducing a *Rpt* (reference point), in addition to the location/reference times (usually represented as t). The *Rpt* is a temporary place holder for the most current reference point, and is constantly overwritten as the narrative progresses.

Note that this method of temporal evaluation is inherently nonmonotonic and therefore cannot be implemented directly within the *Basisformalismus* STUF in Verbmobil. Moreover, recent work by Lascarides and Asher (1991,1993) and Lascarides and Oberlander (1993) has argued that the approaches outlined above actually cannot account for all of the narrative sequencing phenomena. An example is shown in (34).

(34) Max fell. John pushed him.

Here there is no way for the approaches presented in Hinrichs (1986) and Kamp and Reyle (1993) to represent the fact that the pushing event occured before the falling event.

Lascarides and Asher (1991,1993) and Lascarides and Oberlander (1993) instead propose a system called DICE (Discourse and Commonsense Entailment) for the temporal interpretation of text which builds on a version of DRT, SDRT (Asher 1993), and which relies very heavily on world knowledge and the nonmonotonic logic approach proposed by Asher and Morreau (1991).[15] The advantages this approach has to offer is that it allows the formulation of a set of rhetorical relations (*narration*, *background*, *result*, *explanation*, *elaboration*), which determine how fragments of a discourse are related to one another. Thus, one is no longer dependent on temporal information only for the temporal interpretation of a text. In fact, Lascarides, Asher, and Oberlander argue that it is actually not necessary anymore to make use of the reference times in order to process the temporal structure of narratives.

This would appear to be a desirable result, as it avoides the questions of "how many reference times are there and what exactly do they do?" altogether. However, while de Swart (1994b) also points out a very interesting problem with regard to the intepretation of temporal adverbials and reference times, she ultimately comes to the conclusion that, in addition to the set of rhetorical relations, a system of temporal relations is necessary in order to account for the differing interpretations temporal adverbials may receive, depending on their position (clause initial or attached to the VP). The three temporal relations de Swart defines (*at, before, after*) are formulated in terms of a reference time, which serves to locate the event. Furthermore, while Lascarides, Asher, and Oberlander claim that their system can be formulated without explicit recourse to reference times, this is only true because the texts they examine are all set squarely within the past.

If the current set of corpora in Verbmobil is anything to judge by, then the processing of discourse in the past tense will not be much of a concern in the second phase of the project. Instead, we anticipate that the processing of disourse expressed largely in the present tense will lead to novel and interesting insights as to the evaluation of temporal anaphora.

As also realized in the system presented by Eberle (1992), we hope to be able to combine the ideas in Lascarides and Asher (1991,1993) and Lascarides and Oberlander (1993) with the notion of temporal relations as already established within recent Reichenbachian approaches (Kamp and Reyle 1993, Ehrich 1992). Furthemore, since Aktionsarten information has been shown to play a large role in the determination of narrative progression (Hinrichs 1986), we plan to make heavy use of the fine-grained Aktionsarten model developed in Egg and Herweg (1994) and hope that a greater reliance on Aktionsarten will avoid a costly overdependence on world knowledge, as is the case in the DICE system.

[15] A very similar approach is presented independently in Eberle (1992).

5 Temporal Adverbs

In addition to modeling the effect of temporal adverbs on the realization of tense, Tübingen is also responsible for the translation of about half of the adverbs (roughly all of the set of deictic and anaphoric adverbs) that occur in the Verbmobil lexicon (see Appendix B). The other half (roughly the frequential and quantificational adverbs) is covered by IMS-Stuttgart. Since it is impossible to translate each set of adverbs completely autonomously, and since any changes in terms of semantic representation directly impinge on the representation and transfer of tense, a good degree of cooperation was necessary in this area. In the next section, we first describe the semantic representation of adverbs, as it was agreed upon, and the interaction with the tense condition. Once the semantic representation has been presented, a brief disucssion of the transfer of the temporal adverbs is given.

5.1 Semantic Representation

For a modeling of the temporal relations between E, R and S within the restricted possibilities available without recourse to discourse structure, a simple distinction between precedence and coincidence is actually all that is needed. In light of this, earlier implementations of tense contained only the most essential modeling of temporal relations, with a view towards extending the set to a more complete modeling for the Prototype. However, in the course of revising the entries in the semantic lexicon, K. Eberle (IMS-Stuttgart) proposed a more intricate modeling of temporal adverbs than had been planned by the semantic construction, and suggested extending the set of temporal relations to the set presented in Allen (1983).

In the implementation as it stands, Allen's relations have not actually been used for the modeling of temporal adverbs. This is because the semantic lexical entries for temporal adverbs already contained sortal specifications as to temporal relations. These specifications are not equivalent to Allen's set. However, as they are needed by other partners, and the redesigning of temporal adverbs occurred at a rather late stage, it was agreed to use the sortal information already present for the purposes of the Demonstrator and to plan on integrating the relations currently used for the representation of tense (Allen's) with the sortal specifications at a later date.

On the basis of this sortal information, macros within the semantic construction fill the *tloc* slot with the appropriate information.[16] The four differing kinds of temporal adverbs shown in Table (35) are distinguished.

[16] These macros were originally written by K. Eberle, and have since been continuously upgraded cooperatively, with the integration of further macros and suggestions for changes from Tübingen. In particular, the information in the *tloc* slot (Table (35)) is of course determined entirely by Tübingen, as it is crucial to the evaluation of tense.

(35)

Type		Examples
st_dist	(not coincident with S)	*morgen*, *im April*, *montags*
st_equ	(coincident with S)	*heute*, *jetzt*
st_prec	(precedes S)	*gestern*, *vorhin*
st_perf	(perfectivizing)	*seitdem*, *bisher*

Temporal adverbials of the type st_dist are by far the most common and serve to disambiguate the German present tense to a future reading. Temporal adverbials of the type st_equ restrict the German present tense to a present reading. The type st_perf was introduced to allow for the perfectivizing effect of *seitdem* (see discussion in the section on perfects). Finally, the st_prec serves to prevent utterances like (36) from being realized in the future. Instead, a translation in the present or present progressive is rendered, depending on the type of verb (stative or not).

(36) #Ich komme gestern.

While (36) is semantically anamolous by itself, it could occur quite legitimately in a discourse like (37) and can thus not be discounted.

(37) Komme ich doch gestern in die Kneipe und treffe dort den Iren wieder.

The case of *gestern* also raises the very interesting question of how to deal with semantically anamolous input in general. For example, it is very difficult, if not impossible, to imagine a suitable context for (38). Nevertheless, as we are dealing with spontaneous spoken dialog in Verbmobil, such input may occur.

(38) *Ich kam morgen.

The question of what the general strategy in Verbmobil ought to be with regard to anomalous input has been raised at various times, but has not been resolved conclusively. Should the system reject the input altogether, or guess at the intended meaning and translate a “correct version”, or simply translate the utterance faithfully and let the dialog partner puzzle over it (c.f. Hauenschild and Prahl (1993))? The strategy pursued here is that anomalous input is not rejected, but neither should it be rendered more anomalous than it was in the source language.

5.2 Transfer

5.2.1 General Strategy

Within the recursive transfer concept, the actual formulation of transfer rules for adverbs is straightforward. The transfer module recursively traverses the syntactic representation, calls lexical transfer rules when a lexical item is encountered, and passes interlingua representations across where appropriate (e.g., rigid date/time expressions, wh-questions).

For example, when the lexical item *bald* is encountered by the transfer module, the *tau_lex* rule 11. is instantiated. It identifies the corresponding target language item as being *soon*, fetches the sign that it modifies (generally, the verb plus its arguments) via *mod*, which specifies the syntactic path under which the modified structure is located, and recursively passes along this sign to the *tau* relation for further transfer operations.[17] As illustrated by 12., the TargetPred *soon* is passed along to a macro (sem_lex), which instantiates the English target semantics.

11. bald → soon

```
tau_lex(bald, soon, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.
```

12. Transfer Rule for Lexical Items

```
@tau_lex(sign,list) => sem_t.
tau_lex(pred_name(#SourcePred) & #Sign,#Args) =>
tau_lex(#SourcePred,#TargetPred,#SemArgs,#Args,#Sign) &
        sem_lex(#TargetPred,#SemArgs).
```

At this point it must be noted that the transfer component in fact has taken on additional work with regard to the English semantics. No English semantic lexicon was made available in the phase leading up to the Demonstrator. In the current implementation, the transfer component has therefore provided a semantic lexicon for English, in addition to the transfer lexicon represented by the *tau_lex* rules. The complete set of transfer rules and English semantic lexical entries for the adverbs handled by Tübingen are given in Appendices B and C.

5.2.2 Interesting Cases

Given that contextual information is not available for the disambiguation and translation of anaphoric adverbs, it has been necessary to find the most generally applicable translation for highly ambiguous items like *da* and *dann* (Ehrich 1992), *mal*, *gerade* and *gleich*.

[17] The #Args slots is used to pass around the information needed to interface with the generation component.

Da and Dann

The pronominal *da* can function as a locative or temporal adverb, a true locative pronoun, as a conjunction equivalent to the English *as* or *since*, or as a discourse particle. All these readings, except for the locative, are also possible for *dann*: it can serve as a temporal adverb, as a sequential conjunction equivalent to the English *then*, or as a discourse particle.

Within the current implementation, only one variety of *da* and *dann* each are recognized by the Semantic Construction: locative *da* and temporal *dann*. The task of transfer is simplified in the extreme: *da* is realized in an interlingua representation for locative *there*, and *dann* is always translated as *then*.

A close look at kinds of constructions which *da* and *dann* occur in has allowed us to formulate some initial generalizations and analyses, which we hope to expand on and implement in the second phase of the project. For example, a robust pattern which emerges from the data is that sentence-initial *da* is equivalent to the English sentence-final *then* in its "cotemporal" reading (Glasbey 1993). An example is shown in (39).

(39) D1:08-09 das ist der Donnerstag nach Ostern, **da** bin ich noch im Urlaub auf Mallorca
E1:08-09 that is the Thursday after Easter, I will still be on vacation in Mallorca **then**

Sentence-initial *dann*, on the other hand, must always be interpreted as a sequential *then*, as shown in (40).

(40) D1:01 **dann** lassen Sie uns doch noch einen Termin ausmachen
E1:01 **then** let's arrange an appointment

The general strategy with regard to *da* and *dann* will be to separate out their uses as conjunctions in cooperation with the syntax, and to disambiguate the temporal and locational readings based on the insights presented for English sentence-final *then* in Glasbey in terms of Aktionsarten information and world knowledge (see Hamp (1995) for more details). Uses of *da* and *dann* which cannot be disambiguated because anaphoric resolution is not possible will be treated as discourse particles and not translated at all. Again, in order to avoid an overly heavy reliance on world knowledge, we hope to make extensive use of the fine-grained Aktionsarten model of Egg and Herweg (1994).

Mal, Gleich, and Gerade

The German *mal* was originally analyzed as a quantifier in the semantic lexicon, in analogy to *einmal, zweimal*, etc. However, a close look at its usage shows that *mal* does not have any quantificational effects, but instead functions as a discourse particle with no overt English translational equivalent.[18]

(41) KarlsD7:9 ich bin **mal** durch den Terminkalender gestolpert ...
KarlsE7:9 I stumbled through my appointment-book ...

The adverbs *gleich* and *gerade* are also used similarly as discourse particles which serve to focus, or intensify, a particular part of an utterance ((42)). Both can also be used as temporal adverbs ((43)).

(42) a. D1:11 wollen wir's dann **gleich** am Montag den dritten Mai machen
E1:11 do we want to do it **right** on Monday the third of May then

b. KarlsD2:16 warten Sie **gerade** fünf Minuten auf mich
KarlsE2:16 **just** wait five minutes for me

(43) a. KarlsD2:16 ich sage meiner Sekretärin **gleich** Bescheid
KarlsE2:16 I will tell my secretary **right away**

b. KarlsD7:1 wo bist Du **gerade**
KarlsE7:1 where are you **now**

Another very interesting use of *gerade*, which we have not been able to take into account for the Demonstrator, is shown in (44) and (45).

(44) KarlsD10:5 ja elf Uhr fünfzehn sehe ich **gerade** da bin ich in einer Besprechung
KarlsE10:5 yes, eleven fifteen, I've **just** noticed I am in a meeting then

(45) Ich erkäre ihm **gerade** den Weg.
I am/was **just** telling him how to get there.

It has been suggested (Canart 1979) that *gerade* serves to place the reference time unambiguously in the past, which accounts for the past tense interpretation of (44) and (45). That this analysis cannot be quite the right one is shown by (43b) and the possible present progessive translation in (45). Instead, *gerade* seems to be able to refer either to the present, or to a point in the immediate past. In this respect, it is therefore practically the mirror-image of *jetzt*, which can refer to the present, or a point in the immediate future.

[18] In accordance with our suggestion for a non-quantificational analysis, *mal* is now treated as a focus adverb by the Semantic Construction.

The examples in (44) and (45) also illustrate an interesting difference between a perfect and a progressive use. Since the progressive is usually analysed as being sensitive to Aktionsart, this possibility was investigated. However, the relevant parameter with respect to *gerade* seems to be *punctuality*, which is not factored into the representation of Aktionsart: in (45) the explanation of a route may take a while, while in (46) the German *einfallen* can only be momentaneous.

(46) ach, da fällt mir gerade was ein
oh, I just remembered something

A more extensive look at the parameter of punctuality is necessary in order to determine whether it should be factored into the model of Aktionsarten, as is sometimes suggested with regard to achievements, or whether it more properly belongs in the realm of world knowledge as suggested by Egg (p.c.).

6 Quantification

6.1 General Strategy

Quantification is represented in terms of two tense conditions: one introduced by the event in the scope of the quantifier, and one introduced by the quantifier. A typical (simplified) example, in which only the structures pertaining to tense are included, is shown for (47). For a complete semantic structure see Appendix D. The *stehen* is represented by $\boxed{\text{A}}$ (the basic condition for the verb has been left out for ease of representation).

(47) Er steht immer.

FIGURE 4: Source Language Semantic Representation

$$
{}_{sem}\left[\begin{array}{ll}
\text{LAMBDA:} & \langle\,\rangle \\
\text{DRS:} & \left[\begin{array}{ll}
\text{DOM:} & \langle\,\rangle \\
\text{CONDS:} & \left\langle {}_{quant\_condition}\left[\begin{array}{ll}
\text{QTR:} & immer \\
\text{RESTR:} & \left[\text{DRS:CONDS:}\langle\,\rangle\right] \\
\text{SCOPE:} & \left[\begin{array}{ll}
\text{DOM:} & \left[\begin{array}{ll}\text{IDENT:} & \boxed{A}\\ \text{SORT:} & dynamisch\_c\end{array}\right]\\
\text{CONDS:} & \left\langle {}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & \boxed{D}\; assoc\\
\text{R\_REL\_S:} & \boxed{E}\; follow\_eq\\
\text{TENSE\_INST:} & \boxed{A}\\
\text{E\_TIME:} & \boxed{A}\\
\text{R\_TIME:} & \boxed{G}\\
\text{S\_TIME:} & \boxed{H}
\end{array}\right]\right\rangle
\end{array}\right]\\
\text{TYPE:} & univ\\
\text{VAR:} & \boxed{C}\\
 & {}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & \boxed{D}\\
\text{R\_REL\_S:} & \boxed{E}\\
\text{TENSE\_INST:} & \left[\begin{array}{ll}\text{IDENT:} & \boxed{C}\\ \text{SORT:} & entitaet\_c\end{array}\right]\\
\text{E\_TIME:} & \boxed{A}\\
\text{R\_TIME:} & \boxed{G}\\
\text{S\_TIME:} & \boxed{H}
\end{array}\right]
\end{array}\right]\right\rangle
\end{array}\right] \\
\text{ANCHORS:} & \left\langle {}_{time\_anchor}\left[\begin{array}{ll}\text{TIME\_PARAM:} & \boxed{H}\\ \text{TIME\_ROLE:} & now\end{array}\right]\right\rangle
\end{array}\right]
$$

FIGURE 5: Target Language Semantic Representation

$$
{}_{sem}\left[\begin{array}{ll}
\text{LAMBDA:} & \langle\ \rangle \\
\text{DRS:} & \left[\begin{array}{ll}
\text{DOM:} & \langle\ \rangle \\
\text{CONDS:} & \left\langle {}_{quant\_condition}\left[\begin{array}{ll}
\text{QTR:} & always \\
\text{RESTR:} & \left[\text{DRS:CONDS:}\langle\ \rangle\right] \\
\text{SCOPE:} & \left[\begin{array}{ll}
\text{DOM:} & \left[\begin{array}{ll} \text{IDENT:} & \boxed{A} \\ \text{SORT:} & dynamisch\_c \end{array}\right] \\
\text{CONDS:} & \left\langle {}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & \boxed{D}\ overlap\_rel \\
\text{R\_REL\_S:} & \boxed{E}\ equal \\
\text{TENSE\_INST:} & \boxed{A} \\
\text{E\_TIME:} & \boxed{A} \\
\text{R\_TIME:} & \boxed{G} \\
\text{S\_TIME:} & \boxed{H} \\
\text{SUR\_TENSE:} & \boxed{B}\ present
\end{array}\right] \right\rangle
\end{array}\right] \\
\text{TYPE:} & univ \\
\text{VAR:} & \boxed{C} \\
 & {}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & \boxed{D} \\
\text{R\_REL\_S:} & \boxed{E} \\
\text{TENSE\_INST:} & \left[\begin{array}{ll} \text{IDENT:} & \boxed{C} \\ \text{SORT:} & entitaet\_c \end{array}\right] \\
\text{E\_TIME:} & \boxed{A} \\
\text{R\_TIME:} & \boxed{G} \\
\text{S\_TIME:} & \boxed{H} \\
\text{SUR\_TENSE:} & \boxed{B}
\end{array}\right]
\end{array}\right] \right\rangle
\end{array}\right] \\
\text{ANCHORS:} & \left\langle {}_{time\_anchor}\left[\begin{array}{ll} \text{TIME\_PARAM:} & \boxed{H} \\ \text{TIME\_ROLE:} & now \end{array}\right] \right\rangle
\end{array}\right]
$$

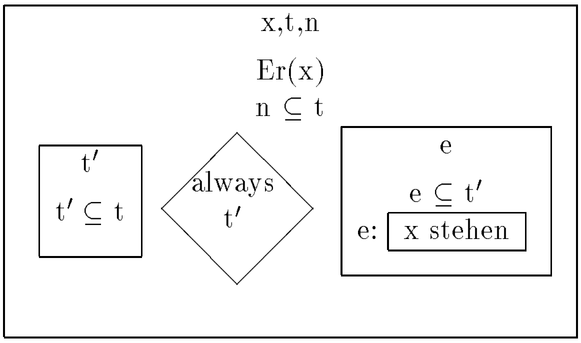
The quantifier does not itself denote an event, so the tense condition of the quantifier is flagged as being nontemporal (*entitaet_c*). The information with regard to the temporal relations that hold between E, R, and S are "copied" up from the embedded tense condition. The connection between the two tense conditions is guaranteed by the fact that they both refer to the same event (e_time).

The details of the copying/raising approach were suggested by K. Eberle to allow an easier integration of the tense module into the transfer component, which simultaneously also allows a more refined treatment of the interaction between temporal adverbs and quantification. It is equivalent to a more modular representation in line with the standard DRT approach, as shown in (48) (see also Bos and McGlashan (1994) for the equivalent formulation within lambda-

DRT). In (48) the

Here the temporal relation between R and S (*t* and *n*) is modeled as a basic condition, and the relation between E and R (*e* and *t'*) lies within the scope of the quantifier. The event thus does not stand in a direct relation to the speech time (*n*), but is distributed around it.

(48)



The copying/raising approach to quantification outlined above models precisely these relations. The quantifier itself does not have tense and does not introduce an event. The event *stehen* is represented in its scope and does introduce a tense condition with specfications for the relations between E, R and S. Since the entire quantificational expression must receive tense, the temporal relations indicated by the morphology of the verb are needed. In order to avoid having to search for the embedded tense condition in the scope of the quantifier, the necessary information is copied/raised and instantiated within the tense condition of the quantifier. Now the English surface tense can be instantiated directly at the level of the quantifier. Thus, unneccessary traversal of the semantic representation is avoided. Since the tense condition of the quantifier and the embedded verb are coindexed, when the surface tense is instantiated in the top (quantifier) tense condition, it is simultaneously instantiated in the embedded tense condition as well.

The fact that the tense condition of a quantifier is flagged as nontemporal allows a triggering of special rules needed for the present tense. As we saw above, German present tense sentence are generally ambiguous between a present and future reading. Furthermore, depending on the Aktionsart of the verb, either a simple present, or a present progressive is appropriate in English. Quantified present tense sentences, however, can only be realized in the simple habitual present tense.

(49) Ich mache immer montags Termine aus.
I always make appointments on Mondays.
*I am always making appointments on Mondays.
*I will always make appointments on Mondays.

The flagging of the tense condition for the quantifier as nontemporal instantiates the special rules in 13 and 14. The rule in 13 ensures that (49) will be realized in the English present tense.

13. Quantification without Temporal Adverb → Present

```
saturate_tense1(assoc,follow_eq,entitaet_c,##,~st_dist) =>
      r_rel_s : equal &
      sur_tense:present.
```

14. Quantification with Temporal Adverb → Future

```
saturate_tense1(assoc,follow_eq,entitaet_c,##,st_dist) =>
       r_rel_s : follow &
       sur_tense:fut.
```

The rule in 14 allows for cases like (50), in which the temporal adverb situates the set of appointment-making events in the next year.

(50) Nächstes Jahr mache ich immer montags Termine aus.
Next year I'll make appointments on Mondays.

Some interesting problems with regard to scope arise in the interaction between quantification and temporal adverbs. In (51), the quantifier has scope over the temporal adverb and cannot be used to loacte the set of events in the future.

(51) Jedes Jahr mache ich am ersten April Termine aus.
I make appointments on the first of April every year.
*I will make appointments on the first of April every year

Examples of this type are not a problem for the present approach because the *tloc* slot of the embedded tense condition is not raised/copied into the tense condition of the quantifier (see Figures 4 and 5). In (50), on the other hand, the temporal adverb *nächstes Jahr* has scope over the quantifier, so the *tloc* is instantiated in the tense condition of the quantifier, and can be used to interpret the German present morphology as future.

Thus, the contrast between (50) and (51) does not present a problem in principle. One question that remains to be tackled, however, is the correct determination of scope. Scope cannot be determined solely on syntactic information, as the precise syntactic position of the temporal adverb is not necessarily a good indication: the scope relations in (52) are the same as in (51), despite the differing placement of the adverb.

(52) Am ersten April mache ich jedes Jahr Termine aus.
I make appointments on the first of april every year.
*I will make appointments on the first of april every year

For the second phase of the project, we therefore propose to evaluate the scope relations on the basis of sortal information modeled in the world knowledge base: greater time intervals (e.g., a year) always take scope over time intervals contained within them (e.g., a day of a month).

6.2 Quantifier or Locational Adverb?

Given that the Verbmobil scenario concentrates on dialogs whose purpose it is to schedule apppointments, adverbs like *montags*, and *werktags* are very common. Buschbeck-Wolf, Egg, and Herweg (1994) first pointed out the systematic ambiguity that these types of adverbs produce. For example (53) can be interpreted either as (54a), (54b), or (54c).[19]

(53) Ich mache montags Termine aus.

(54) a. What I do on Mondays is to make appointments.

b. When I make appointments, I schedule them on Mondays.

c. I will make appointments on Monday.

That is, *montags* can either function as a simple locational adverb ((54c)), or as a frequential/quantificational adverb in (54a,b). In (54a) *montags* is in the restrictor of the quantifier, in (54b) it is in the scope, thus giving rise to the differing interpretations. A close scrutiny of the Verbmobil corpora reveals that the preferred reading for *montags* is actually (54c) (see (55)). This poses a problem for an analysis of *montags* as a quantificational adverb.

(55) a. D2:13:b ... aber am sechsten April **dienstags** have ich den ganzen Tag Zeit
E2:23:b ... but on the sixth of April, **Tuesday**, I still have time the whole day

b. D4:09 ich habe Dienstag nur **vormittags** eine Vorlesung
E4:09 I only have class **in the morning** on Tuesday.

In fact, adverbs like *montags* should not be analysed as inherently quantificational. The example in (56) shows that *montags*, *werktags*, etc., can occur in the scope of a quantifier. This is not possible with true quantifiers.

(56) Wir machen immer montags/werktags/*meistens Termine aus.

[19] Buschbeck-Wolf et al. actually focus on a further reading: *I schedule appointments which take place on a Monday.* This reading is not available in (53), and so I will not elaborate on it here.

This suggests that adverbs like *montags* should be analysed primarily as locational, with the fundamental ambiguity in German consisting of the fact that *montags* can denote either a single, definite Monday, or a set of Mondays. It can be either existentially bound, or quantified over. The generic (quantificational) reading of *montags* in sentences without an overt quantifier is induced contextually through a non-overt quantifier (c.f. Heim (1982)). For an analysis which naturally relates sets of location (reference) times to an eventuality, see de Swart's (1991) analysis of temporal connectives under a generalized quantifier approach.

7 Negation

There are no temporal effects analagous to those found with quantification for negation. Therefore, in cases of negation the tense rules for the simple transfer cases apply as described in the section on tense.

In the Semantic Formalism, as in standard DRT, negation is analysed as an operator which results in a complex condition. The treatment of the tense condition with regard to negation thus parallels the strategy employed for quantification: the tense condition of the verb is raised/copied to the DRS of the negative operator. For some examples see Appendix D.

While negation does not play a great role within the Verbmobil scenario, there are some interesting and difficult problems to resolve with regard to the interaction of negation, tense, and aspect (de Swart 1994a) which we would like to focus on as well in the next phase of the project.

8 Modals and Conditionals

From a translational point of view, modals and conditionals are extremely straightforward. Modals like *können*, *wollen*, *sollen* always map to *can, want*, and *should.* Subjunctive modals like *könnten*, *wären*, and *sollten* can always be translated with *could*, *would*, and *should.*

In the Semantic Formalism, modals are represented as complex conditions in a *modal condition* whose basic structure is shown in below (Bos and McGlashan 1994).[20]

$$\begin{bmatrix} \textsc{modal\_op}: & \textit{modal\_op} \\ \textsc{modal\_pred}: & \textit{pred\_name} \\ \textsc{inst}: & \textit{marker} \\ \textsc{modal\_arg}: & \textit{drs} \end{bmatrix}_{modal\_condition}$$

The *modal_op* indicates the type of modality expressed, the *modal_pred* contains the predicate name of the modal (*können* in (57)). The *modal_arg* contains the DRS that the modal modifies.

With respect to tense, a tense condition each is constructed for the modal and the embedded main verb. The speech time (s_time) in each tense condition is the speech time specified contextually (in the *anchors* feature). The tense condition of the embedded verb remains underspecified and is assigned a value of *nonfin*(inite) for the English surface tense. For the modal a finite surface tense value is instantiated according to the tense transfer rules described above. The presence of temporal adverbs has no effect on tense realization because modals are consistently analysed as states. Semantic representations (source and target language) for the example in (57) are shown in Figures 6 and 7. The nonfinite verb *kommen* is represented by $\boxed{\text{B}}$.

(57) Er kann kommen.

[20] Though the structure of a modal condition in the current implementation differs somewhat from the structure described in Bos and McGlashan (1994), we abstract away from these differences here.

FIGURE 6: Source Language Semantic Representation

$$
{}_{sem}\left[\begin{array}{ll}
\text{LAMBDA:} & \langle\,\rangle \\
\text{DRS:} & \left[\begin{array}{ll}
\text{DOM:} & \left[\begin{array}{ll} \text{IDENT:} & \boxed{A} \\ \text{SORT:} & statisch\_c \end{array}\right] \\
\text{CONDS:} & \left\langle \begin{array}{l}
{}_{modal\_condition}\left[\begin{array}{ll}
\text{MODAL\_OP:} & poss \\
\text{MODAL\_PRED:} & koennen \\
\text{MODAL\_INST:} & \boxed{A} \\
\text{MODAL\_ARG:} & \left[\begin{array}{ll}
\text{DOM:} & \left[\begin{array}{ll} \text{IDENT:} & \boxed{B} \\ \text{SORT:} & dynamisch\_c \end{array}\right] \\
\text{CONDS:} & \left\langle {}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & assoc \\
\text{R\_REL\_S:} & assoc \\
\text{TENSE\_INST:} & \boxed{B} \\
\text{E\_TIME:} & \boxed{B} \\
\text{R\_TIME:} & \boxed{C} \\
\text{S\_TIME:} & \boxed{D}
\end{array}\right] \right\rangle
\end{array}\right]
\end{array}\right] \\
{}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & assoc \\
\text{R\_REL\_S:} & follow\_eq \\
\text{E\_TIME:} & \boxed{A} \\
\text{TENSE\_INST:} & \boxed{A} \\
\text{R\_TIME:} & \boxed{C} \\
\text{S\_TIME:} & \boxed{D}
\end{array}\right]
\end{array} \right\rangle
\end{array}\right] \\
\text{ANCHORS:} & \left\langle {}_{time\_anchor}\left[\begin{array}{ll} \text{TIME\_PARAM:} & \boxed{D} \\ \text{TIME\_ROLE:} & now \end{array}\right] \right\rangle
\end{array}\right]
$$

FIGURE 7: Target Language Semantic Representation

$$
\left[\begin{array}{ll}
\text{LAMBDA:} & \langle\,\rangle \\
\text{DRS:} & \left[\begin{array}{ll}
\text{DOM:} & \left[\begin{array}{ll} \text{IDENT:} & \boxed{A} \\ \text{SORT:} & statisch\_c \end{array}\right] \\
\text{CONDS:} & \left\langle \begin{array}{l}
{}_{modal\_condition}\left[\begin{array}{ll}
\text{MODAL\_OP:} & poss \\
\text{MODAL\_PRED:} & can \\
\text{MODAL\_INST:} & \boxed{A} \\
\text{MODAL\_ARG:} & \left[\begin{array}{ll}
\text{DOM:} & \left[\begin{array}{ll} \text{IDENT:} & \boxed{B} \\ \text{SORT:} & dynamisch\_c \end{array}\right] \\
\text{CONDS:} & \left\langle {}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & assoc \\
\text{R\_REL\_S:} & assoc \\
\text{TENSE\_INST:} & \boxed{B} \\
\text{E\_TIME:} & \boxed{B} \\
\text{R\_TIME:} & \boxed{C} \\
\text{S\_TIME:} & \boxed{D} \\
\text{SUR\_TENSE:} & nonfin
\end{array}\right] \right\rangle
\end{array}\right]
\end{array}\right] \\
{}_{tense\_condition}\left[\begin{array}{ll}
\text{E\_REL\_R:} & assoc \\
\text{R\_REL\_S:} & follow\_eq \\
\text{E\_TIME:} & \boxed{A} \\
\text{TENSE\_INST:} & \boxed{A} \\
\text{R\_TIME:} & \boxed{C} \\
\text{S\_TIME:} & \boxed{D} \\
\text{SUR\_TENSE:} & present
\end{array}\right]
\end{array} \right\rangle
\end{array}\right] \\
\text{ANCHORS:} & \left\langle {}_{time\_anchor}\left[\begin{array}{ll} \text{TIME\_PARAM:} & \boxed{D} \\ \text{TIME\_ROLE:} & now \end{array}\right] \right\rangle
\end{array}\right]_{sem}
$$

The surface tense for the two tense conditions is instantiated as nonfinite and present for the embedded verb *kommen* and the modal *kann*, respectively.

Though modals are quite straightforward with respect to tense and transfer, several complications arose in the implementation.[21] One of the more interesting ones, and one which has not as yet received a satisfactory solution, is the

[21] C.J. Rupp (IMS-Stuttgart) undertook the initial integration of the tense module into the Semantic Construction, and both he and K. Eberle have played a crucial role in the subsequent stages of further integration and bug-fixing. According to the original agreement on the integration of the tense and aspect module, Tübingen and IBM (for Aktionsart) were supposed to deliver precise specifications and idealized macros based on access predicates for the integration of the module. The intention was that the user would not have to be concerned with the implementational details of the Semantic Construction, allowing room for internal changes without direct consequences for users interfacing with the formalism. In actual practice, however, it has turned out not only to be more efficient, but crucial in terms of time and communication, to work directly with the source STUF files and to implement changes and additions on site before sending them on to be integrated centrally.

problem posed by conditionals (subjunctives) like *könnte*, *sollte*, and *ständen*. For one, all of these are analyzed as past tense in the syntax because of their morphological form. The rules which map from the syntactic information in the *mtv* (mood, tense, voice) access predicate to temporal relations therefore initially assigned *precede* as the relation between R and S and situated all conditionals squarely in the past. And while it could be argued that at least *sollte* in principle has a past tense reading, in actual fact, none of the conditionals in question are ever used in the past tense in the Verbmobil dialogs. Examples are shown in (58).

(58) a. D7:05b dann **sollten** wir unseren Termin davor ausmachen
E7:05b then we **should** arrange for our appointment before then

b. D7:03a Anfang Juli **hätte** ich noch Zeit
E7:03a I **would** still **have** time at the beginning of July

This problem is circumvented easily for most of the conditionals by taking mood into account in addition to the morphological tense in the mapping from syntax to temporal relations.

A further problem are subjunctive main verbs like *ständen*, *bräuchten*, or *hätte* in (58b). In the Semantic Construction, the subjunctive is analysed as a modal which embeds a predicate. In cases like (59), this analysis is unproblematic as there is both a subjunctive (*würde*), and a predicate which it modifies (*ausmachen*).

(59) Ich **würde** gerne einen Termin **ausmachen**.

In cases like (58b), the *hätte* embodies both the subjunctive and the main predicational verb (*haben*) of the sentence, and is split up accordingly in the semantic representation: a *modal_pred* whose value is *subjunctive* (the value of the *modal_op* is *poss*(ibility)) modifies the predicate *haben*. With regard to tense, this arrangement is highly problematic because both the subjunctive and the embedded predicate need to receive a tense condition, and yet the syntax only provides morphological tense information for only one verb. Within the current implementation, there is no straightforward way of assigning an underspecified (infinitive) tense condition to *haben* in (58b).

While this problem can be solved by means of a more elaborate implementation with respect to tense, we would like to suggest that it actually thematizes a further problem with the current analysis of the subjunctive as a modal. In the Verbmobil dialogs the subjunctive is generally used as an indicator of politeness, and does not correspond strictly to the semantic interpretation it must receive as a modal operator. The sentence in (60), for example, should not receive a modal analysis, as it is truthconditionally equivalent to (61) in this context.

(60) D7:03a Anfang Juli **hätte** ich noch Zeit
E7:03a I **would** still **have** time at the beginning of July

(61) Anfang Juli **habe** ich noch Zeit
I still **have** time at the beginning of July

This *politeness subjunctive* needs to be taken into account as well as modality, and in fact is the one more common to the current scenario. We would like to suggest that the subjunctive not be analysed in parallel to modals like *can*, *may*, as these modals themselves interact with the subjunctive. Rather, the subjunctive would appear to be an added dimension which should be encoded in another type of condition (e.g., the subjunctivity introduced by *if*-clauses is represented by a complex boolean condition) which can interact with the modal condition, rather than be represented within it.

Note that subjunctivity would not be placed in connection with a tense condition at all under this scenario. With subjunctives, as with conditional *if*-phrases, the subjunctive morphology must be instantiated by the generation component on the basis of information outside of the tense condition. This allows the necessary flexibility needed for generating politeness subjunctives as well as true conditionals.

9 Summary

The approach to the transfer of temporal and aspectual phenomena presented here allows a broad coverage of the Verbmobil corpora, while maintaining monotonocity. A tense condition within a DRS is constructed compositionally through a lexical specification of Reichenbachian temporal relations in the semantic lexicon, and information about the morphological tense of a predicate that is provided by the syntax. The compositional construction of tense conditions is realized in parallel with the Semantic Construction. The subsequent evaluation and instantiation of the English surface tense takes place within the Transfer module. The instantiation of target language tense also takes into account the interaction of tense with temporal adverbs, quantification, and negation. In particular, temporal adverbs serve to disambiguate the German present tense.

Since our primary focus for the Demonstrator was the German present tense, the system naturally needs be extended to allow a more complete treatment of tense and aspect in the second phase of the project. The extension is planned in terms of a greater reliance on Aktionsart, the use of a calendar model and world knowledge (modeled in BACK/FLEX) to allow a more precise evaluation of temporal relations and a modeling of temporal anaphora.

The treatment presented here has been necessarily restricted in these respects because of the fact that contextual information has not been available in the first phase of the project. Nevertheless, the coverage of phenomena is much more extensive than planned originally in the grant proposal, which hoped to realize only a prototypical implementation of transfer rules for tense. Instead, a well motivated modeling of temporal relations, and a subsequent instantiation of English surface tense has been achieved for the bulk of the phenomena encountered in the Verbmobil corpora. In addition, transfer rules for deictic and anaphoric adverbs were formulated which provide adequate translations despite the fact that the anaphoric resolution of these adverbs will only become possible in the second phase of the project.

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Appendix

A Instantiation of Target Language Tense

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%  English Surface Tense instantiated as part of the recursive
%%  transfer statement (IMS-Stuttgart)

@trs(top) => list. % list;sign=top
trs([]) => [].

trs([#F&prag:#P|#R]) =>
        [sem:(saturate_sem(tau(#F,[]))&surface_tense)&prag:#P|trs(#R)].

% for single words!
trs(#Sign&sign) => trs([#Sign]).


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Information contained in the tense_condition is used to determine
% surface tense: type of tense_condition (quantificational or not),
% E,R,S relations, stative vs. dynamic (to be replaced
% by aktionsarten information later), and whether or not temporal
% adverbials are present.

% Extracts the information necessary  from a tense condition for the
% evaluation and instantiation of English surface tense.
@saturate_tense => tense_condition.
saturate_tense =>  (e_rel_r:#ER & r_rel_s:#RS & tense_inst:sort:#TIS &
                    e_time:sort:#ES & tloc:#TL) &
                    saturate_tense1(#ER,#RS,#TIS,#ES,#TL).


@saturate_tense1(tense_rel,tense_rel,dm_sort,dm_sort,tloc_type) =>
                   tense_condition.


%% Infinitives: (MJB)
saturate_tense1(#X,#Y,##,##,##) =>
      true(sub_tense(#X)&assoc) &
      true(sub_tense(#Y)&assoc) &
      sur_tense:nonfin.
```

```
% Quantification is checked by seeing if it is temporal - if the
% tense_inst is marked as an entitaet_c, then there is quantification
% An instantiation of sur_tense here automatically also saturates
% the sur_tense in the tense_condition of the scope, as they are
% coindexed.

% Quantification
saturate_tense1(#X,equal,#Y,##,~st_dist) =>
      true(sub_tense(#X)&assoc) & true(subsumes(#Y)&entitaet_c) &
      sur_tense:present.
saturate_tense1(#X,follow,#Y,##,sub_tense(st_dist)) =>
       true(sub_tense(#X)&assoc) & true(subsumes(#Y)&entitaet_c) &
       sur_tense:fut.


% Negation and positive cases

% Present of dynamic verbs -> Present Progressive
saturate_tense1(~precede,sub_tense(follow_eq),subsumes(temporal_c),dynamisch_c,
                         ~st_dist&~st_perf& ~st_prec) =>
               cp_tcond(e_rel_r:overlap_rel & r_rel_s:equal) &
               sur_tense:presprog.

% Present of stative verbs -> Present
saturate_tense1(~precede,sub_tense(follow_eq),subsumes(temporal_c),statisch_c,
                         ~st_dist& ~st_perf& ~st_prec) =>
      cp_tcond(e_rel_r: overlap_rel) &
      cp_tcond(r_rel_s: equal) &
      sur_tense:present.

% Present of stative verbs with temporal adverb -> Present
saturate_tense1(~precede,sub_tense(follow_eq),subsumes(temporal_c),statisch_c,
                         sub_tense(st_dist)) =>
      e_rel_r : overlap_rel &
      r_rel_s: follow &
      sur_tense:present.

% disambiguation by imagined context and future -> future
saturate_tense1(~precede,sub_tense(follow),subsumes(temporal_c),##,
                         ~st_dist& ~st_equ& ~st_perf& ~st_prec) =>
```

```
      cp_tcond(e_rel_r:overlap_rel & r_rel_s:follow) &
      sur_tense:fut.


% Present Disambiguated to future by temporal adverbial -> future
saturate_tense1(~precede,sub_tense(follow_eq),subsumes(temporal_c),dynamisch_c,
                         sub_tense(st_dist)) =>
      cp_tcond(e_rel_r:overlap_rel & r_rel_s:follow) &
      sur_tense:fut.


% checks for st_prec (gestern, etc.)

saturate_tense1(~precede,follow_eq,temporal_c,dynamisch_c,
                         sub_tense(st_prec)) =>
     (sur_tense:presprog&
      e_rel_r:overlap_rel&
      r_rel_s:equal).

saturate_tense1(~precede,follow_eq,temporal_c,statisch_c,
                         sub_tense(st_prec)) =>
     (sur_tense:present&
      e_rel_r:overlap_rel&
      r_rel_s:equal).

% Perfect reading introduced by seitdem and similar items -> perfect
saturate_tense1(precede,sub_tense(follow_eq),subsumes(temporal_c),##,
                        sub_tense(st_perf)) =>
      cp_tcond(r_rel_s: equal) &
      sur_tense:presperf.

%% German pres perf -> simple past
saturate_tense1(sub_tense(precede),equal,##,##,##) =>
      sur_tense:spast.

%% German praeteritum of dynamic verbs -> past progressive
saturate_tense1(overlap_rel,sub_tense(precede),##,dynamisch_c,##) =>
      sur_tense:pastprog.

%% German praeteritum -> simple past
saturate_tense1(overlap_rel,sub_tense(precede),##,statisch_c,##) =>
      sur_tense:spast.
```

B Transfer Rules for Adverbs

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% day of the week: heute, morgen, uebermorgen, gestern, vorgestern

tau_lex(gestern, yesterday, [tau(#Mod,#Args)],#Args,mod([#Mod])) => sem_t.

tau_lex(heute, today, [tau(#Mod,#Args)],#Args,mod([#Mod])) => sem_t.

tau_lex(morgen, tomorrow, [tau(#Mod,#Args)],#Args,mod([#Mod])) => sem_t.

tau_lex(uebermorgen, day_after_tomorrow,
        [tau(#Mod,#Args)],#Args,mod([#Mod])) => sem_t.

tau_lex(vorgestern, day_before_yesterday,
        [tau(#Mod,#Args)],#Args,mod([#Mod])) => sem_t.


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Temporal (deictic,anaphoric) Adverbs
% bald, sofort, soeben, kuerzlich, neulich, vorhin
%
% bald, damals, eben, irgendwann, neulich
%
% einstweilen, kuerzlich, nachher, seinerzeit, seitdem, soeben, sofort
% unterdessen, vorher, vorhin, zwischendurch,

tau_lex(bald, soon, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(damals, then,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(einstweilen, for_the_time_being,
        [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(irgendwann, at_some_point,
        [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(kuerzlich, recently,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(nachher, afterwards,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(neulich, the_other_day,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.
```

```
tau_lex(seinerzeit, at_that_time,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(seitdem, since_then, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(soeben, just_now, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(sofort, right_away,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(unterdessen, in_the_meantime, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(vorher, before_then, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(vorhin, a_little_while_ago,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(zwischendurch, in_between,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% gleich
%
% 1) right_away  "Ich komme gleich, ich sage gleich Bescheid"
% 2) right (on, at)  "gleich am Montag, gleich um 10, gleich hier"


% gleich as focus adverb
tau_lex(gleich1, right, [tau(#Mod,#Args)],#Args, mod([#Mod]))  => sem_t.

% gleich as a temporal adverb
tau_lex(gleich2, right_away, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.



%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%  gerade/grade
%
%  The rules here cover the data in the BB
%  dialogs, however, "gerade" shows some very
%  interesting properties with regard to
%  Aktionsarten and the Progressive, which
%  will need to be taken into account for the Prototyp.
%
%  Also, the parameter of punctuality should be
```

```
%  factored in:
%  ich sehe gerade -> I've just noticed  (punctual)
%  ich erklaere gerade  -> I'm just explaining (non-punctual)
%
%  The tendency of "gerade" to be interpreted as a
%  past adverb (I was just explaining...), appears to
%  be context dependent and has not been taken into account.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% States in the "future"
% Da ist gerade Fasching -> Fasching is right then.

tau_lex(gerade, right, [tau(#Mod,#Args)],#Args, mod([#Mod])
   & (sem: ip: idx: sort:  statisch_c)
   & (sem: drs: conds: [alfa_cond(sort: zeit_c,alfa_type_val,list)])) => sem_t.

tau_lex(gerade, right, [tau(#Mod,#Args)],#Args, mod([#Mod])
  & (sem: ip: idx: sort:  statisch_c)
  & (sem: drs: conds: [rigid_cond(rd_pred_val,top,sort:raum_zeit_c)]))=> sem_t.

% States in the present
% Wo bist Du gerade -> where are you now
% For the moment also modals:
% Sie muessten mir nur noch grade den Weg erklaeren ->
% You would only/just have to tell me how to get there now

tau_lex(gerade, now, [tau(#Mod,#Args)],#Args, mod([#Mod])
        & (sem: ip: idx: sort: statisch_c)) => sem_t.

% All other cases
tau_lex(gerade, just, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% mal, einmal
%
% In the context of the dialogs, "mal" functions as discourse
% particles which can have no overt realization in English.
% "einmal" functions as a quantifying adverb.

tau_lex(mal, null_pred,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

tau_lex(einmal, once,  [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% dann -> then
%

tau_lex(dann, then, [tau(#Mod,#Args)],#Args, mod([#Mod])) => sem_t.
```

C English Semantic Lexical Entries for Adverbs

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% day of the week:
% today, tomorrow, day_after_tomorrow, yesterday, day_before_yesterday

sem_lex(day_after_tomorrow, #Args) => temporal_adv_sem1(day_after_tomorrow,
   temploc(rel(st,temporal_point_anterior_rel,temporal_inclusion_rel)), #Args).

sem_lex(today, #Args) => temporal_adv_sem1(today,
   temploc(rel(st,dur_temporal_inclusion_rel,temporal_inclusion_rel)), #Args).

sem_lex(tomorrow, #Args) =>  temporal_adv_sem1(tomorrow,
   temploc(rel(st,temporal_point_anterior_rel,temporal_inclusion_rel)), #Args).

sem_lex(yesterday, #Args) => temporal_adv_sem1(yesterday,
   temploc(rel(st,temporal_point_posterior_rel,temporal_inclusion_rel)) #Args).

sem_lex(day_before_yesterday, #Args) => temporal_adv_sem1(day_before_yesterday,
   temploc(rel(st,temporal_point_posterior_rel,temporal_inclusion_rel)),#Args).


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Temporal Adverbs (deictic and anaphoric)
%
% afterwards,  a_little_while_ago,
% at_some_point, at_that_time, back_then,
% before, before_then, for_the_time_being, in_between,
% in_the_meantime, just, just_now, now, recently
% right_away, since_then, soon, then,  the_other_day


sem_lex(afterwards, #Args) => temporal_adv_sem1(afterwards,
   temploc(rel(rt,temporal_point_anterior_rel,temporal_inclusion_rel)), #Args).

sem_lex(a_little_while_ago, #Args) => temporal_adv_sem1(a_little_while_ago,
   temploc(rel(rt,temporal_point_posterior_rel,temporal_inclusion_rel)),#Args).

sem_lex(at_some_point, #Args) => pronoun_adv_sem1(at_some_point,
        zeit_c,std,temporal_rel,#Args).

sem_lex(at_that_time, #Args) => temporal_adv_sem1(at_that_time,
```

```
    temploc(rel(st,temporal_point_posterior_rel,temporal_inclusion_rel)),#Args).

sem_lex(back_then, #Args) => temporal_adv_sem1(back_then,
    temploc(rel(rt,temporal_point_posterior_rel,temporal_inclusion_rel)),#Args).

sem_lex(before_then, #Args) => temporal_adv_sem1(before_then,
    temploc(rel(rt,temporal_point_posterior_rel,temporal_inclusion_rel)),#Args).

sem_lex(for_the_time_being, #Args) => temporal_adv_sem1(for_the_time_being,
   temploc(rel(st,dur_temporal_inclusion_rel,dur_temporal_inclusion_rel)),#Args).

sem_lex(in_between, #Args) => temporal_adv_sem1(in_between,
     temploc(rel(rt,dur_temporal_inclusion_rel,dur_temporal_inclusion_rel)),#Args).

sem_lex(in_the_meantime, #Args) => temporal_adv_sem1(in_the_meantime,
   temploc(rel(st,dur_temporal_inclusion_rel,dur_temporal_inclusion_rel)), #Args).

sem_lex(just_now, #Args) => temporal_adv_sem1(just_now,
   temploc(rel(st,dur_temporal_inclusion_rel,temporal_inclusion_rel)), #Args).

sem_lex(recently, #Args) => temporal_adv_sem1(recently,
    temploc(rel(rt,temporal_point_posterior_rel,temporal_inclusion_rel)),#Args).
sem_lex(right_away, #Args) => temporal_adv_sem1(right_away,
   temploc(rel(rt,temporal_point_anterior_rel,temporal_inclusion_rel)), #Args).

sem_lex(since_then, #Args) => temporal_adv_sem1(since_then,
  temploc(rel(rt,temporal_point_posterior_rel, temporal_inclusion_rel)), #Args).

sem_lex(soon, #Args) => temporal_adv_sem1(soon,
   temploc(rel(rt,temporal_point_anterior_rel,temporal_inclusion_rel)), #Args).

sem_lex(then, #Args) => temporal_adv_sem1(then,
    temploc(rel(rt,temporal_point_anterior_rel,temporal_inclusion_rel)),#Args).

sem_lex(the_other_day, #Args) => temporal_adv_sem1(the_other_day,
    temploc(rel(rt,temporal_point_posterior_rel,temporal_inclusion_rel)), #Args).
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% right (on/at)
% Treat like an intensifier
%
% "I'll come right at ten"
% "Let's make it right here"

sem_lex(right, #Args) => focus_adv_sem1(right, ##, #Args).


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% once

sem_lex(once,#Args)  => temporal_adv_sem1(once,quant(exist), #Args).
```

D Sample Transfer Outputs

Present Tense

```
| ?- tsp("wir machen einen termin aus").
 wir machen einen termin aus
%%% used time (msec): 4183
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[(A &
                     marker &
                     snumber:individual &
                     sort:veranstaltung_c),
                    (B &
                     marker &
                     sort:dynamisch_c)] &
               conds:[(alfa_condition &
                       alfa_arg:(C &
                                 marker &
                                 snumber:collective &
                                 sort:person_c) &
                       alfa_type:std &
                       alfa_restr:(drs_t &
                                   dom:[C] &
                                   conds:[])),
                      (basic_condition &
                       pred:appointment &
                       inst:A &
                       args:[]),
                      (D &
                       basic_condition &
                       pred:arrange &
                       inst:B &
                       args:[(arg_role &
                              arg:C &
                              role:agent_rel),
                             (arg_role &
                              arg:A &
```

```
                                role:theme_rel)]),
                        (tense_condition &
                         e_rel_r:overlap_rel &
                         e_time:B &
                         r_rel_s:equal &
                         r_time:(marker &
                                 sort:temporal_c) &
                         s_time:(E &
                                 marker &
                                 sort:temporal_c) &
                         sur_tense:presprog &
                         tense_inst:B &
                         tloc:(tloc_type & ~st_dist & ~st_perf &~st_prec))]) &
          quants:[] &
          anchors:[(disc_anchor &
                    param:C &
                    discourse_role:speaker_hearer),
                   (time_anchor &
                    time_param:E &
                    time_role:now)] &
          ip:(ip_t &
              cond:D &
              idx:B) &
          persp:(persp_t &
                 p_inst:B)) &
     prag:(prag_t &
           imp:no &
           key_wds:[] &
           prosody:prosody_val &
           verb_position:verb2 &
           whq:no))]
```

Present Tense Interaction with a Temporal Adverb

```
| ?- tsp("wir machen uebermorgen einen termin aus").
 wir machen uebermorgen einen termin aus
%%% used time (msec): 4083
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[(A &
                     marker &
                     snumber:individual &
                     sort:veranstaltung_c),
                    (B &
                     marker &
                     sort:dynamisch_c)] &
               conds:[(alfa_condition &
                       alfa_arg:(C &
                                 marker &
                                 snumber:collective &
                                 sort:person_c) &
                       alfa_type:std &
                       alfa_restr:(drs_t &
                                   dom:[C] &
                                   conds:[])),
                      (basic_condition &
                       pred:appointment &
                       inst:A &
                       args:[]),
                      (D &
                       basic_condition &
                       pred:arrange &
                       inst:B &
                       args:[(arg_role &
                              arg:C &
                              role:agent_rel),
                             (arg_role &
                              arg:A &
                              role:theme_rel)]),
                      (tense_condition &
                       e_rel_r:overlap_rel &
```

```
                    e_time:B &
                    r_rel_s:follow &
                    r_time:(marker &
                            sort:temporal_c) &
                    s_time:(E &
                            marker &
                            sort:temporal_c) &
                    sur_tense:fut &
                    tense_inst:B &
                    tloc:st_dist),
                   (basic_condition &
                    pred:timeloc &
                    inst:B &
                    args:[(arg_role &
                           arg:(F &
                                marker) &
                           role:temporal_inclusion_rel)]),
                   (basic_condition &
                    pred:day_after_tomorrow &
                    inst:F &
                    args:[(arg_role &
                           arg:E &
                           role:temporal_point_anterior_rel)])]) &
     quants:[] &
     anchors:[(disc_anchor &
               param:C &
               discourse_role:speaker_hearer),
              (time_anchor &
               time_param:E &
               time_role:now)] &
     ip:(ip_t &
         cond:D &
         idx:B) &
     persp:(persp_t &
            p_inst:B)) &
prag:(prag_t &
      imp:no &
      key_wds:[] &
      prosody:prosody_val &
      verb_position:verb2 &
      whq:no))]
```

Past Tense

```
| ?- tsp("ich dachte an den achten").
 ich dachte an den achten
%%% used time (msec): 8667
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[(A &
                     marker &
                     sort:dynamisch_c)] &
               conds:[(alfa_condition &
                       alfa_arg:(B &
                                 marker &
                                 snumber:individual &
                                 sort:mensch_c) &
                       alfa_type:std &
                       alfa_restr:(drs_t &
                                   dom:[B] &
                                   conds:[])),
                      (alfa_condition &
                       alfa_arg:(C &
                                 marker &
                                 sort:datum_c) &
                       alfa_type:anaphor &
                       alfa_restr:(drs_t &
                                   dom:[C] &
                                   conds:[(rigid_condition &
                                           rigid_pred:dofm &
                                           rigid_inst:C &
                                           designator:8)])),
                      (D &
                       basic_condition &
                       pred:think_of &
                       inst:A &
                       args:[(arg_role &
                              arg:B &
                              role:agent_rel),
                             (arg_role &
                              arg:C &
```

```
                              role:of_rel)]),
                         (tense_condition &
                          e_rel_r:overlap_rel &
                          e_time:A &

                          r_rel_s:precede &
                          r_time:(marker &
                                  sort:temporal_c) &
                          s_time:(E &
                                  marker &
                                  sort:temporal_c) &
                          sur_tense:pastprog &
                          tense_inst:A &
                          tloc:tloc_type)]) &
            quants:[] &
            anchors:[(disc_anchor &
                       param:B &
                       discourse_role:speaker),
                      (time_anchor &
                       time_param:E &
                       time_role:now)] &
            ip:(ip_t &
                cond:D &
                idx:A) &
            persp:(persp_t &
                   p_inst:A)) &
       prag:(prag_t &
             imp:no &
             key_wds:[] &
             prosody:prosody_val &
             verb_position:verb2 &
             whq:no))]
```

Future

```
| ?- tsp("wir werden uns treffen").
 wir werden uns treffen
%%% used time (msec): 4250
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[(A &
                     marker &
                     sort:dynamisch_c)] &
               conds:[(alfa_condition &
                       alfa_arg:(B &
                                 marker &
                                 snumber:collective &
                                 sort:person_c) &
                       alfa_type:std &
                       alfa_restr:(drs_t &
                                   dom:[B] &
                                   conds:[])),
                      (C &
                       basic_condition &
                       pred:meet1 &
                       inst:A &
                       args:[(arg_role &
                              arg:B &
                              role:agent_rel)]),
                      (tense_condition &
                       e_rel_r:overlap_rel &
                       e_time:A &
                       r_rel_s:follow &
                       r_time:(marker &
                               sort:temporal_c) &
                       s_time:(D &
                               marker &
                               sort:temporal_c) &
                       sur_tense:fut &
                       tense_inst:A &
                       tloc:(tloc_type & ~st_dist & ~st_equ & ~st_perf & ~st_prec))])
          quants:[] &
```

```
      anchors:[(disc_anchor &
                 param:B &
                 discourse_role:speaker_hearer),
                (time_anchor &
                 time_param:D &
                 time_role:now)] &
      ip:(ip_t &
          cond:C &
          idx:A) &
      persp:(persp_t &
             p_inst:A)) &
prag:(prag_t &
      imp:no &
      key_wds:[] &
      prosody:prosody_val &
      verb_position:verb2 &
      whq:no))]
```

Modal

```
| ?- tsp("er kann kommen").
 er kann kommen
%%% used time (msec): 4700
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[(A &
                     marker &
                     sort:statisch_c)] &
               conds:[(modal_condition &
                       modal_op:poss &
                       modal_pred:can &
                       modal_inst:A &
                       modal_arg:(drs_t &
                                  dom:[(B &
                                        marker &
                                        sort:dynamisch_c)] &
                                  conds:[(alfa_condition &
                                          alfa_arg:(C &
                                                    marker &
                                                    snumber:individual &
                                                    sort:person_c) &
                                          alfa_type:anaphor &
                                          alfa_restr:(drs_t &
                                                      dom:[C] &
                                                      conds:[])),
                                         (D &
                                          basic_condition &
                                          pred:come &
                                          inst:B &
                                          args:[(arg_role &
                                                 arg:C &
                                                 role:agent_rel)]),
                                         (tense_condition &
                                          e_rel_r:tense_rel &
                                          e_time:B &
                                          r_rel_s:assoc &
```

```
                                    r_time:(marker &
                                            sort:temporal_c) &
                                    s_time:(E &
                                            marker &
                                            sort:temporal_c) &
                                    sur_tense:nonfin &
                                    tense_inst:B &
                                    tloc:tloc_type)])),
                  (tense_condition &
                   e_rel_r:overlap_rel &
                   e_time:A &
                   r_rel_s:equal &
                   r_time:(marker &
                           sort:temporal_c) &
                   s_time:E &
                   sur_tense:present &
                   tense_inst:A &
                   tloc:(tloc_type & ~st_dist & ~st_perf & ~st_prec))]) &
     quants:[] &
     anchors:[(time_anchor &
               time_param:E &
               time_role:now)] &
     ip:(ip_t &
         cond:D &
         idx:B) &
     persp:(persp_t &
            p_inst:B)) &
prag:(prag_t &
      imp:no &
      key_wds:[aux_koennen] &
      prosody:prosody_val &
      verb_position:verb2 &
      whq:no))]
```

Subjunctive

```
| ?- tsp("ich koennte kommen").
 ich koennte kommen
%%% used time (msec): 3183
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[(A &
                     marker &
                     sort:statisch_c)] &
               conds:[(modal_condition &
                       modal_op:poss &
                       modal_pred:subjunctive &
                       modal_inst:A &
                       modal_arg:(drs_t &
                                  dom:[(B &
                                        marker &
                                        sort:dynamisch_c)] &
                                  conds:[(alfa_condition &
                                          alfa_arg:(C &
                                                    marker &
                                                    snumber:individual &
                                                    sort:mensch_c) &
                                          alfa_type:std &
                                          alfa_restr:(drs_t &
                                                      dom:[C] &
                                                      conds:[])),
                                         (D &
                                          basic_condition &
                                          pred:come &
                                          inst:B &
                                          args:[(arg_role &
                                                 arg:C &
                                                 role:agent_rel)]),
                                         (tense_condition &
                                          e_rel_r:assoc &
                                          e_time:B &
                                          r_rel_s:assoc &
                                          r_time:(marker &
```

```
                                              sort:temporal_c) &
                                      s_time:(E &
                                              marker &
                                              sort:temporal_c) &
                                      sur_tense:present &
                                      tense_inst:B)])),
                    (tense_condition &
                     e_rel_r:overlap_rel &
                     e_time:A &
                     r_rel_s:equal &
                     r_time:(marker &
                             sort:temporal_c) &
                     s_time:E &
                     sur_tense:present &
                     tense_inst:A &
                     tloc:(tloc_type & ~st_dist & ~st_perf & ~st_prec))]) &
      quants:[] &
      anchors:[(disc_anchor &
                param:C &
                discourse_role:speaker),
               (time_anchor &
                time_param:E &
                time_role:now)] &
      ip:(ip_t &
          cond:D &
          idx:B) &
      persp:(persp_t &
             p_inst:B)) &
 prag:(prag_t &
       imp:no &
       key_wds:[aux_koennen] &
       prosody:prosody_val &
       verb_position:verb2 &
       whq:no))]
```

Quantification

```
| ?- tsp("er kommt immer").
 er kommt immer
%%% used time (msec): 3250
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[] &
               conds:[(quant_condition &
                       qtr:always &
                       restr:(drs_t &
                              conds:[]) &
                       scope:(drs_t &
                              dom:[(A &
                                    marker &
                                    sort:dynamisch_c)] &
                              conds:[(alfa_condition &
                                      alfa_arg:(B &
                                                marker &
                                                snumber:individual &
                                                sort:person_c) &
                                      alfa_type:anaphor &
                                      alfa_restr:(drs_t &
                                                  dom:[B] &
                                                  conds:[])),
                                     (C &
                                      basic_condition &
                                      pred:come &
                                      inst:A &
                                      args:[(arg_role &
                                             arg:B &
                                             role:agent_rel)]),
                                     (tense_condition &
                                      e_rel_r:(D &
                                               tense_rel) &
                                      e_time:A &
                                      r_rel_s:(E &
                                               equal) &
```

```
                                  r_time:(marker &
                                          sort:temporal_c) &
                                  s_time:(F &
                                          marker &
                                          sort:temporal_c) &
                                  sur_tense:present &
                                  tense_inst:A)]) &
                   type:univ &
                   var:A),
                  (tense_condition &
                   e_rel_r:D &
                   e_time:A &
                   r_rel_s:E &
                   s_time:F &
                   sur_tense:present &
                   tense_inst:(marker &
                               sort:entitaet_c) &
                   tloc:(tloc_type & ~st_dist))]) &
     quants:[] &
     anchors:[(time_anchor &
                time_param:F &
                time_role:now)] &
     ip:(ip_t &
         cond:C &
         idx:A) &
     persp:(persp_t &
            p_inst:A)) &
prag:(prag_t &
      imp:no &
      key_wds:[] &
      prosody:prosody_val &
      verb_position:verb2 &
      whq:no))]
```

Interaction of Quantification with a Temporal Adverb

```
| ?- tsp("er kommt immer im april").
 er kommt immer im april
%%% used time (msec): 3600
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[] &
               conds:[(quant_condition &
                       qtr:always &
                       restr:(drs_t &
                              conds:[]) &
                       scope:(drs_t &
                              dom:[(A &
                                    marker &
                                    sort:dynamisch_c)] &
                              conds:[(alfa_condition &
                                      alfa_arg:(B &
                                                marker &
                                                snumber:individual &
                                                sort:person_c) &
                                      alfa_type:anaphor &
                                      alfa_restr:(drs_t &
                                                  dom:[B] &
                                                  conds:[])),
                                     (C &
                                      basic_condition &
                                      pred:come &
                                      inst:A &
                                      args:[(arg_role &
                                             arg:B &
                                             role:agent_rel)]),
                                     (tense_condition &
                                      e_rel_r:(D &
                                               tense_rel) &
                                      e_time:A &
                                      r_rel_s:(E &
                                               equal) &
                                      r_time:(marker &
```

```
                                                sort:temporal_c) &
                                        s_time:(F &
                                                marker &
                                                sort:temporal_c) &
                                        sur_tense:present &
                                        tense_inst:A &
                                        tloc:st_dist),
                                       (alfa_condition &
                                        alfa_arg:(G &
                                                  marker &
                                                  sort:monate_c) &
                                        alfa_type:std &
                                        alfa_restr:(drs_t &
                                                    dom:[G] &
                                                    conds:[(rigid_condition &
                                                            rigid_pred:mofy &
                                                            rigid_inst:G &
                                                            designator:4)])),
                                       (basic_condition &
                                        pred:in &
                                        inst:A &
                                        args:[(arg_role &
                                               arg:G &
                                               role:unspec_temporal_inclusion_rel)])]) &
                         type:univ &
                         var:A),
                        (tense_condition &
                         e_rel_r:D &
                         e_time:A &
                         r_rel_s:E &
                         s_time:F &
                         sur_tense:present &
                         tense_inst:(marker &
                                     sort:entitaet_c) &
                         tloc:(tloc_type & ~st_dist))]) &
quants:[] &
anchors:[(time_anchor &
          time_param:F &
          time_role:now)] &
ip:(ip_t &
    cond:C &
    idx:A) &
```

```
          persp:(persp_t &
                 p_inst:A)) &
     prag:(prag_t &
           imp:no &
           key_wds:[] &
           prosody:prosody_val &
           verb_position:verb2 &
           whq:no))]
```

Negation

```
| ?- tsp("er kommt nicht").
 er kommt nicht
%%% used time (msec): 3667
%%% result:

   [(sign &
     sem:(sem_t &
          lambda:[] &
          drs:(drs_t &
               dom:[] &
               conds:[(neg_condition &
                       neg_arg:(drs_t &
                                dom:[(A &
                                      marker &
                                      sort:dynamisch_c)] &
                                conds:[(alfa_condition &
                                        alfa_arg:(B &
                                                  marker &
                                                  snumber:individual &
                                                  sort:person_c) &
                                        alfa_type:anaphor &
                                        alfa_restr:(drs_t &
                                                    dom:[B] &
                                                    conds:[])),
                                       (C &
                                        basic_condition &
                                        pred:come &
                                        inst:A &
                                        args:[(arg_role &
                                               arg:B &
                                               role:agent_rel)]),
                                       (tense_condition &
                                        e_rel_r:(D &
                                                 overlap_rel) &
                                        e_time:A &
                                        r_rel_s:(E &
                                                 equal) &
                                        r_time:(marker &
                                                sort:temporal_c) &

                                        s_time:(F &
```

```
                                                      marker &
                                                      sort:temporal_c) &
                                              sur_tense:presprog &
                                              tense_inst:A &
                                              tloc:(G &
                                    (tloc_type & ~st_dist & ~st_perf & ~st_prec)))])),
                           (tense_condition &
                            e_rel_r:D &
                            e_time:A &
                            r_rel_s:E &
                            s_time:F &
                            sur_tense:presprog &
                            tense_inst:(marker &
                                        sort:zeit_c) &
                            tloc:G)]) &
             quants:[] &
             anchors:[(time_anchor &
                       time_param:F &
                       time_role:now)] &
             ip:(ip_t &
                 cond:C &
                 idx:A) &
             persp:(persp_t &
                    p_inst:A)) &
        prag:(prag_t &
              imp:no &
              key_wds:[] &
              prosody:prosody_val &
              verb_position:verb2 &
              whq:no))]
```