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KRDB RESEARCH CENTRE  
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Faculty of Computer Science, Free University of Bozen-Bolzano  
Piazza Domenicani 3, 39100 Bolzano, Italy  
Tel: +39 04710 16000, fax: +39 04710 16009, <http://www.inf.unibz.it/krdb/>

## KRDB Research Centre Technical Report:

# Visual Tools for Annotating Temporal Expressions with TimeML: a Critical Overview.

T. Di Mascio<sup>1</sup>, R. Gennari<sup>2</sup>, I. Lang<sup>2</sup>, P. Vittorini<sup>1</sup>

<b>Affiliations</b>	1: KRDB, Faculty of Computer Science, FUB 2: University of l'Aquila
<b>Corresponding author</b>	R. Gennari <a href="mailto:gennari@inf.unibz.it">gennari@inf.unibz.it</a>
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## Abstract

*Electronic texts, such as internet newspaper articles, describe the world around us by talking about people, and the events they participate in. The capability of identifying what events are being described, and their temporal flow is a crucial step in the natural language processing of the electronic texts, whether it is for automatic question answering, summarisation or other natural language processing tasks. TimeML is the de-facto standard temporal markup language in the natural language processing community. The annotation in TimeML is also manual. The current available tools for annotating e-texts have an editable and fully graphical display of TimeML events and temporal relations. Nevertheless, such tools face two challenges. The first one is concerned with reasoning with vague information, essentially due to the need of a refined mapping from TimeML temporal relations to IA relations. The second one is concerned with the visualisation of TimeML temporal annotations, that is usable and intuitive for the annotators. This paper overviews the available visual tools for annotating temporal events and relations with TimeML, and compare them with respect to their automated reasoning capabilities, and their visualisation metaphors.*

# Contents

<b>1</b>	<b><i>Introduction</i></b>	<b><i>1</i></b>
1.1	<i>TimeML</i> . . . . .	1
1.2	<i>The Allen Interval Algebra</i> . . . . .	2
1.3	<i>TimeML and IA</i> . . . . .	3
<b>2</b>	<b><i>Visual Representations of Temporal Annotations</i></b>	<b><i>4</i></b>
2.1	<i>Alembic Workbench</i> . . . . .	4
2.2	<i>Event Diagram</i> . . . . .	4
2.3	<i>Tango</i> . . . . .	5
2.4	<i>T-BOX</i> . . . . .	8
2.4.1	<i>Explicit Timeline</i> . . . . .	9
2.4.2	<i>Imprecise Temporal Relations</i> . . . . .	9
<b>3</b>	<b><i>Discussion</i></b>	<b><i>12</i></b>
<b>4</b>	<b><i>Conclusions</i></b>	<b><i>13</i></b>



# Chapter 1

## Introduction

*Natural language processing applications to electronic texts, ranging from question answering to text summarisation, demand systems that can extract temporal information from documents in various languages: coherent text understanding depends on the proper ordering of events in time, their sequences, and linking them to explicit and implicit time references in text or to the time of reading.*

*Perceiving practical needs such as these, various initiatives by the US-Government and the European Community invested in research on related theoretical foundations as well as practical methods. In 2003, TimeBank, a corpus with annotated temporal information in English, was created as a test-bed for the TimeML temporal mark-up language [4]. TimeML established a new standard for temporal annotations, introducing tags related to time, such as TIMEX3, EVENT, and TLINK.*

*Newspaper articles describe the world around us by talking about people and the events and states of affairs they participate in. As it happens, however, much of the temporal information in a report or narrative is left implicit in the text. The exact temporal locations of events are rarely explicit and many temporal expressions are vague at best. A crucial first step in the automatic extraction of TimeML tags from such texts is the capability of identifying what events are being described and to make explicit when these events occurred.*

*Consider the following questions that a user browsing the web may pose:*

- *Is Gates currently the CEO of Microsoft?*
- *Did Iraq pull out of Kuwait during the first Gulf War?*
- *When did the Enron merger with Dynegy take place?*

*Such or similar questions can still be challenging for current automated natural processors. The recognition of temporal “keywords” (e.g., currently, during) is clearly a prerequisite for understanding and answering these questions. In addition, further temporal knowledge needs to be represented and further temporal inferences need to be drawn. Therefore the automatic annotation of temporal expressions is often complemented by a manual revision or integration.*

*ISO, S. W. G. (2008). ISO DIS 24617-1: 2008 Language resource management - Semantic annotation framework - Part 1: Time and events. ISO Central Secretariat, Geneva.*

*In this paper, we give a critical overview of tools for the manual annotation of TimeML tags.*

### 1.1 TimeML

*ISO-TimeML [5] has two types of tags for temporal objects: EVENT, TIMEX3. The EVENT tag serves for labelling a textual element that qualitatively describes a situation that has a duration in time. Syntactically, events are typically expressed as*

inflected verbs, although event nominals, such as “crash” in “...killed by the crash”, should also be annotated as *EVENTS*. *TIMEX* tags refer to quantitative or quantifiable temporal expressions, such as times, dates, durations. Such information are usually expressed in English by adverbial or prepositional phrases, like “on Thursday” or “yesterday morning”.

A *TLINK*, temporal link, represents a temporal relationship between two temporal *EVENTS* or *TIMEX*. Their BNF representation is in Figure 1.1.

```
relType  ::= BEFORE | AFTER | INCLUDES |
           IS_INCLUDED | DURING |
           DURING_INV | SIMULTANEOUS |
           IAFter | IBEFORE |
           IDENTITY | BEGINS |
           ENDS | BEGUN_BY | ENDED_BY
```

**Figure 1.1. The TLINK relations.**

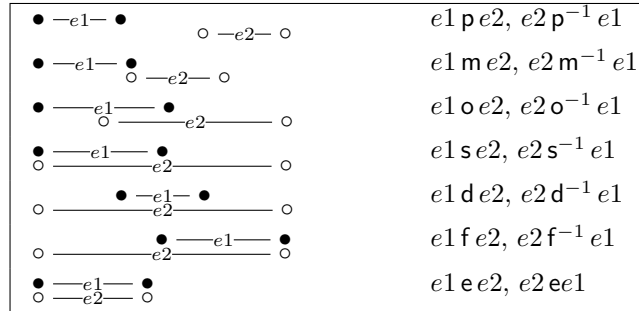
According to [6], the *TLINK* relations are based on the atomic Allen relations. In order to clarify this and hence the semantics of the *TLINKS*, we first need to introduce the Allen temporal relations.

## 1.2 The Allen Interval Algebra

In the Allen temporal representation, a time event is represented as a closed interval on the real line. Between any two pairs of events, there is an atomic Allen relation, namely, a relation *rel* of the form

$p, m, o, s, d, f, e$

or  $rel^{-1}$ , where  $rel^{-1}$  is the inverse of *rel*. See Fig. 1.2 for the standard representation of the atomic Allen relations between two events, *e1* and *e2*, over the real line.



**Figure 1.2. The atomic Allen relations.**

Let *A* denote the set of the atomic Allen relations. Then the set  $2^A$  forms a proper relational algebra, the Allen Interval algebra (IA) for intersection ( $\cap$ ) and composition/join ( $\odot$ ). A relation  $\{a_1, \dots, a_n\}$  of  $2^A$ , with  $a_i \in A$  for all  $i = 1 \dots n$ , is usually written as  $a_1 \dots a_n$ . It is read as “ $a_1$  or ... or  $a_n$ ” and is used to represent “uncertain information”. For instance, let us consider the following sentence: “the small eggshells crack while Mammy duck is sitting on her five eggs”. It states that the relation *df* can hold between the event “the small eggshells crack” and the event “Mammy duck is sitting on her five eggs”.

In particular, the composition operation  $\odot$  is used to perform deductions. For instance, the result of the composition  $p \odot p$  is *p*. This means that

*if*  $e1 p e2$  and  $e2 p e3$   
*then*  $e1 p e3$ .

### 1.3 TimeML and IA

A clear mapping of ISO-TimeML relations onto IA, reproduced as in Table 1.1, was proposed in [10]. As such, it constitutes a first attempt at formalising the semantics of TLINKs in terms of the atomic relations of IA and their standard representation over the real line, see Figure 1.2.

ISO-TimeML relation	IA
$e1$ BEFORE $e2$	b
$e1$ AFTER $e2$	bi
$e1$ IBEFORE $e2$	m
$e1$ IAFTER $e2$	mi
$e1$ INCLUDES $e2$	di
$e1$ IS_INCLUDED $e2$	d
$e1$ IDENTITY $e2$	=
$e1$ SIMULTANEOUS $e2$	
$e1$ DURING $e2$	
$e1$ DURING_INV $e2$	
$e1$ BEGINS $e2$	s
$e1$ BEGUN_BY $e2$	si
$e1$ ENDS $e2$	f
$e1$ ENDED_BY $e2$	fi

**Table 1.1. Mapping TLINKs to atomic relations of IA and PA [82].**

Note that there is no mapping to the Allen atomic relations  $\circ$  and  $\circ^{-1}$ .

Moreover, according to the annotation guidelines to TimeML [5], there is a certain amount of imprecision in some of the TLINKs. More precisely, the semantics of SIMULTANEOUS is not as clearly defined as BEFORE or INCLUDES in ISO-TimeML. Setzer in [9] provides an example where this imprecision arises: the temporal relations in Figure 1.2, where events Z and Y are considered to be “fuzzily” simultaneous, and event X is before event Y. Albeit a clear advance towards a formalisation of the semantics of TLINKS, the mapping in Table 1.1 cannot account for such imprecision. It will translate SIMULTANEOUS into e, an Allen atomic relation. Given this translation, the computation of the deduction will entail that event X is related through BEFORE to event Z, which is not correct.



## Chapter 2

# Visual Representations of Temporal Annotations

### 2.1 Alembic Workbench

*In the early days of TimeML, the TimeBank corpus [2] was created as an illustration of the temporal annotation proposed by TimeML. The first version of TimeBank was annotated almost exclusively with MITRE's Alembic Workbench [1]. The Alembic Workbench is a generic tool for adding SGML tags to a text. It allows annotators to define and edit tags, and has a mechanism to define relations between text strings which can be used to annotate links.*

*The Workbench was adapted to the requirements of TimeML in two ways. Firstly, a tag preferences file was added that defined the TimeML tags EVENT, TIMEX, SIGNAL (illustrated in Figure 2.1). Secondly, a new relation TML-LINK was added.*

*Alembic works well for annotation of few temporal expressions, but the mechanism to deal with large amounts of temporal relations is not ideal. Temporal links are displayed in a table where the columns display the annotated EVENT, TIMEX3, and TML-LINK tags. The table does not display the temporal relation intuitively, as the presence of an explicit timeline would do.*

### 2.2 Event Diagram

*In 2002, in the context of the ARDA workshop TERQAS, Verhagen proposed a semi-graphical tool for TimeML named Event Diagram [7]. The Event Diagram is a first step towards a fully editable annotation tool with a reference to a timeline. It displays spatially how a focus event is temporally related to all other events and time expressions in a text. Figure 2.2 shows how “murdered”, the event in focus, relates to all other EVENT and TIMEX tags. The box below the focus holds all events that are related through IDENTITY or SIMULTANEOUS with the focus event. The boxes to the left and right hold events that precede or follow the focus events. So, in this case, “slayings” and “murdered” are correlated through IDENTITY, and “Thursday” is temporally situated after “murdered”.*

*Adding TLINKs is simpler and faster than in Alembic. It is also easy to change focus and follow a chain of links. In addition, it is possible to zoom in on a segment of the text. The Event Diagram comes with an extra window that displays the text and highlights the events selected in the diagram. The text window has tag editing functionalities similar to Alembic, but adds many short-cuts that make editing of events and time expressions easier.*

*This tool was designed to initially complement and eventually replace Alembic. It was written in Tcl/Tk and functions as an extension to Alembic. But the complexity and high density of TLINKs required a more intuitive annotation tool. The ARDA-funded the Tango project [8] for addressing such a scalability need.*

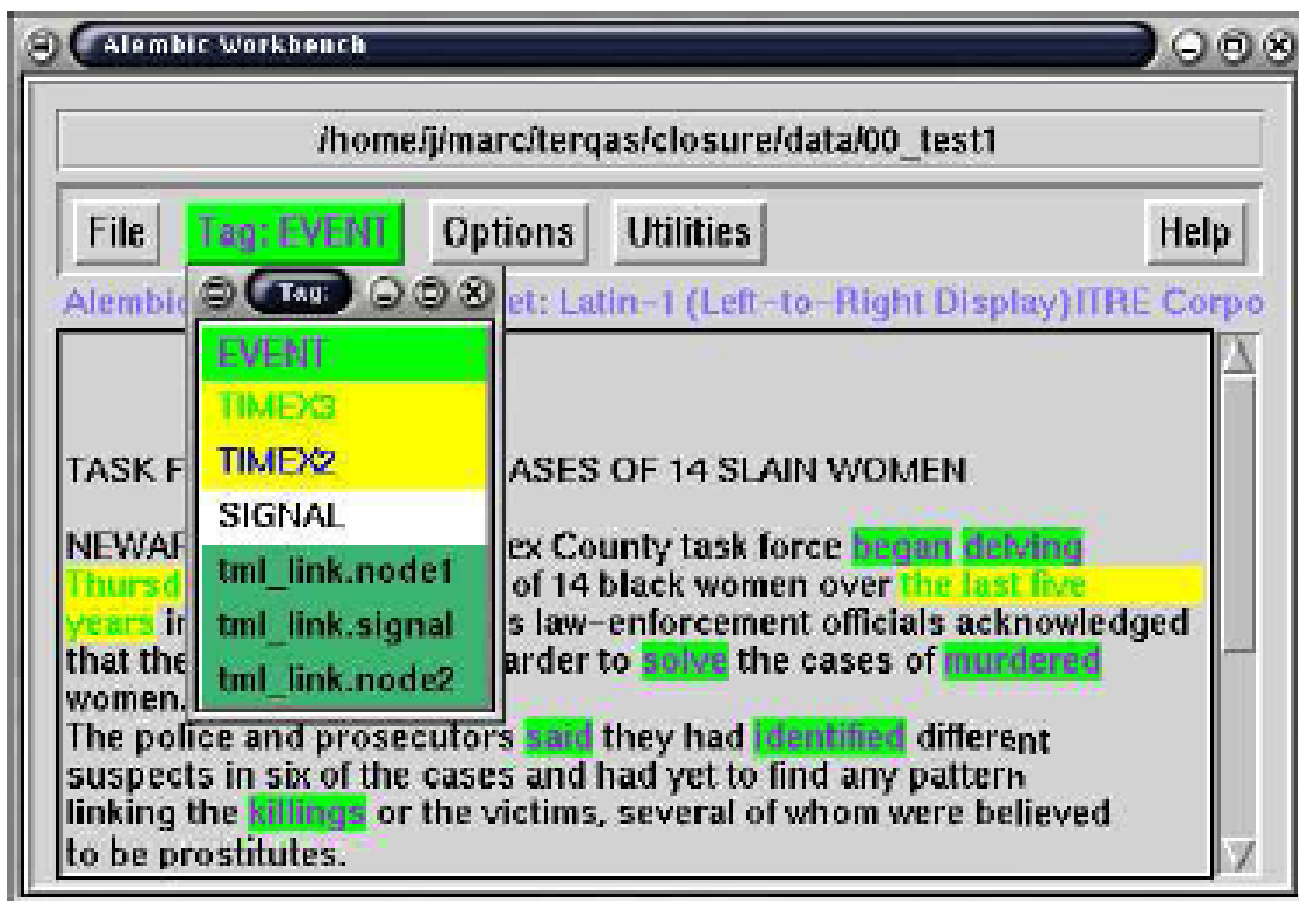


Figure 2.1. The Alembic Workbench: Annotation Options.

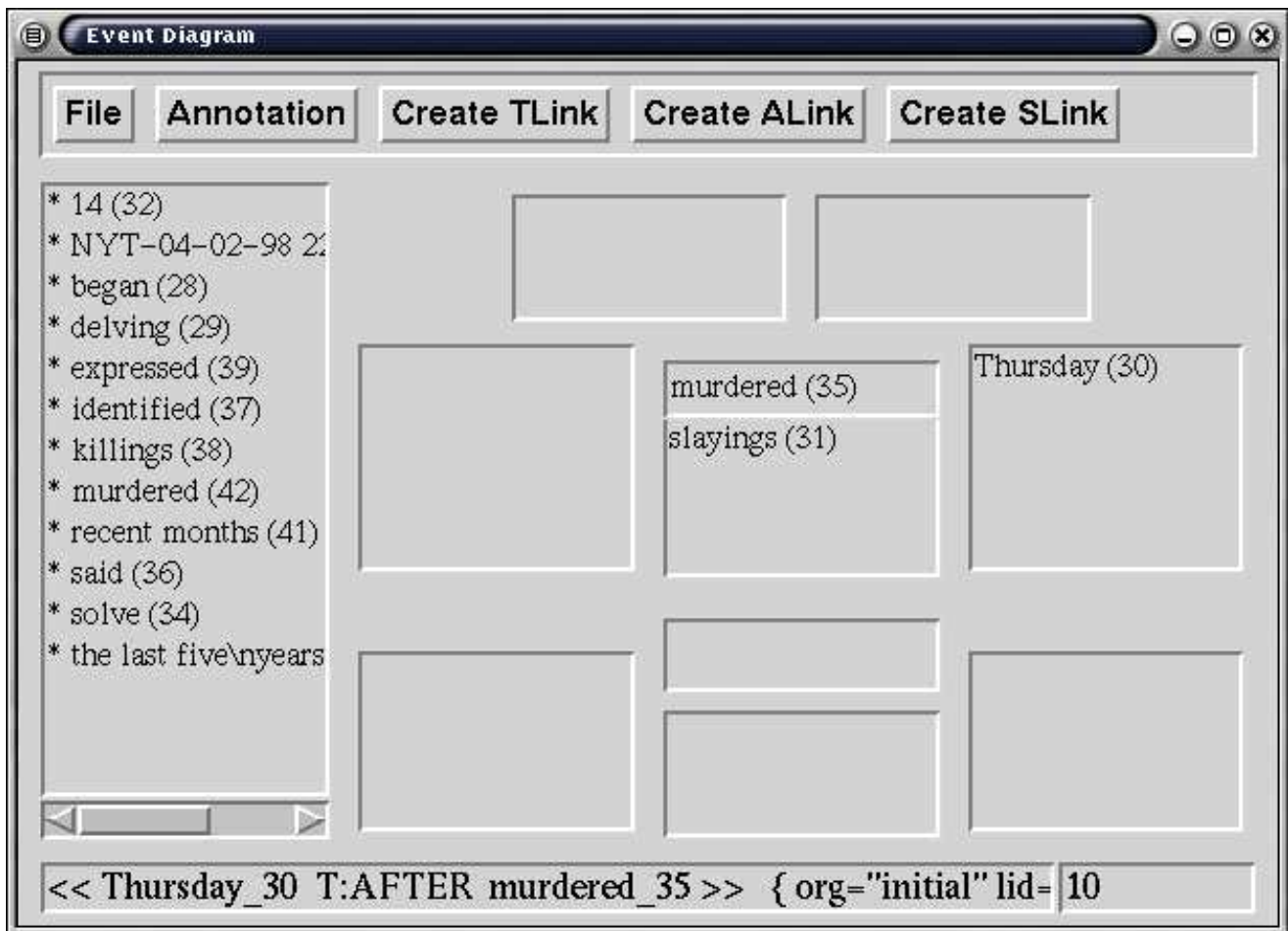
## 2.3 Tango

In 2003, a new tool named Tango [8], was developed in order to make TimeML annotation even more intuitive. Tango is a graphical annotation that uses a graph visualisation of temporal and event orderings: temporal objects (EVENTS, TIMEX3) are represented as nodes, and TLINKs as arcs. See Figure 2.3.

Tango is used in conjunction with another annotation tool such as Callisto (see Figure 2.4), that replaced Alembic (see <http://callisto.mitre.org>). Callisto, although arguably a better annotation tool, still uses the same table metaphor that does not serve temporal annotation very well. Therefore, once a document has been fully tagged with EVENT, TIMEX3, and SIGNAL tags in Callisto, the Tango tool is used to visually represent the anchoring and ordering relationships that TLINKs contain, the subordinating relationships that SLINKs signify, and the aspectual information that ALINKs supply.

A bit surprisingly, Tango did not make the annotation process faster than it was with Alembic. This seems to be explained by the willingness of annotators to sit down and really dive into the temporal structure of a document. Also, with Alembic, annotators quickly zero in on a very specific strategy: they go through the text linearly and add table entries that typically link an event to nearby event or time. This, although requiring an elaborate sequence of mouse clicks, made for a relatively quick workflow. However, it does not facilitate creation of non-local links, that is, the vast majority of links in Alembic-annotated documents are within a sentence or cross one sentence boundary only. This is not the case with Tango.

Differently than Alembic and Event Diagram, TANGO has some automated reasoning capabilities. TLINKs are mapped into IA relations (see Section 1), and then TANGO uses a standard algorithm for inferring the deduction of a set of relations,



**Figure 2.2. A screenshot of Event Diagram.**

*albeit returning UNKNOWN for IA relations that cannot be mapped into TLINKS.*

*Given this, the annotation process with Tango reduced the number of mistakes made by the annotators. A mini-experiment conducted during the TANGO project indicated that the percentage of TLINKs that received the correct relation type went up from 64 per cent to 76 per cent when Tango was used as the annotation tool rather than Alembic.*

*With Tango, it seems to be easier to achieve a complete annotation since it leads to more densely connected graphs than Alembic does, and more connected graphs make complete annotation easier to achieve. An earlier version of TimeBank was annotated in large part with Alembic, running deduction over that version resulted in a fourfold increase in the number of TLINKs. The AQUAINT Opinion Corpus was annotated using Tango, here the number of TLINKs after deduction increased by a factor ten. One should be careful to not read too much into this. For example, differences in genre may account for part of these differences.*

*There are no solid data to support claims that annotation with Tango increases inter-annotator agreement. The latest agreement score for annotation of temporal links is 55 per cent average precision and recall. That is, two annotators choose to specify a temporal relation between the same EVENT OR TIMEX tags in 55% of the cases. Out of those 55%, the annotators agree in 77% of the cases on the temporal relation to specify. The only figure available for TLINK annotation with Alembic is 20%. However, this number is from an experiment with novice annotators at a time that the TimeML specification was still under constant revision.*

*Tango has been used effectively to annotate 186 TimeBank and 73 Opinion corpus documents. It has also served well in*

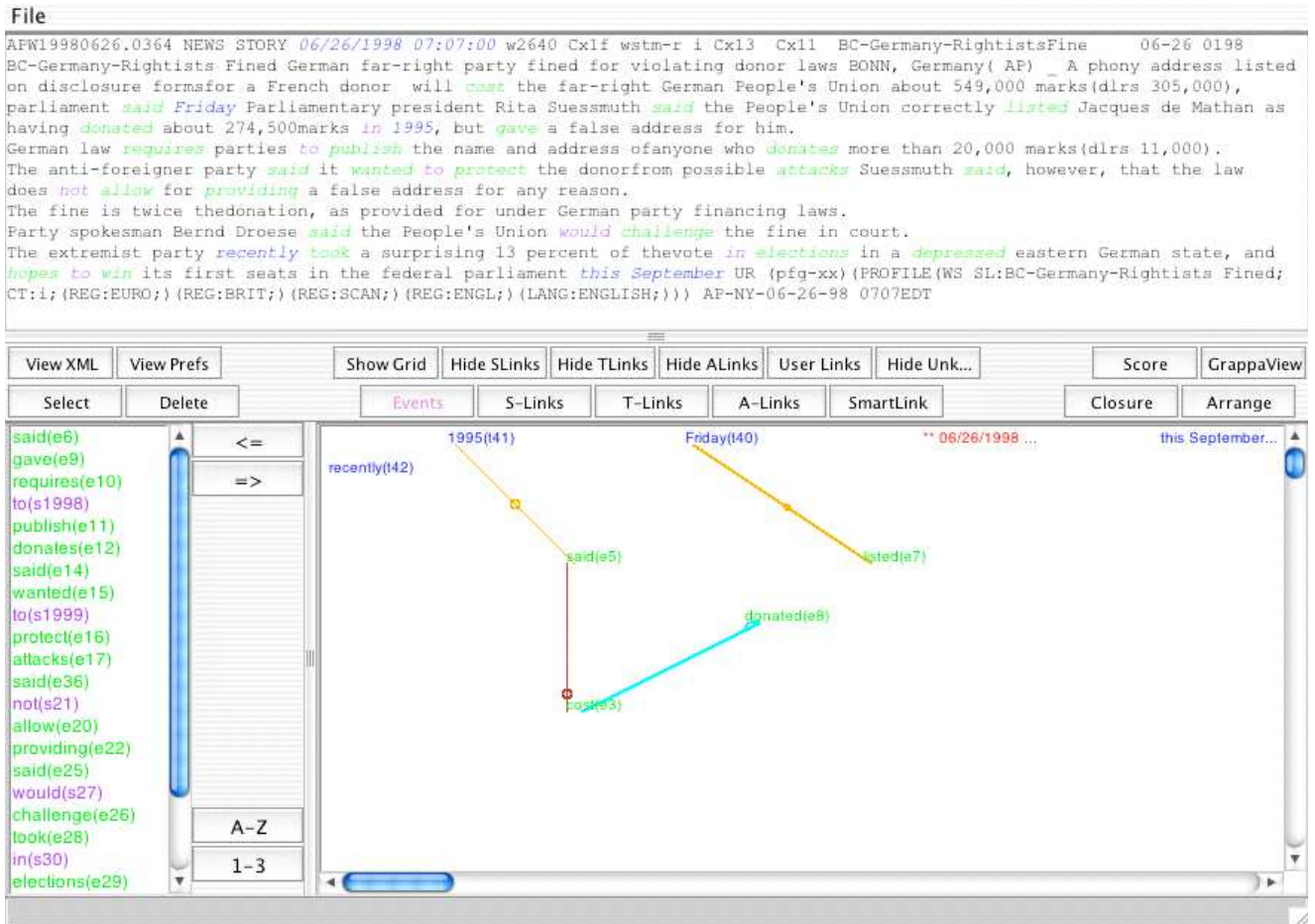


Figure 2.3. A screenshot of Tango.

visualising and correcting output from automatic TimeML annotations.

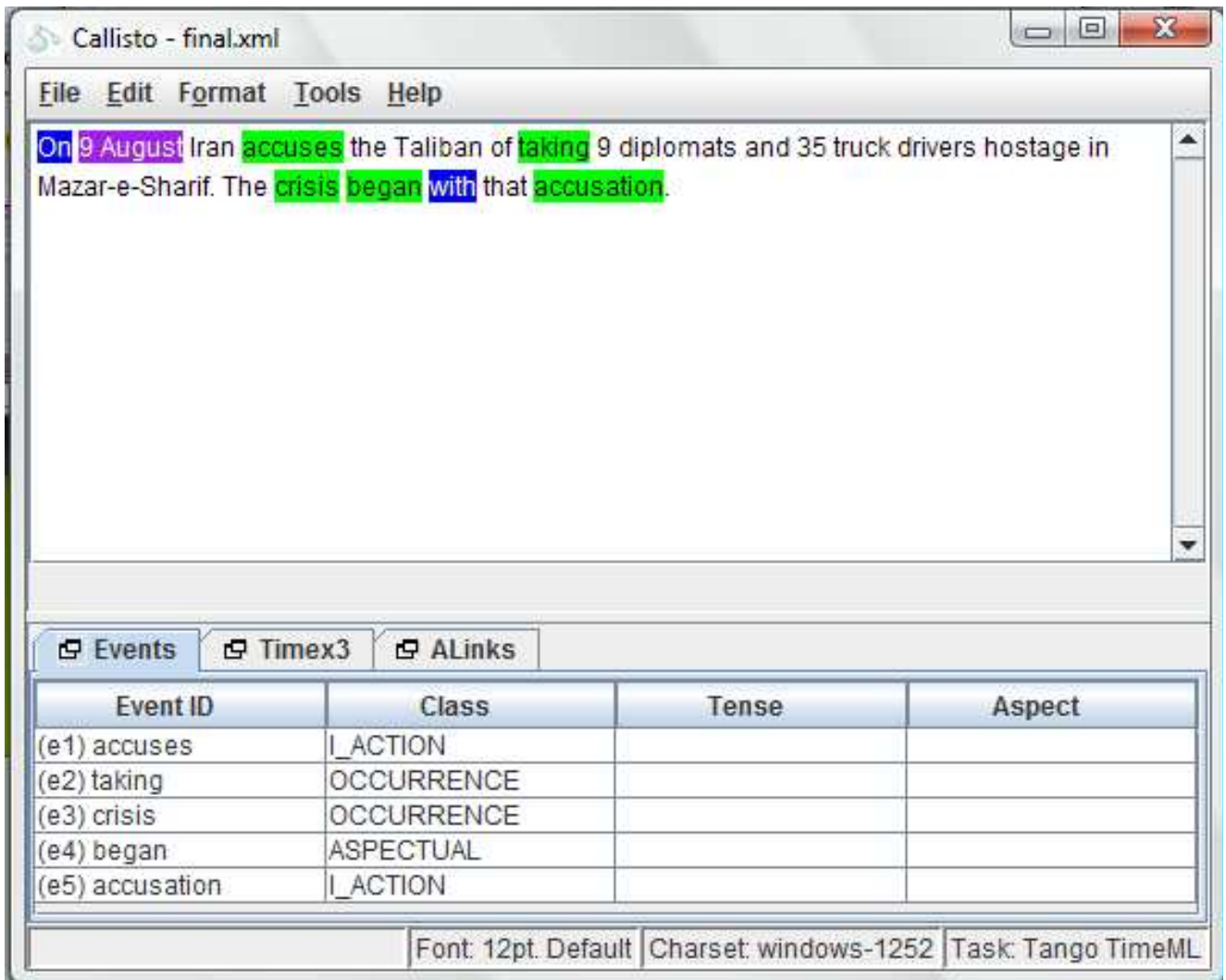
One of the main motivations behind Tango was to create an annotation tool that displays the temporal structure of a document as clearly as possible. The connected graph is certainly easier to read than a table, and it is also very easy to see how complete an annotation is. However, the display still has a couple of drawbacks:

- the display can easily get crowded, especially after computing deduction,
- placement of events relative to each other is not predictable, and the auto layout feature does not completely solve this,
- the graph-based visualisation does not provide a clear semantics, as Figure 1.2 does.

The main problem is that the dimensions and directions of the graph are not unambiguously mapped to a standard temporal representation, and that potential clutter is not controlled.

The main limitations, however, depend on the expressive power of the TimeML TLINKs, and the mapping of TLINKs to IA atomic relations (see Section 1). They are:

- TLINKs are not closed for composition, and hence the deductive closure algorithm of Tango is not complete; the deduced IA relations that cannot be mapped into TLINKs are marked as UNKNOWN in a light shade;



**Figure 2.4. A screenshot of Callisto.**

- the mapping from TLINKS to IA in Table 1.1 does not capture the imprecision inherent in the SIMULTANEOUS TLINK, thus possibly not displaying consistent temporal TLINKS after the deduction process (see Section 1).

## 2.4 T-BOX

*T-BOX* was created as a more intuitive alternative to *Tango*. As Verhagen describes in [11], the central idea of *T-BOX* is that the relative placement of two event or time tags is completely determined by the TLINKs between them. Each event or time expression is placed in a box, also called a *T-BOX*. Events and times have the same ontological status. That is, both participate in TLINKs and both are placed in boxes in the graph. *T-BOX* uses arrows, box inclusion and stacking instead of the labelled edges of *Tango*. See also Table 2.1.

There are four rules that determine the visual representation of TLINKS of Table 2.1, described as follows.

1. If event *X* is before event *Y*, then *X*'s box will always be displayed to the left of *Y*'s box and there is a sequence of arrows that leads from one box to the other. A variation of this theme is when *X* is immediately before *Y*, that is, there is a

TAG		VISUAL REPRESENTATION
EVENTS	→	box
TIMEX3	→	box
TLINKS	→	arrow, box inclusion, box stacking

**Table 2.1. The visual representation of TimeML tags as in T-BOX.**

*IBEFOR*E between *X* and *Y*. In that case, the arrow is replaced by a line ending in a solid dot.

2. If *X* includes *Y* then the T-BOX of *X* is extended with a box that has thinner lines. The included event *Y* is placed inside this box. *Y* does not touch any side of the box.
3. If *X* and *Y* are simultaneous then their boxes will be stacked directly on top of each other or there is a series of boxes between *X* and *Y* that are stacked similarly.
4. If *X* begins *Y* then *X* is placed inside *Y*'s extended box and *X* will hug the left side of *Y*'s box. The case is similar if *X* ends *Y*.

These four rules are claimed to cover all the TLINKS. If no rule governs placement of two events *X* and *Y*, then none of the configurations above will occur.

Figure 2.5 shows the visual representations of Tango and the T-BOX for the same TimeBank fragment. The interpretation of the T-BOX representation is more intuitive than the one of Tango. Despite a more intuitive semantics for TLINKS, the visual metaphor of T-BOX can still be improved in several directions, put forward below.

#### 2.4.1 Explicit Timeline

As stated by Verhagen, T-BOX still incorporates several limitations. For instance, T-BOX does not include an explicit timeline. Times are represented in the same way as events, namely as boxes, but are coloured differently. The times are ordered where the time expressions are provided explicitly, while others such as “four year” or “five year” in Figure 2.6 are not ordered along the timeline.

Moreover, the IBEFORE relation is not displayed in a very intuitive way. In T-BOX the two events are connected by a line ending in a solid dot (see Figure 2.6). There is no relative vertical positioning between the related events.

Verhagen himself says that vertical and horizontal placement by themselves are meaningless in the T-BOX visualisation scheme. While a timeline strongly suggests that vertical placement under a time or date actually means something, for T-BOX it does not. The relative placements only mean something in connection with arrows, box inclusion or stacking. The timeline metaphor is abandoned.

#### 2.4.2 Imprecise Temporal Relations

The limited expressive power of TLINKS, namely, not allowing for disjunctive information, affects T-BOX as well. However, T-BOX allows for expressing some disjunctions of TLINKS, as in the case “*X INCLUDES Y*” and “*Y BEFORE Z*”, represented as in Figure 2.7. However, such a representation of disjunctions can easily get crowded and ambiguous. For instance, in the visualisation of Figure 2.7, it also seems that *X* is before *Z* (*X BEFORE Z*), which is not necessarily the case according to the semantics of the TLINKS specified in Section 1, e.g., it could well be IBEFORE or SIMULTANEOUS or INCLUDES or IS\_FINISHED.



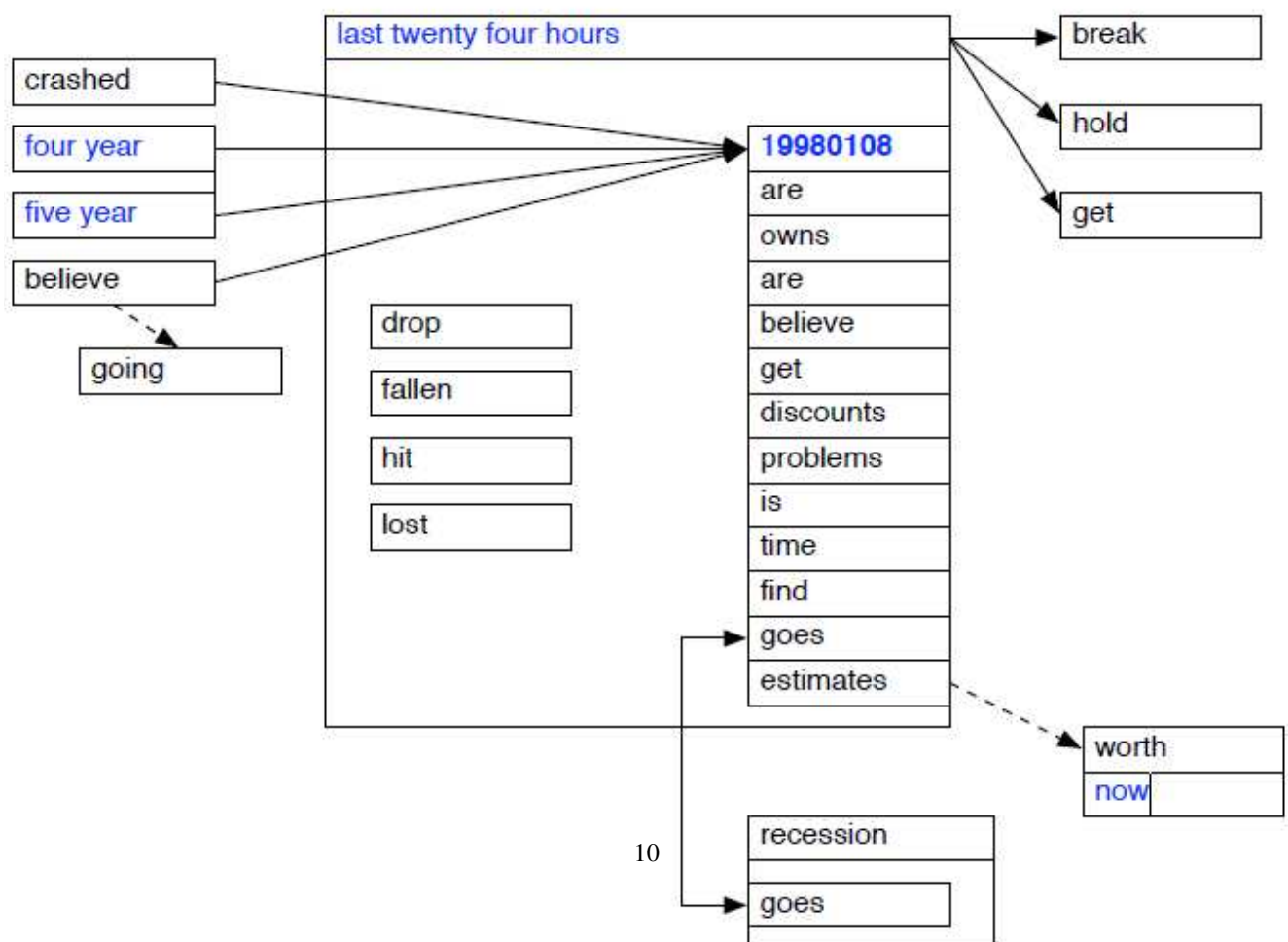
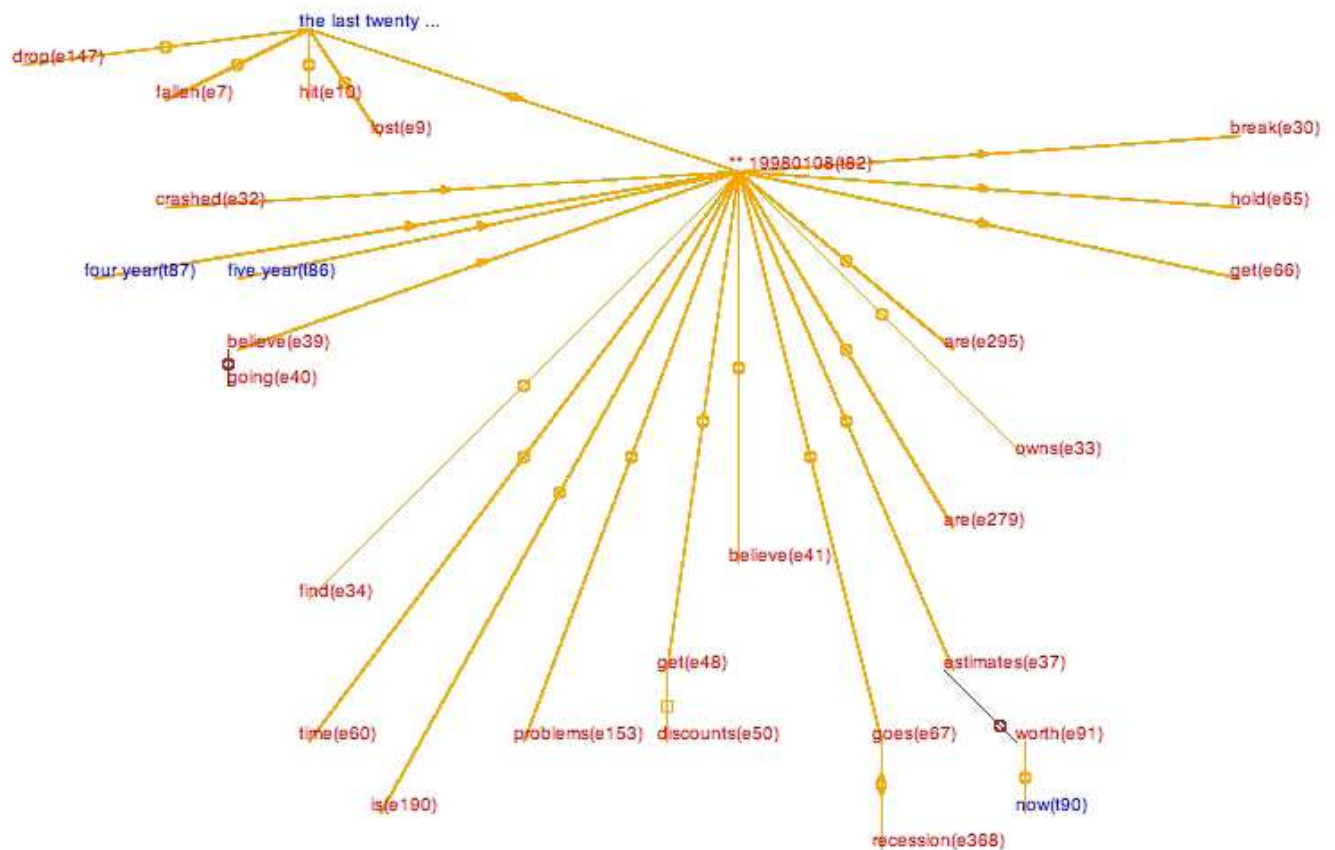


Figure 2.5. Visual representations of Tango (top) and T-BOX (bottom) for the same TimeBank fragment.

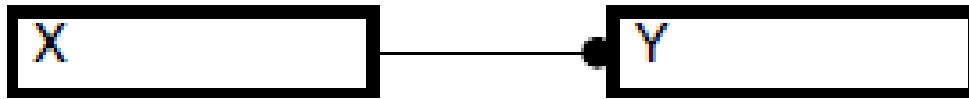


Figure 2.6. The IBEFORE TLINK in T-Box.

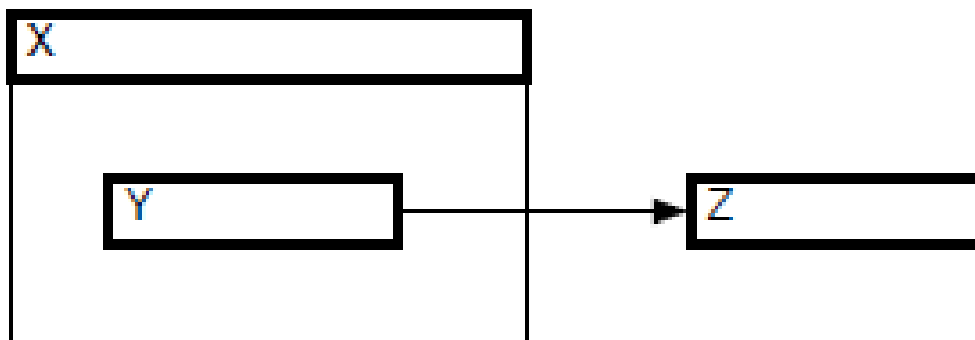


Figure 2.7. T-BOX representing “X INCLUDES Y” and “Y BEFORE Z”.



## Chapter 3

# Discussion

*Annotating texts in natural language with TimeML is not an easy task. The overviewed visualisation tools try to assist the annotators in their work, but they incorporate several limitations that also depends on the unclear semantics of the TLINKs.*

*The mapping of Table 1.1 into IA atomic relations is a first step towards the creation of a formal clean semantics for TLINKS. However, as outlined in Section 1, the mapping is rather restrictive. In particular, the SIMULTANEOUS relation can be used to annotate relations that are not only (or not at all) related by the Allen identity relation (e). A possible solution, that considers the ambiguity of SIMULTANEOUS, would map SIMULTANEOUS into a disjunction of atomic Allen relations, such as,  $oo^{-1}ss^{-1}dd^{-1}eff^{-1}$ .*

*This said, the TLINK relations and the above mapping are insufficient if one aims at a visualisation tool that can also compute the deduction of TLINKS, an aim that both Tango and T-BOX shared. The computation of the deductive closure would still return disjunctions that cannot be mapped into TLINKS. Therefore a revision of the expressive power of TLINKs seems to be necessary, so as to allow for computing or approximating the deductive closure of TLINKS, taking care that such a task can be performed at most in polynomial time.*

*The visual metaphor of Tang are readable for a rather under-connected graph of relations, but becomes soon unreadable otherwise. T-BOX tries to improve on this but, possibly due to the expressive power of TimeML, the visual representation is ambiguous. The visualisation could indeed be improved by studying a formal semantics for the TLINKs, that is correct and, ideally, complete (e.g., [3]) so as to avoid the remaining ambiguities in the visualisation of temporal expressions as in T-BOX, cfr. Section 2.*

## Chapter 4

# Conclusions

*The ability to represent time in a correct way, reason about it effectively and visualise it intuitively and unambiguously is central to the success of annotating temporal information of texts. We reviewed visual tools for annotating texts, comparing them in terms of the chosen visual metaphors. We also showed how the automated reasoning power and visualisation choices of such tools are constrained by the expressive power of the TLINKS of Time-ML.*

*Starting from our review, future work will tackle the problem of proposing a novel visual representation of TLINKs in Time-ML by strengthening the expressive power of the language, and proposing an unambiguous correct visual representations of TLINKs. This requires to first identify which disjunctions among the relations of IA would be most useful and intuitive for the annotation task.*

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