

# SlinkET: A Partial Modal Parser for Events

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## Abstract

We present SlinkET, a parser for identifying contexts of event modality in text developed within the TARSQI (Temporal Awareness and Reasoning Systems for Question Interpretation) research framework. SlinkET is grounded on TimeML, a specification language for capturing temporal and event related information in discourse, which provides an adequate foundation to handle event modality. SlinkET builds on top of a robust event recognizer, and provides each relevant event with a value that specifies the degree of certainty about its factuality; e.g., whether it has happened or holds (factive or counter-factive), whether it is being reported or witnessed by somebody else (evidential), or if it is introduced as a possibility (modal). It is based on well-established technology in the field (namely, finite-state techniques), and informed with corpus-induced knowledge that relies on basic information, such as morphological features, POS, and chunking. SlinkET is under continuing development and it currently achieves a performance ratio of 70% F1-measure.

## 1. Introduction

Event recognition is at the core of diverse areas in NLP, from highly domain-oriented disciplines, such as bioinformatics, to more topic and genre-oriented applications, like Question Answering. Recognizing events in these fields is generally accomplished by identifying predefined lists of relations or event types, possibly structured into an ontology (Brill et al., 2002; Soubbotin and Soubbotin, 2002), a strategy which makes the task feasible but domain-dependent. In Information Extraction, the most representative work on event recognition is the Scenario Template task of the different Message Understanding Conference competitions (Grishman and Sundheim, 1996). Within this framework as well, event identification was restricted to specific domains relying on preestablished event templates. A main drawback of such an approach to the task is that it is not sensitive to modality, the linguistic level expressing whether the represented events are assumed as having happened, or whether their factuality status is uncertain. Modality is a fundamental piece of information for subsequent reasoning about events in discourse. The inferences that can be drawn from events introduced as holding are of a different nature than those derivable from events mentioned in a text but which have not happened, or about which we do not have enough knowledge. Consider:

- (1) Putin replied that Chernomyrdin helped to settle the problem of Ukraine's debt to Russia.
- (2) During the campaign Fox promised **to settle the Zapatista problem**, peacefully and politically, "in 15 minutes".

In (1), the verb *help* in the past tense establishes a presupposition that the problem of Ukraine's debt has already been settled. This, however, is not the case of the event characterized as the settling of the Zapatista problem in (2), which is used in an intensional context created by *promised*.

A more sophisticated approach sensitive to event modality would benefit NLP tasks which require some degree of text understanding, such as QA or Narrative Understanding. This is supported by the impressive scores obtained in the previous TREC competitions by a system attempting a minimal interpretation of text, in contrast to more surface-based approaches (Voorhees, 2002; Voorhees, 2003). As a matter of fact, there is growing interest on event modality as a necessary information component in both domain-oriented disciplines such as bioinformatics, e.g., (Light et al., 2004), and genre-based applications like Question Answering. For example, some of the systems that participated in the Knowledge-based Inference Pilot organized within the ARDA AQUAINT program during last summer, attempted to handle modality information to some extent.<sup>1</sup>

## 2. Linguistic Settings

### 2.1. Event Modality

Events in discourse can be couched in terms of a veridicality axis that ranges from truly factual to counter-factual, passing through a whole spectrum of different modality shades, including:

- (3) a. Degrees of possibility: *These results indicate that Pb2+ **may** inhibit neurite initiation by inappropriately stimulating protein phosphorylation by CaM kinase.*
- b. Belief: *Chinese analysts **believe** that the United States will continue to provoke North Korea.*
- c. Evidentiality: *Subcomandante Marcos **said** that the Mexican government is not interested in putting an end to the conflict.*
- d. Expectation: *Hans Blix **wants** the US to allow UN inspectors back into Iraq to verify any weapons found by coalition forces.*

<sup>1</sup><http://www.ic-arda.org/InfoExploit/aquaint>

- e. Attempting: *George Mallory and Andrew Irvine first **attempted** to climb Everest in 1924.*
- f. Command: *John Murtha **called** for the immediate withdrawal of U.S. troops from Iraq.*

In the linguistics literature, this level of information is identified as epistemic modality (Palmer, 1986). Epistemic modality expresses the speaker's degree of commitment to the truth of the proposition; in other words, it expresses his/her degree of certainty about the situation being denoted by the proposition. Characterizing the boundaries of this grammatical category is still a matter of research. There is discussion about the status of evidentiality, the grammatical system coding the source of information (3c), traditionally subsumed under epistemic modality. A more crosslinguistic-oriented research suggests that evidentiality is in fact an independent system, although in languages such as English it is clearly related to modality (de Haan, 1999; de Hann, 2000).

For our current purposes, we will adopt the conservative approach that subsumes evidentiality under epistemic modality, based on Palmer's work (Palmer, 1986). In addition, our use of the term modality will be wider than what is generally assumed in the literature, encompassing event factuality as well. That is, we will understand event modality as the feature indicating the factuality status of a particular event.

## 2.2. Modality in English

Event modality in natural language is marked by a variety of different strategies and constructions. In English, these include both lexical items and syntactic constructions.

### 2.2.1. Lexical modality markers:

At the lexical level, modality can be introduced by what we refer to as **Situation Selecting Predicates** (SSPs). These are predicates (either verbal, nominal, or adjectival) that select for an argument denoting and event (or situation) of some sort. Syntactically, they subcategorize for a *that*-, gerundive, or infinitival clause, but also an NP headed by an event denoting noun. Some examples are verbs like *claim*, *suggest*, *offer*, *avoid*, *try*, *delay*, *think*, nouns like *promise*, *hope*, *love*, *request*, and adjectives such as *ready*, *eager*, *able*:

- (4) a. The Human Rights Committee **regretted** that discrimination against women persisted in practice.
- b. Uri Lubrani also **suggested** Israel was willing to withdraw from southern Lebanon.
- c. Kidnappers **kept** their promise to kill a store owner they took hostage.

SSPs are interesting because part of their lexical semantics is projected as modality information onto the event denoted by its argument (underlined in examples (4)) by syntactic means. The event denoted by the argument is then marked as:

- **Not totally certain:** This is the case of the complements to the so-called weak assertive predicates (Hooper, 1975), such as *think*, and *suppose*.

- **Certain according to a source:** Complements of reporting predicates (Bergler, 1992).
- **Factual:** Complements of *regret* and *forget* (Kiparsky and Kiparsky, 1970; Karttunen, 1970; Karttunen, 1971).
- **Counterfactual:** Arguments of *avoid*, *prevent*.
- **Possible in a future time:** Arguments of volition and commitment predicates, among others.

Also at the lexical level, there are **modal auxiliaries** of possibility (5a), obligation (5b), necessity (5c), etc.

- (5) a. *could*, *may*;
- b. *must*, *have to*;
- c. *need to*.

Clausal and sentential **adverbial modifiers** may express similar modal information:

- (6) a. Possibility: *probably*, *perhaps*;
- b. Frequency: *usually*, *always*.

Finally, **negative polarity** particles are important because they express the counterfactual nature of the event that is referred to by negated expressions:

- (7) a. It became clear controllers **could not** contact the plane.
- b. **No one** reached the site in time.

### 2.2.2. Syntactic modality contexts:

Syntactic structures introducing modality involve the presence of two clauses, generally one embedded within the other. The following list, although not exhaustive, gives an indication of how pervasive this phenomenon is.

**Relative clauses:** The event denoted by the relative clause (underlined in the following example) is presupposed as true (e.g., *Rice, who became secretary of state two months ago today, took stock of a period of tumultuous change.*)

**Cleft sentences:** The event of the embedded clause (underlined) is presupposed as true (e.g., *It was Mr. Bryant who, on July 19, 2001, asked Rep. Bartlett to pen and deliver a letter to him.*)

**Subordinated temporal clauses:** Again, the event in the temporal clause is presupposed as true (e.g., *While Chomsky was revolutionizing linguistics, the rest of the social sciences was asleep.*)

**Purpose clauses:** The event denoted by the clause is intensional in nature. (e.g., *The environmental commission must adopt regulations to ensure people are not exposed to radioactive waste.*)

**Conditional constructions:** The event denoted by the consequent clause (underlined) is intensional and dependent on the factuality of the event denoted in the antecedent clause (bold face), which is also intensional (e.g., ***On Dec. 2 Marcos promised to return to the negotiating table if the conflict zone was **demilitarized.*****)

### 3. Related work

Current progress on event extraction has shifted from the domain-based perspective of previous work to attempts at unrestricted coverage of events in text. The work of (Filatova and Hatzivassiloglou, 2003), for example, is based on the same notion of event as in the MUC initiative (namely, as a relationship among participants, locations, and times), but it diverges from it in that the extraction of events is not constrained to predefined templates. Instead, it is approached by identifying all those relations that connect two named entities together. Still, it assumes the sentence level as the scope for events in text, thus missing the subtlety of certain modality introducing contexts, such as sentences headed by SSPs and contexts of syntactic subordination, like those introduced in section 2.2.2.

EvITA (Saurí et al., 2005) takes a different approach to the task. EvITA relies on the notion of event as defined by TimeML,<sup>2</sup> a specification language designed to annotate event and temporal information in text (Pustejovsky et al., 2003a; Pustejovsky et al., 2005). The TimeML definition of event corresponds broadly speaking to that assumed by the previous work: events are considered "situations that happen or occur", including "states or circumstances in which something obtains or holds true". TimeML however differs from its preceding work in adopting a more natural, linguistic definition of event, and hence assuming a smaller scope for events. They can be expressed at either the clause or the phrase level –including, for instance, NPs headed by event-denoting nouns such as *demonstration* and *fire*.

From our perspective, a major benefit derives from this strategy: a more atomic approach to event identification is guaranteed, thus recognizing SSPs as introducing an event that is independent from the one denoted by their complement. In (1), for example, the event of Chernomyrdin helping will be identified as different from the settling of the debt in Russia. This outcome is fundamental for a subsequent processing stage aiming at capturing modality information introduced by SSPs.

In addition to that, EvITA also identifies modal information contributed by modal auxiliaries at the VP level, as well as the polarity of each event-denoting expression. The module described in this paper, SlinkET, builds on EvITA and enriches its output with the modality information introduced by certain subordinating contexts.

### 4. SlinkET, A Partial Modal Parser

SlinkET (Slink Events in Text) is a tool developed under the TARSQI research framework, a project devoted to building a set of resources for identifying, annotating, and reasoning about temporal information in discourse (Pustejovsky et al., 2003a; Pustejovsky et al., 2005; Mani, 2005; Mani and Schiffman, forthcoming; Verhagen et al., 2005). Among other products, TARSQI has matured TimeML, the spec language which is at the basis of all the work developed within this framework, and produced EvITA, introduced in section 3. The following subsection gives an overview of the treatment of modality information in our research

framework, and locates the role of SlinkET within that picture. Section 4.2. details how SlinkET works, and Section 4.3. gives an overview of its output.

#### 4.1. Event Modality in TimeML

As already mentioned, EvITA copes with some of the modality sources of lexical nature; namely, it identifies and annotates SSPs, modal auxiliaries, and polarity particles. SlinkET builds on top of that and handles event modality introduced at the syntactic level, involving subordination relations between two clauses.

In TimeML, these contexts are annotated by means of SLINKs (subordination links) between the two events implicated in the relation. SLINKs encode all subordination relations triggered by SSPs, as well as those introduced by purpose clauses or conditional constructions (refer to section 2.2.2.). Depending on the modality information contributed to the event denoted by the subordinated clause, the SLINK will be classified with one of the following types:

1. *factive*: When the argument event is entailed or presupposed, as is the case with *persisted*, in the following example, due to the SSP *regretted*: *The Human Rights Committee regretted that discrimination against women **persisted** in practice.*
2. *counter\_factive*: When the SSP (here *avoided*) presupposes the non-veracity of the event denoted by its argument (*jail*); e.g., *A Time magazine reporter avoided **jail** at the last minute.*
3. *evidential*: Typically introduced by reporting or perception events; e.g., *Iran said an Iraqi diplomatic delegation was **going** to Tehran to deliver Sadam's message.*
4. *negative\_evidential*: Introduced by reporting and perception events conveying negative polarity; e.g., *The minister denied the kingdom had **notified** any of its customers.*
5. *modal*: For annotating events introducing a reference to possible world. This is also the value used for the relation between the event in a purpose clause and the one in the main clause that is being modified. In the following example, both *willing* and *withdraw* will be characterized as modal: *Uri Lubrani also suggested Israel was **willing** to **withdraw** from Southern Lebanon.*
6. *conditional*: For annotating conditional constructions; e.g., *Bush held out the prospect of more **aid** to Jordan if it cooperates with the trade embargo .*

#### 4.2. SlinkET Functionality

Given a text or set of texts as input, SlinkET identifies those subordinating contexts involving modality information and annotates them with the TimeML SLINK tag. Its functionality breaks down into two parts.

First, lexical information is used for preselecting SSPs, the candidates to introducing SLINKs. This information is based on corpus-induced knowledge from Time-

<sup>2</sup><http://www.timeml.org>

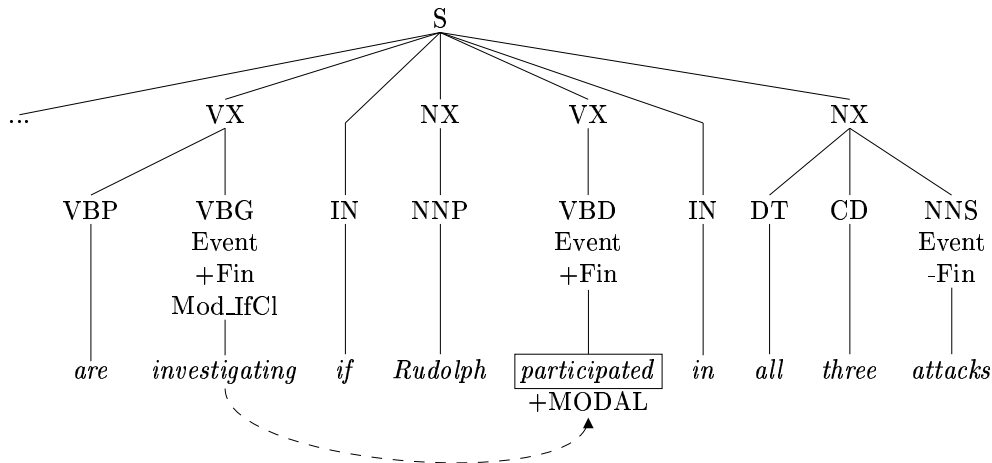


Figure 1: SlinkET processing

Bank (Pustejovsky et al., 2003b)<sup>3</sup> as well as standard linguistic classifications of such predicates; e.g., (Kiparsky and Kiparsky, 1970; Karttunen, 1970; Karttunen, 1971; Hooper, 1975) and subsequent elaborations of that work. Table 1 gives the 10 most frequent SLINK-triggering event expression in TimeBank1.2.

event expression	freq
say	797
expect	81
report	55
agree	34
announce	33
seek	33
think	27
add	26
tell	24
help	22

Table 1: SLINK-triggering events in TimeBank1.2

Next, a finite-state syntactic module identifies the subordinated event in the clause based on the subcategorization properties of the subordinating event. Such subcategorization information has been derived largely from corpus analytics as well, and subsequently compiled into normalized dictionary entries. For each event, the dictionary specifies its possible subordinating contexts and its SLINK types (*factive*, *counter\_factive*, *evidential*, *neg\_evidential*, or *modal*). This is critical for disambiguating the modal force of such predicates. For example, *investigate* introduces an SLINK of type *modal* when subordinating an *if/whether*-clause (8), but an SLINK of type *factive* when subcategorizing for an event-denoting NP (9):

- (8) Officials are investigating whether Rudolph **participated** in all three attacks.
- (9) Officials are investigating all three **attacks**.

<sup>3</sup>TimeBank can be browsed at [http://www.timeml.org/site/timebank/browser\\_1.2/](http://www.timeml.org/site/timebank/browser_1.2/)

Syntactic patterns can be applied forward (from the located SLINK-triggering event to its right, as in (8-9)), or backwards (to its left), as in (10).

- (10) This activity resulted in a **discharge** to state waters, which was investigated by John Klauzenberg.

A simplified version of the lexical entry for *investigate* is as shown in Figure 2, where each possible syntactic structure for the complement is associated to one SLINK type:

```
"investigate":{
  forward:{
    (thatClause_if, MODAL),
    (indirectInterrog, FACTIVE),
    (NP_event, FACTIVE)},
  backwards:{
    (relClause, FACTIVE)}}
```

Figure 2: Lexical entry for *investigate*

The syntactic patterns referred to in the lexical entries are expressed using the standard syntax of regular expressions. They are then compiled into finite state automata that work with grammatical objects instead of characters. Figure 3 illustrates the syntactic pattern *NP\_event*, describing NPs headed by an event-denoting noun.

```
NP_event = [
  token_PREDET?
  token_DETERMINER?
  (token_ADJ|chunk_Particip|token_SYM)*
  token_NUMBER*
  chunk_EVENT_nominal ]
```

Figure 3: Syntactic pattern for event-denoting NPs

SlinkET patterns are based on very basic lexical and structural features, listed below, which are derived from both EvITA's output and a preprocessing stage applying POS tagging and chunking:

# TARSQI Demo

CNN19980213.2130.0155.cnk Evita GUTime GUTenLINK Slinket SLink2TLink

[Browse manual annotation](#)

CNN19980213.2130.0155  
NEWS STORY

President Clinton **says<sub>e1</sub>** he is **committed<sub>e2</sub>** to a possible **strike<sub>e3</sub>** against Iraq, despite **objections<sub>e4</sub>** from other countries. e1 e2

Steve Hurst **has<sub>e5</sub>** that.

The US military **buildup<sub>e6</sub>** in the Persian gulf **continues<sub>e7</sub>** apace, more planes **headed<sub>e8</sub>** from the united states and senior officials **say<sub>e9</sub>** e9 e10

Iraq's president Saddam Hussein can **expect<sub>e10</sub>** **punishing<sub>e11</sub>** air **strikes<sub>e12</sub>** to **continue<sub>e13</sub>** well into the future if he does n't **stop<sub>e14</sub>** building biological and chemical weapons.

Saddam will **know<sub>e15</sub>** by our **actions<sub>e16</sub>** and our **warning<sub>e17</sub>** that we will be **prepared<sub>e18</sub>** to **act<sub>e19</sub>** again if we **have<sub>e20</sub>** evidence he is e15 f e18  
**trying<sub>e21</sub>** to **rebuild<sub>e22</sub>** his weapons of mass destruction capabilities. e18 m e19  
e21 m e22

In a bit of television diplomacy, Iraq's deputy foreign minister **responded<sub>e23</sub>** from Baghdad in less than one hour, **saying<sub>e24</sub>** Washington e24 e25  
would **break<sub>e25</sub>** international law by **attacking<sub>e26</sub>** without UN **approval<sub>e27</sub>**.

The united states is not **authorized<sub>e28</sub>** to **use<sub>e29</sub>** force before **going<sub>e30</sub>** to the council. e28 m e29

President Clinton, meantime, **glossed<sub>e31</sub>** over stern **warnings<sub>e32</sub>** from Moscow on Thursday that US air **strikes<sub>e33</sub>** against Iraq could **do<sub>e34</sub>** e31 f e32  
serious harm to relations with the Kremlin.

We're **trying<sub>e35</sub>** to **find<sub>e36</sub>** a diplomatic solution. e35 m e36

Figure 4: SlinkET output

1. POS tag.
2. Chunking structure.
3. Sentence boundaries.
4. Event tags obtained from EvITA. SlinkET only operates on expressions that have been recognized as referring to an event.
5. Finite vs. non-finite morphology. Such information is obtained from EvITA, but can be derived from the preprocessing step as well.
6. Lexical form of the subordinating expression.
7. Subordinating predicate class (e.g., reporting, evidential, or intensional), as obtained from EvITA.

SlinkET uses that knowledge for identifying and wrapping the subordinated event with the appropriate modal information, as illustrated in Figure 1.

### 4.3. SlinkET Output

Currently, SlinkET is embedded in the TARSQI suite of tools devoted to the identification of event and temporal information in real text. Figure 4 offers a screenshot of the relevant output from our TARSQI application. Event expressions there are marked in red, and the SLINKs are annotated at the right hand side of the text as relations between event IDs (where *m* stands for SLINKs of modal type, *e* for evidential, and *f* for factive).

## 5. Current Status and Results

SlinkET aims at introducing SLINKs from two different sources: either triggered by the presence of a specific lexical item (namely, an SSP), or based on the syntax, in the case of purpose clauses and conditional constructions. The part devoted to syntactically-based SLINKs is still under development. Yet, SlinkET already identifies purpose clauses triggered by verbs with a strong tendency to be modified by such structures, such as *address*:

- (11) The President addressed the nation to **announce** a new election.

SlinkET dictionary contains 225 lexical forms, distributed among the different event-denoting POS categories in the following way: 150 verbs, 68 nouns, and 7 adjectives. On the other hand, there are over 40 syntactic patterns compiled into FSAs, which cover: infinitival and *that* clauses, gerundive clauses and event-referring NPs, both of which may be preceded by a specific preposition depending on the subordinating verb, relative clauses, and finally, a subset of passive structures.

Current performance of SlinkET has been calculated over 10% of the TimeBank corpus containing a total of 218 SLINKs and 681 events. Precision is at 92%, Recall at 56%, with an F1-measure of 70%. Precision is good, but Recall still leaves some room for improvement, which can be achieved by enriching the dictionary and adding syntactic patterns to the FSA module. We are also exploring modal parsing using machine learning algorithms; i.e., Maxent and Conditional Random Fields.

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