Similarity of Cases: From Temporal Relations of Affairs

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Abstract

Searching for a similar precedent case is one of the most important parts of legal reasoning (case-based reasoning). As one criteria for such similarity, temporal structure among affairs in cases should be compared, because these relations may represent the causality, that is a key feature of the case. Thus far in many legal reasoning systems, cases have been described as sequences of pointwise events. Namely, temporal relations such as *before, after, during,* and so on, in these events have been given manually, independently of events' own temporal features. In this paper, we propose a classification of event-type by their temporal features. And after that, we also propose several default rules that prescribe the temporal relations between event-types. Finally, we discuss how these temporal relations work in the comparison of similarity of cases.

1 Introduction

Case-based reasoning has played an important role in legal inference systems, as are found in [L.C89, L.C90, Gar84, RS91, Bra90]. We have developed Helic-II system [NOM$^+$92], that is a composite system of CBR and RBR (Rule-base reasoning), where a case is described by a semantic network. In Helic-II, we made much of the importance of temporal relations between events and states, and we utilized Allen's interval logic [All84] for temporal relations in the network and improved the representation of time far better than that of pointwise sequences of events.

However, it is much labor to write down interval relations manually on each case. The objective of our research began with the endeavor to automate those generation of temporal relations [TN94]. In this paper, we polish up the process, and in addition, we propose an actual procedure of CBR with regard to temporal structure.

First, we define temporal types that represent the temporal features of each affair. The classification of verbs has been studied in linguistics, and we utilize the classification to our problem. Then, time intervals are introduced according to these types. Next, temporal relations between these affairs are generated by given, default rules.

The similarity of cases is decided based upon these temporal relations. For that purpose, we attach *relevance value* to each affair in cases. In order to claim a similarity, those affairs with high relevance value in one case must exist in another case, and in addition, the temporal relations between highly relevant affairs must also exist in another.

In Section 2, we survey the methods of verb classification, and based on the result, we propose our classification of affair from temporal point of view. Next in Section 3, we propose default rules between affairs according to their temporal types. In the following Section 4, we propose the concept of similarity from the point of relevance value, and show the procedure to com pare two legal cases. Section 5 concludes this paper.

2 Events, Processes, and States in Legal Case Description

2.1 Problems of Temporal Description

First, we give a sample case, mentioned in [NOM$^+$92] as well, as below:

> "**Mary's case:** On a cold winter's day, Mary abandoned her son Tom on the street because she was very poor. Tom was just 4 months old. Jim found Tom crying on the street and started to drive Tom by car to the police station. However, Jim caused an accident on the way to the police station. Tom was injured. Jim thought that Tom had died in the accident and left Tom on the street. Tom froze to death."

We can pick up many affairs from the case description above: for example,

> being cold, abandon, being poor, being four months old, find, crying, ···

and so on. Our objective is to relate them adequately enough to be compared with other cases later.

For the formalization of temporal relations of affairs, a sequence of pointwise events that are aligned on a time axis is too naïve and has only poor information. Therefore, many linguists and computer scientists have proposed so called *event calculus* that defines the relations between *time intervals* for affairs. Namely, an interval can be interpreted as some time duration where an affair persists. McDermott [D.V82], Kamp [Kam79, Kam81], Shoham [Sho88] and Kowalski [KS86], as well as Allen [All84], proposed event calculi in different ways, however, they are common in that they can articulate time from a set of events. However, interval relations are often hard to define within this kind of interval calculi. Cooper [Coo86] pointed out the problem of interval inclusion as follows. Suppose that we can define an interval of an affair as $\|a\|$. In case a is *stative*, if '$l \subset \|a\|$' then $\forall l'(\subset l) : l' \subset \|a\|$. This feature is called *temporally ill-founded.* On the contrary, in case a is *eventual* that happens on some instance, if '$l \supset \|a\|$' then $\exists l'(\subset l) : l' \not\supset \|a\|$. The latter feature is called *temporally well-founded.* Namely, when we try to define an inclusion relation between two affairs, the relation depends upon their intrinsic temporal features. Shoham formalized this matter in a more generalized way as upward/ downward hereditary [Sho88].

In this paper, we basically observe this interval logic though we also need to avoid the problem of interval inclusion. In the following section, we introduce a certain kind of time point as well to avoid this problem.

2.2 Temporal features of states, processes, and events

2.3 Classification of verbs

An affair is called *telic* when its terminative point can be defined, and otherwise it is called *atelic* [Com76]. This distinction becomes important in relating two affairs, because it decides whether a certain event occurred during the preceding deed or after the deed. Especially, in legal reasoning, the scope of duration of a deed may affect upon the legal judgement.

As for the classification of verbs with regard to their temporal features, Vendler's one (States/ Activities/ Accomplishments/ Achievements) [Ven57] is historically important. In that classification, both of Accomplishments and Activities have progressive, changing phase, however, the former are telic and the latter are atelic. Achievements are also telic but happen instantaneously and do not have progressive phase.

Parsons [Par90] overviewed recent studies on verb classification with this (telic/ atelic) point of view. Allen's classification (Processes/ Events/ Properties) [All84] and McDermott's classification (Fact type/ Event type) [D.V82] can be rather easily mapped into the Parsons' chart. Binnick's classification [R.I91] is also almost same with Parsons' though more precise.[1] Therefore, in this paper, we observe Parsons' latest classification.

First, we distinguish *stative* verbs from *active* ones. Next, active verbs can be divided into telic ones and atelic ones. We call the former as *eventual* and the latter as *processive.* We call *affair* for the most general class including states and activities. We will redefine these terms with use of intervals in the following subsection.

2.4 Classification wrt intervals

In order to formalize the distinction of states, events, and processes, we need to define the following two states (intervals) and one time point [Par90], as follows.

Definition 1 (Intervals and points)

in-progress state *In-progress state is the interval from the inceptive point of progressive activity, to the culminative (terminative) point.*

time of culmination *The culminative point is the point where the objective of deed is achieved.*

holding state *Holding state is the interval from the culminative point, to the point to recover to the original state.* □

We call in-progress state,[2] holding state,[3] and culminative point, as **IP-state, HL-state,** and **C-point** for short, respectively.[4]

In general, an affair begins its IP-state from some beginning time, and ascends to C-point. Then the target state is held for its HL-state. We give the definitions of verb types in terms of the above interval features. The variety of temporal features of affairs is given rise to by the following two attributes.

- Length of each interval:
  If IP-state has zero-length then it happened *instantaneous*-ly, and otherwise it was *durative.* If HL-state has zero-length then the state recovered to the original state immediately. ,

[1] Binnick divided first states from non-states, then non-states into telic ones and atelic ones, and then telic ones into development and punctual occurrence, that corresponds to accomplishments and achievements, respectively.

[2] Some linguists call the interval as *development* portion.

[3] Although we introduced the interval under the name of 'holding', the state may recover immediately to the original state and it may not hold. Some linguists may be sensitive to the usage between *target* state and *holding* state, however, the discussion is out of the scope of this paper. As our position is based upon interval logic, we adopt the name of holding state.

[4] Parsons also introduced *resultant* state that is the scope of the influence of the deed, regardless whether the target state is recovered to the original state or not, however we do not mention this state furthermore in this paper because the concept only concerns with the interpretation of perfective.

- Both ends of each interval:
  IP-state begins with the inceptive point and finishes with C-point, and HL-state begins with C-point and finishes with the point to recover to the original state. These points are often unknown, and for such unknown points we call the ends of the interval is *open*.

Definition 2 (Classification) *Verb types are classified in terms of states as follows:*

1. *An affair is* **stative** *iff it is in HL-state. Both ends of HL-states are open.*

2. *An affair is* **processive** *iff it is in IP-state. Both ends of IP-states are open.*

3. *An affair is* **eventual** *iff it culminates. IP-state and HL-state meets at C-point. The recovering point of HL-state is open.* □

2.5 Perspective functions

Here, we define functions IP, HL, and C, which retrieve IP-state, HL-state, and C-point respectively, given an affair. Our position in this paper is that these functions refer different parts of an affair that is a common ontology for any type of occurrence: we call them *perspective* functions.

Definition 3 (Perspective functions)

1. $IP(x)$: *affair* $\rightarrow$ *IP-state*

2. $HL(x)$: *affair* $\rightarrow$ *HL-state*

3. $C(x)$: *affair* $\rightarrow$ *C-point*

where '$f(x) : \alpha \rightarrow \beta$*' means that* f *is a function from* α *to* β. □

The affair type is depicted in Fig. 1, where the light gray area represents IP-state and the dark gray area HL-state.

Perspective functions works as follows. For an eventual affair, we can refer both of its IP-state and HL-state, as well as its C-point. However, for a processive affair, we can only retrieve its IP-state, and for a stative affair, we can only refer its HL-state. Namely, these functions retrieve time intervals that each affair can refer, as in Table 1 where 'w.d.' means well-defined, and '-' means unknown. '•' is originally an interval though it is seen as a compressed point (or, in other words, none pays any attention inside of the interval; note that the perspective include the whole of IP-state in Fig. 1).

a	$IP(a)$	$C(a)$	$HL(a)$
stative	-	-	w.d.
processive	w.d.	-	-
eventual	•	w.d.	w.d.

Table 1: Perspective functions and affair type

2.6 Inclusion relation

In Section 2.1, we left the problem of the definition of an inclusion relation in intervals. The cause of the problem was the ambiguous definition of 'duration of an affair $\|a\|$.' To avoid this, we mention *points* instead of time duration. C-points are the only points we can define, so that we give the definition as below:

Definition 4 (Inclusion relation)
An interval s *includes an affair* a *iff* s $\ni C$(a). *We write the same relation as:*

$$s \models a. \ \square$$

Note that only eventual type affairs can come to the right-hand side of the inclusion relations because only they can define C-points.

3 Generation of temporal relations

In the previous section, we discussed the fundamental theory for the classification of temporal features of affairs. In this section, we introduce default rules that prescribe temporal relations between two virtually consecutive affairs.

3.1 Flow of processing

In this subsection, we summarize the flow of processing that gives temporal relations to affairs in a case. We formalize the story given in Section 2.1, as an example.

1. Given a sequence of affairs Γ:

$$\begin{aligned}\Gamma = \ & \text{poor(mary)} \preceq \\ & \text{abandon(mary, tom)} \preceq \\ & \text{find(jim, tom)} \preceq \\ & \text{pick\_up(jim, tom)} \preceq \\ & \text{driving(jim, tom, to\_the\_police)} \preceq \\ & \text{cause\_traffic\_accident(jim)} \preceq \\ & \text{misunderstand(jim, dead(tom))} \preceq \\ & \text{alive(tom)} \preceq \\ & \text{leave(jim, tom, on\_the\_road)} \preceq \\ & \text{dead(tom)}\end{aligned}$$

   where '$\preceq$' is a virtual order of affairs, that represents just the order of original sentences and no further information.

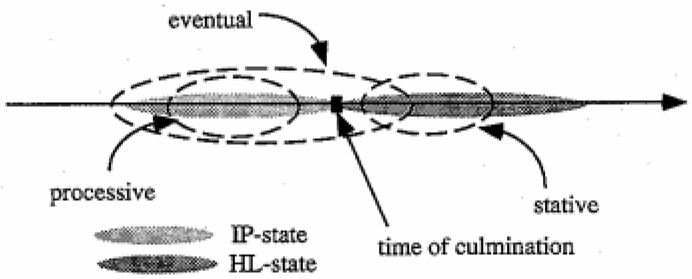

Figure 1: *Affair* type and *perspective*

2. set up time intervals according to Table 1:

   driving: processive
   ⇒ IP-state
   poor, live, dead: stative
   ⇒ HL-state
   abandon, find, pick_up, ⋯: eventual
   ⇒ C-point, HL-state

3. claim inclusion relations, based on default rules.

   $IP(a_1) \models a_2,\ HL(a_1) \models a_3,\ HL(a_3) \models a_4, \cdots$

   where a_i's are affairs.

3.2 Default rules

In this subsection, we propose four default rules.

(1) Consecutive events Our policy for two, or more, consecutive eventual affairs is very simple. We showed the referring scope of an eventual affair in Fig. 1. Actually, the requirement is that the scope must include the C-point and IP-state. Accordingly, we set up the following rewriting rule.

Default rule 1 (Consecutive events) *If $e_1 \preceq e_2$, and both of e_1 and e_2 are eventual then:*

$$HL(e_1) \models e_2. \ \square$$

That claims the HL-state of the preceding event includes the C-point of the following event, as in Fig. 2.

(2) Process-event sequence Both ends of IP-state of a processive affair are open. This means that all the other events might happen during this IP-state. However, in actual cases, a processive affair seems to relate only to the following event. For this practical reason, we narrowed the scope as follows:

Default rule 2 (Processive) *If p is processive and e is eventual, and $p \preceq e$, then:*

$$IP(p) \models e. \ \square$$

This condition is shown in Fig. 3.

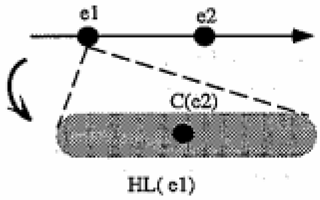

Figure 2: Consecutive events

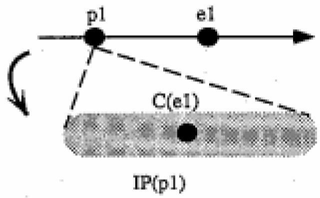

Figure 3: Process-event sequence

(3) State-event sequence On the contrary, stative affairs often persist for long time. We assume that a stative affair includes all the eventual affairs, as below.

Default rule 3 (Stative) *If s is stative, and e_i's are eventual, then:*

$$\forall e_i : s \models e_i. \ \square$$

This rule claims that all the C-points of eventual affairs, regardless before or after s, are included in $HL(s)$, as in Fig. 4.

3.3 Sample Generation

Now, we show the result of application of all the rules to the given case in Section 2.1 in Fig. 5. We omit parameters of each predicate for visibility. The bare result is awkward because every event is supported both by HL(alive(tom)) and by HL(dead(tom)). In such a case, we need to refute inadequate statements manually. In

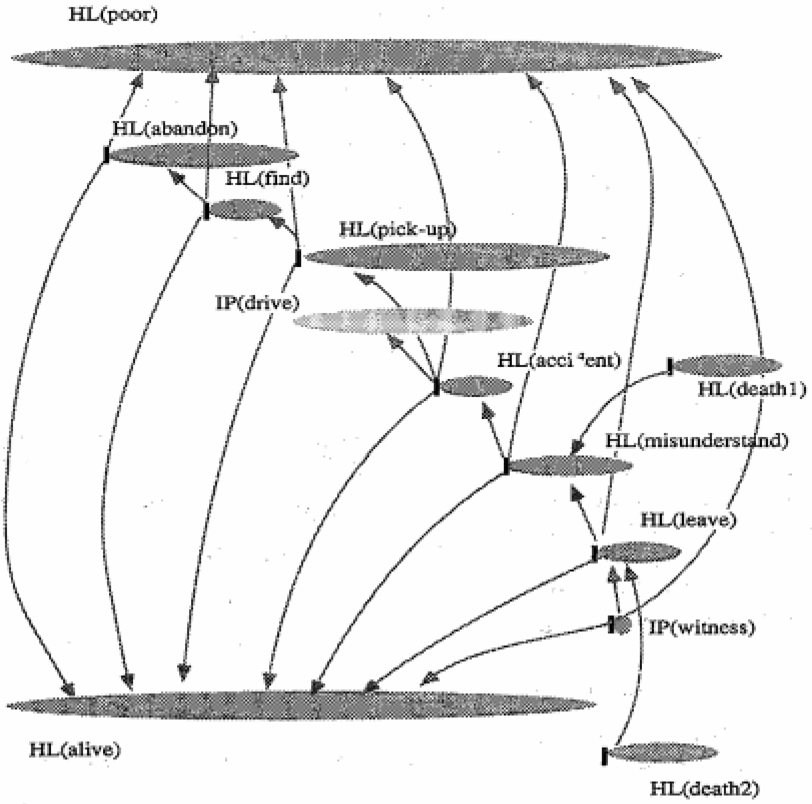

Figure 5: Result of Mary's case

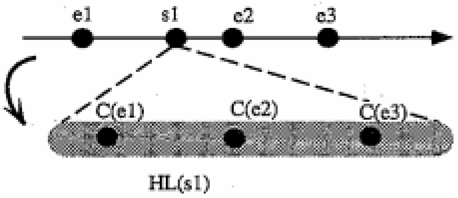

Figure 4: State-event sequence

this case, we need to eliminate all the supporting relations by HL(dead(tom)).

4 Similarity Comparison in Cases

4.1 Matching of Cases

We give concepts of case matching below [TW94].

Definition 5 (Case Matching) *For cases s_1 and s_2,*

1. *If, for every affair in s_1, there is an affair that can match it in s_2, and vice versa, then the two cases are interpreted as* exactly matched *cases.*

2. *For any σ_1 in s_1, there is an affair σ_2 in s_2 that can match σ_1, case s_1 can be* partially matched *with case s_2.*

3. *For any σ_1 in s_1 whose* relevance *value is larger than a given threshold level, there is an affair σ_2 in s_2, that can be matched with σ_1, s_1 can be* partially matched *with s_2* with regard to relevance value. □

Note that this partially matching relation is one way; even though s_1 can be partially matched with s_2, s_2 may not be partially matched with s_1. Among several matching definitions, we will adopt *partially matching w.r.t. relevance value* for cases in the following section, for practical reasons. Let us consider the following pair of descriptions:

$$s_{new} \ni \{ \ abandon(mary), \ leave(mary, june)\}$$
$$s_{prec} \ni \{ \ abandon(jim, tom) : 3^{relevance}, \ leave(jim, tom) : 2^{relevance}, \ poor(jim) : 1^{relevance}\}$$

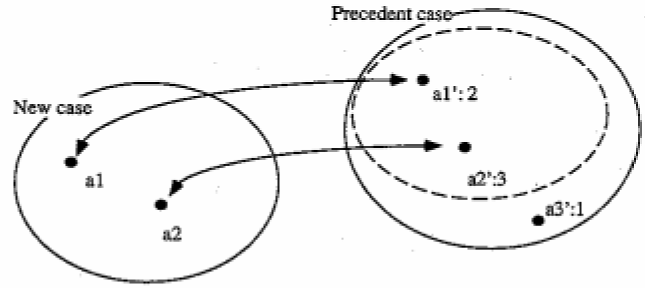

Figure 6: case matching with relevance value

If the threshold value is 2, then s_{new} can be *partially matched* with s_{prec} *w.r.t. the value 2*. On the other hand, if 3 is the threshold instead, s_{new} cannot be *partially matched* with s_{prec} *w.r.t. the value 3*. s_{prec} always cannot be matched with s_{new} because s_{new} does not contain the affair of *poor*. Fig. 6 describes this matter.

4.2 The Strategy for Comparison

We call those events with high relevance value *important* and those with low relevance value *trivial*. The strategy for the similarity evaluation between two cases follows the procedure below:

1. Expansion of Precedent Case. Temporal relations between important events are newly set up by default rules, and are claimed to be also important.
2. Expansion of New Case. Temporal relations between important events are newly set up by default rules, and are claimed to be also important.
3. Comparison by two cases by '*matching of cases w.r.t. to relevance value*'.
4. Meta-level inference

Meta-level inference is required when we cannot find an important temporal relation that exists in a precedent case but not in the new case. Now, we clarify the nature of meta-level inference rules. We proposed four default rules in Section 3.2. Naturally, all these rules should be amended if necessary. Therefore, all the following meta-level inference rules become counter-arguments for the preceding four default rules.

(1) Transitive supports of consecutive events In Section 3.2, we claimed that the HL-state of an event only supports one following event. However, in real paragraphs, A HL-state may support multiple C-points of events. This expansion of HL-state can be stated as follows:

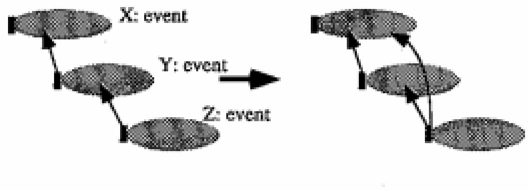

Figure 7: Sequence of events

Meta rule 1 (Transitive support)

$$HL(X) \models Z \Leftarrow HL(X) \models Y,\ HL(Y) \models Z$$

where X, Y, *and* Z *are all eventual affairs.* □

This rule can be interpreted as follows: if an event sequence X, Y, Z occurred in this order, then the third Z may have occurred in the HL-state of the first event X, as in Fig. 7.

(2) Expansion of IP-state of process We suggested that a processive event's IP-state only supports one C-point of a following event. The second meta-rule refutes this default:

Meta rule 2 (Expansion of IP-state)

$$IP(X) \models Z \Leftarrow IP(X) \models Y,\ HL(Y) \models Z$$

where X *is a process, and* Y *and* Z *are events.* □

This means the second event Z, as well as Y, may have culminated within the IP-state of X, as in Fig. 8.

(3) The Limitation of State-supporting Zone The final suggestion we made in Section 3.2 is that for stative affairs. In that section, we suggested that stative affairs do not change their states everlastingly. However, of course, those static conditions may finish at some incidents. The third meta-rule is to terminate the HL-states of stative affairs. If we find that some event Y is not in $HL(X)$ of state X, we should declare '$HL(X) \not\models Y$' manually. Then, the meta-rule infers that successive events after Y are not also in $HL(X)$ (Fig. 9).

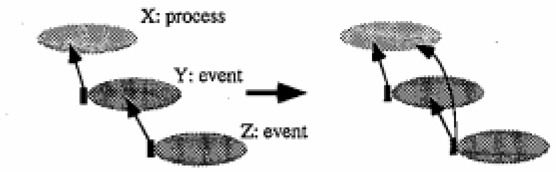

Figure 8: Expansion of process

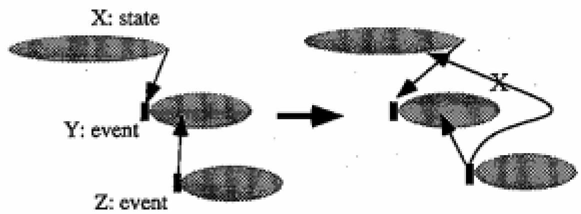

Figure 9: Limitation of state

Meta rule 3 (Termination of HL-state of state)

$$HL(X) \not\models Z \Leftarrow HL(X) \not\models Y,\ Y \preceq Z$$

where X *is a state, and* Y *and* Z *are events, and '*$Y \preceq Z$*' means a virtual order of events.* □

4.3 Example

We will us show a sample case comparison, with the same cases mentioned in [NOM+92]. In addition to the first case representation of Section 2.1, we introduce another case description below.

> "**Jane's case:** Jane strangled Dick to kill him. Though Dick only lost consciousness, Jane thought he was dead. Then, she took him to the seashore, and left him there. He inhaled sand and suffocated to death.

Now, we will generate temporal relations of this case, and let us compare this case with Mary's case. Fig. 10 shows the similarity comparison between the two cases. In both cases, *trivial* (irrelevant) affairs are omitted, and *important* (highly relevant) affairs are joined by the gray arrows.

Here, we can find two easy application of meta-rules. First, we claim that:

$$HL(leave) \models die \Leftarrow HL(leave) \models inhale,\ HL(inhale) \models die.$$

Thus, we can generate the same *important* temporal relation '$HL(leave) \models die$' in the new case, as well as the precedent case. Secondly, if there is a declaration that $HL(alive)$ terminated at $C(die)$ in the precedent case, we can also infer in the new case that:

$$HL(alive) \not\models die \Leftarrow (true).$$

Therefore, we can make the temporal structure of the new case same as the precedent case, for those important affairs.

5 Conclusion

We introduced a theory of verb types, and according to this, we attached each verb its temporal features. With these temporal types, different intervals are set up, and by default rules, we proposed a method to make temporal relations automatically in a legal case.

However, default rules are not general principles but heuristic rules dependent upon a given sequence of affairs. Actually, most of the temporal relations are the complication of the given simple order. Thus, the notion of rules lacks sound foundation. However, there is another aspect for these rules. They also can be guidelines for us to write down a course of affairs. Namely, as far as we observe the manner of rules, we can obtain faithful temporal descriptions of cases. In order to use them in this way, we need to polish up rules more, and also need to set up an environment to refute those defaults easily.

As methods for the refutation of default rules, we proposed meta-rules that are used to compare case similarity. Namely, when we need to claim that certain two cases are similar, we may utilize meta-rules and can produce the same temporal relations as a precedent case, from a new case. However still, these meta-rules themselves are ad hoc, and this fact arises from the feature of default rules. We need to polish up these default rules through applying them to a number of actual cases.

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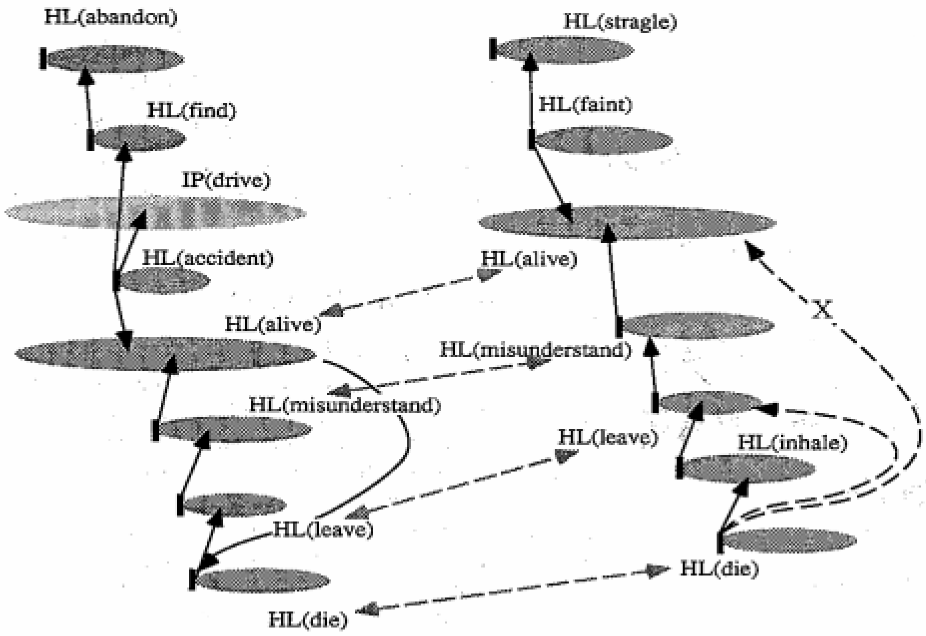

Figure 10: Comparison of Temporal relations

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