TimeLine: Cross-Document Event Ordering

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Introduction

NewsReader project

The goal of the project is to reconstruct story lines across news articles in order to provide policy and decision makers with an overview of what happened, to whom, when and where.

Task

Given a set of documents and a set of target entities, the task consists of building a timeline for each entity, by detecting, anchoring in time and ordering the events involving that entity.

Target entity: Steve Jobs

Document 1

DCT: 2005-06-06

Apple Computer CEO Steve Jobs gave his annual opening keynote on Monday.
He announced a seamless integration of podcast with iTunes.

Document 2

DCT: 2011-08-24

Steve Jobs has chosen to step down from his post as CEO of the company.
Steve Jobs has been fighting pancreatic cancer since 2004 and has been on medical leave since January of this year.

Document 3

DCT: 2011-10-06

He has been fighting pancreatic cancer since 2004.

Target entity: Steve Jobs

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DCT: 2011-10-06

He has been fighting pancreatic cancer since 2004 .

Timeline about Steve Jobs

1	2004	18315-7-fighting	18355-4-fighting
2	2005-06-05	1664-2-keynote	
2	2005-06-05	1664-3-announced	
3	2011-01	18315-7-leave	
4	2011-08-24	18315-2-step_down	

Task

4 (sub)tracks, depending on the input and the output:

- Track A (main track)
- SubTrack A
- Track B
- SubTrack B

Task

Track A (main track):

input data: raw texts

output: full TimeLines (ordering of events and assignment of time anchors)

SubTrack A:

input data: raw texts

output: TimeLines consist of just ordered events (no assignment of time anchors)

Task

Track B:

input data: texts with manual annotation of event mentions

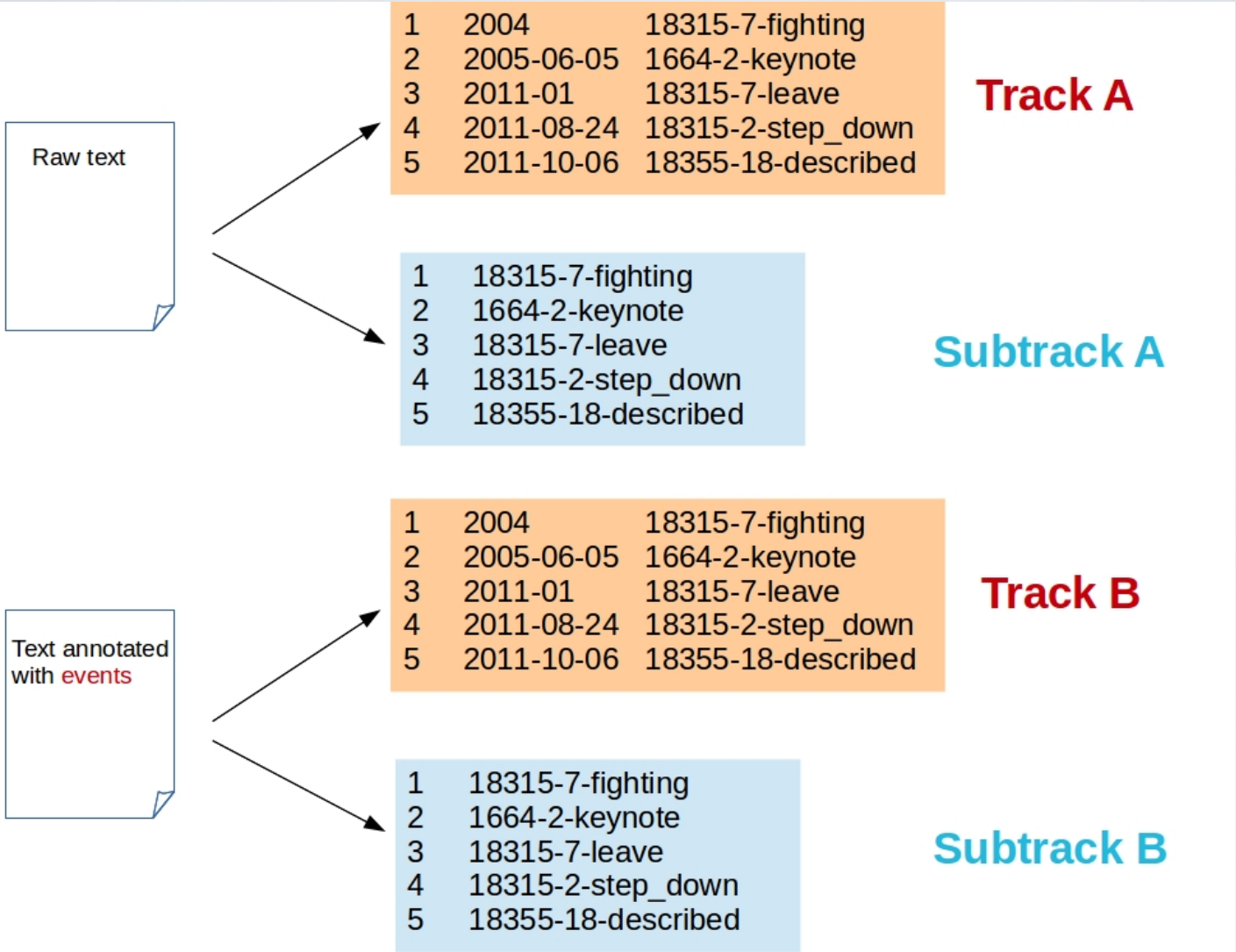
output: full TimeLines (ordering of events and assignment of time anchors)

SubTrack B:

input data: texts with manual annotation of event mentions

output: TimeLines consist of just ordered events (no assignment of time anchors)

Task


Raw text
1 2004 18315-7-fighting
2 2005-06-05 1664-2-keynote
3 2011-01 18315-7-leave
4 2011-08-24 18315-2-step_down
5 2011-10-06 18355-18-described
Track A
1 18315-7-fighting
2 1664-2-keynote
3 18315-7-leave
4 18315-2-step_down
5 18355-18-described
Subtrack A
Text annotated with events
1 2004 18315-7-fighting
2 2005-06-05 1664-2-keynote
3 2011-01 18315-7-leave
4 2011-08-24 18315-2-step_down
5 2011-10-06 18355-18-described
Track B
1 18315-7-fighting
2 1664-2-keynote
3 18315-7-leave
4 18315-2-step_down
5 18355-18-described
Subtrack B

Data

Documents

- Articles selected from the English Wikinews (`en.wikinews.org`) about four topics: (i) Apple Inc., (ii) Airbus and Boeing, (iii) General Motors, Chrysler and Ford and (iv) Stock Market
- 30 documents per topic

Seed entities

- The target entities are of type: PERSON (Steve Jobs), ORGANISATION (Airbus), PRODUCT (Airbus A380) and FINANCIAL (Nasdaq)
- 44 selected target entities

Quantitative data about the dataset

	Trial corpus Apple Inc.
# documents	30
# sentences	464
# tokens	10,373
# events	187
# target entities	6
# timelines	6
# events / timeline	31.2
# docs / timeline	5.8

Quantitative data about the dataset

	Trial corpus	Evaluation dataset			
	Apple Inc.	Airbus	GM	Stock	Total
# documents	30	30	30	30	90
# sentences	464	446	430	459	1,335
# tokens	10,373	9,909	10,058	9,916	29,893
# events	187	343	308	264	915
# target entities	6	13	12	13	38
# timelines	6	13	11	13	37
# events / timeline	31.2	26.4	25.7	20.3	24.1
# docs / timeline	5.8	6.2	5.7	9.1	6.9

Evaluation metrics

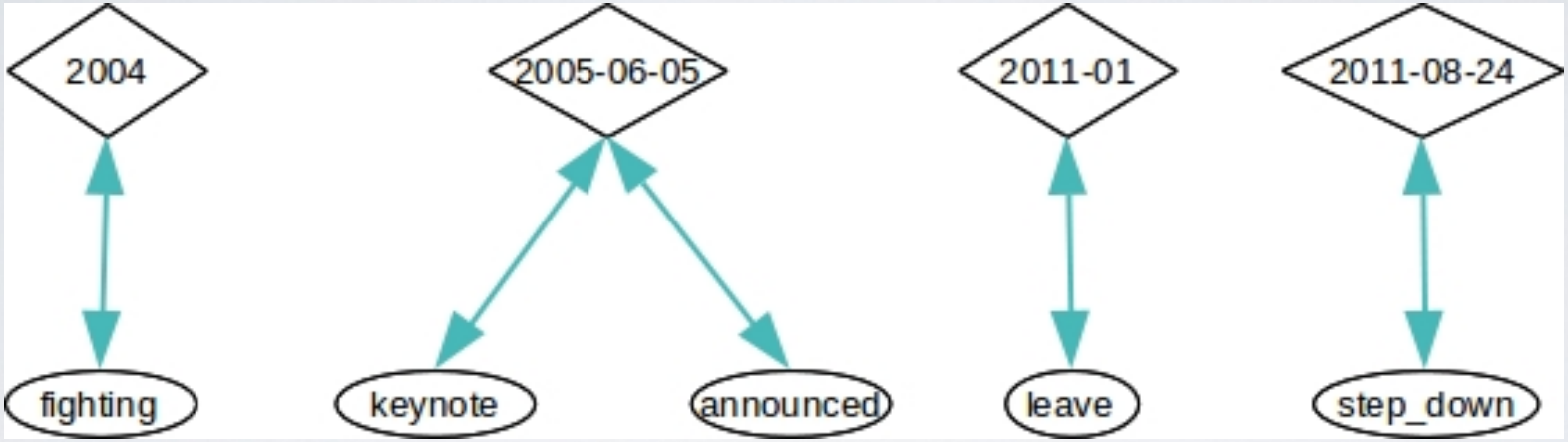
Temporal relation evaluation methodology

- Methodology based on the metric used for TempEval-3 at SemEval 2013 (UzZaman et al., 2013)
- Relations represented as timegraph
- Evaluation in terms of recall, precision and F1-score

From a timeline to a set of temporal relations

- Each time anchor is represented as a TIMEX3 element
- Each event is related to one TIMEX3 with a relation of type SIMULTANEOUS
- If one event happens before another one: a BEFORE relation is created
- If one event happens at the same time as another one: a SIMULTANEOUS relations is created

Evaluation


2004
2005-06-05
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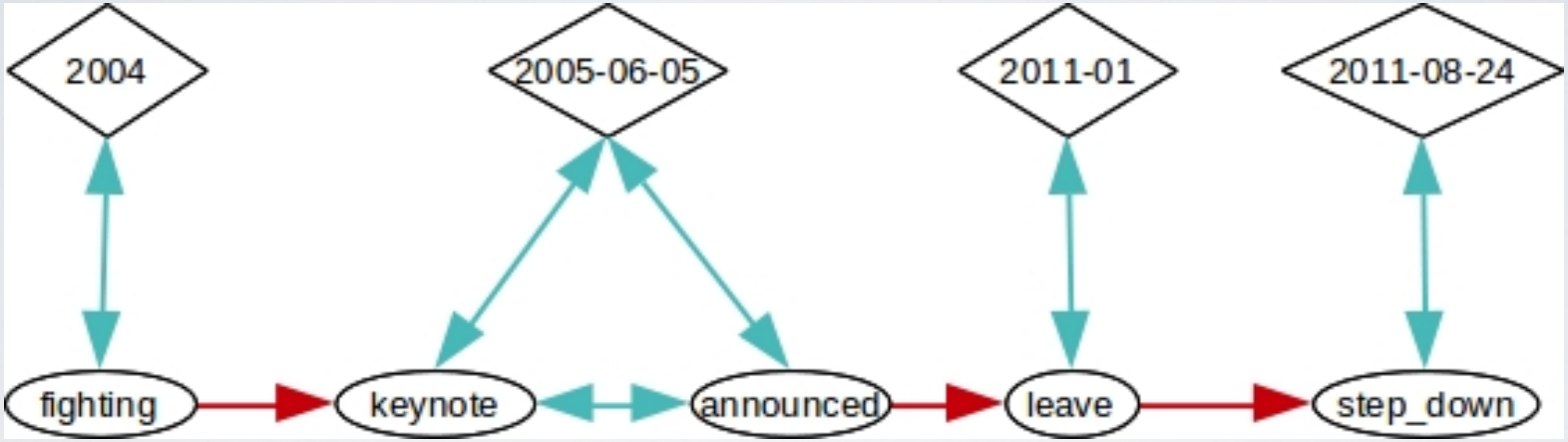
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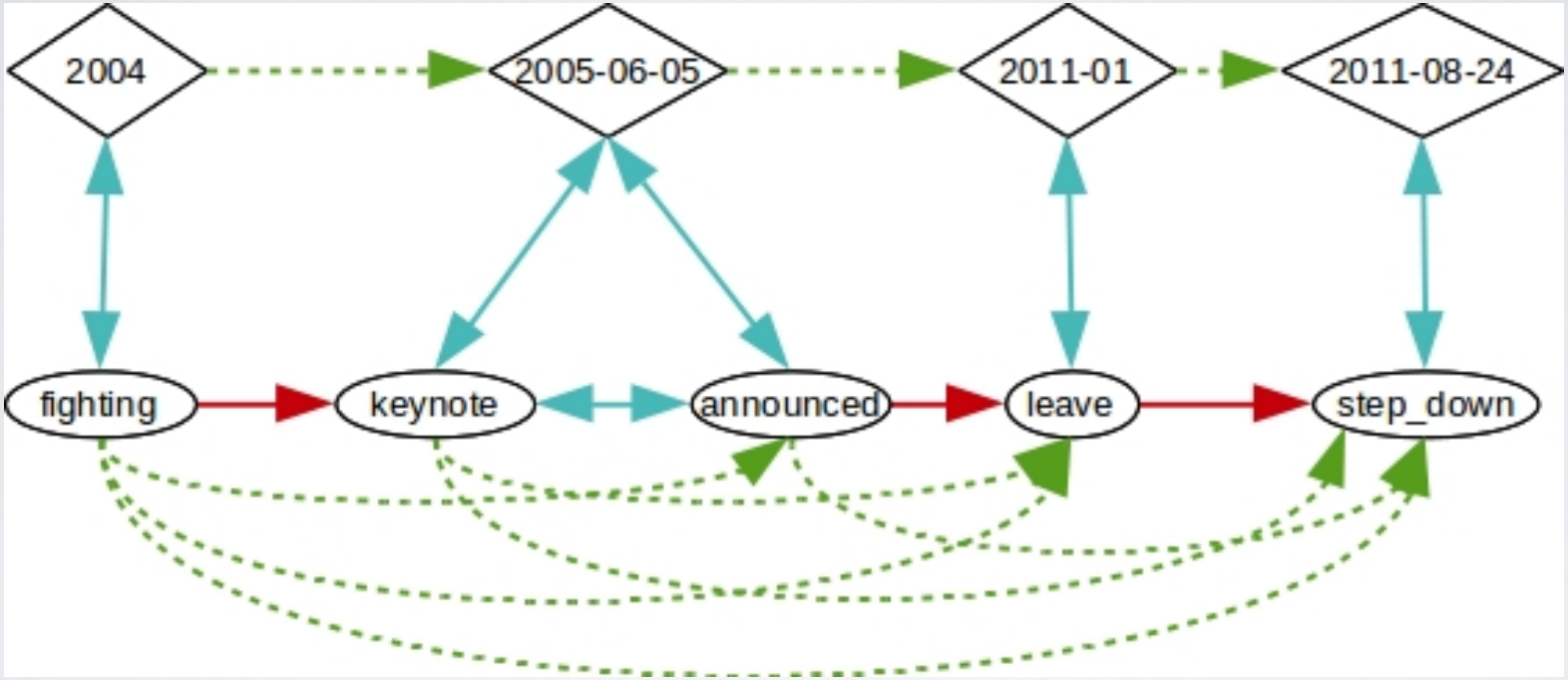
2004
2005-06-05
2011-01
2011-08-24
fighting
keynote
announced
leave
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Participants

- 29 teams registered
- 4 teams participated
  - University of Alicante, Spain
  - Heidelberg University, Germany (University of Toulouse Paul Sabatier, France / University of Tunis El-Manar, Tunisia)
  - VU University Amsterdam, The Netherdland
  - Wuhan University, China

Results (Tracks A and B)

		Airbus F1	GM F1	Stock F1	Total P	Total R	Total F1
A	WHUNLP_1	9.42	5.97	7.26	14.59	5.37	**7.85**
	SPINOZAVU_1	4.07	5.31	0.42	7.95	1.96	3.15
	SPINOZAVU_2	2.67	0.62	0.00	8.16	0.56	1.05
B	GPLSIUA_1	22.35	19.28	33.59	21.73	30.46	**25.36**
	GPLSIUA_2	20.47	16.17	29.90	20.08	26.00	22.66
	HEIDELTOUL_1	19.62	7.25	20.37	20.11	14.76	17.03
	HEIDELTOUL_2	16.50	10.94	25.89	13.58	28.23	18.34

Results (Subtracks A and B)

		Track			Subtrack		
		P	R	F1	P	R	F1
A	WHUNLP_1	14.59	5.37	7.85	-	-	-
	SPINOZAVU_1	7.95	1.96	3.15	6.70	0.97	**1.69**
	SPINOZAVU_2	8.16	0.56	1.05	13.04	0.14	0.27
B	GPLSIUA_1	21.73	30.46	25.36	18.90	29.85	**23.15**
	GPLSIUA_2	20.08	26.00	22.66	16.19	23.52	19.18
	HEIDELTOUL_1	20.11	14.76	17.03	19.58	11.42	14.42
	HEIDELTOUL_2	13.58	28.23	18.34	12.18	26.41	16.67

Main Track A

System	P	R	F1
SPINOZAVU-RUN-1	7.95	1.96	3.15
SPINOZAVU-RUN-2	8.16	0.56	1.05
WHUNLP_1	14.10	4.90	7.28
OC_SPINOZA_VU	-	-	7.12
WHUNLP_1	**14.59**	**5.37**	**7.85**

- OC_SPINOZA_VU and WHUNLP_1 based on NLP pipelines

Baseline TimeLine extraction (BTE)

- TimeLines which contain events with explicit time-anchoring
- Generic NLP pipeline
- TimeLine extraction in 3 steps

Baseline TimeLine extraction (BTE)

NLP pipeline

Named-Entity Recognition (NER) and Disambiguation (NED)

NER using the ixa-pipe-nerc that is part of IXA pipes. NED module is based on DBpedia Spotlight.

Coreference Resolution (CR)

Module loosely based on the Stanford Multi Sieve Pass sytem.

Semantic Role Labelling (SRL)

SRL system included in the MATE-tools.

Time Expression Identification (TEI) and Normalization (TEN)

Time module from TextPro suite.

Time Relation Extraction (TRE)

Module from TextPro.

Baseline TimeLine extraction (BTE)

TimeLine extraction in 3 steps

1. Target entity identification
2. Event selection
3. Time-anchoring

Baseline TimeLine extraction (BTE)

1. Target entity identification

Target entities identified by the NED module

- Redirect links contained in DBpedia

  Example: Apple $\rightarrow$ Apple Computer, Apple Inc., ...

Apple Computer was started in 1976.
They launched the iTunes Music Store in 2003.

Baseline TimeLine extraction (BTE)

1. Target entity identification

Target entities identified by the NED module

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  Example: Apple → Apple Computer, Apple Inc., ...

Apple Computer was started in 1976.
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Baseline TimeLine extraction (BTE)

2. Event selection

SRL module to extract the events that occur in a document.

- Combine NER, NED, CR and SRL to obtain events with the target entity as participant.

Apple Computer was started in 1976.
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Baseline TimeLine extraction (BTE)

2. Event selection

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Baseline TimeLine extraction (BTE)

3. Time-anchoring

Time-anchors from the output of the TRE and SRL.

- TRE: SIMULTANEOUS relations between events and time-expressions
- SRL: ARG-TMP related to time-expressions
- TEI + TEN: Normalized time-expressions

Sort the events by their time-anchors.

Apple Computer was started in 1976.

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Sort the events by their time-anchors.

Apple Computer

1	1976	started
2	2003	launched

Results on the SemEval-2015 task

System	P	R	F1
SPINOZAVU-RUN-1	7.95	1.96	3.15
SPINOZAVU-RUN-2	8.16	0.56	1.05
WHUNLP_1	14.10	4.90	7.28
OC_SPINOZA_VU	-	-	7.12
WHUNLP_1	14.59	**5.37**	**7.85**
BTE	**26.42**	4.44	7.60

- **BTE**: explicit time-anchors; similar results as best SemEval systems

Error analysis

Errors produced in the 3 steps:

- Target entity identification
- Event selection
- Time-anchoring

Error analysis

Target entity identification

- The entity is wrongly disambiguated
- Example:

  “a new Toyota car” → Toyota Motor Company

Error analysis

Event selection

- Mainly due Coreference errors
- Example:

  “General Motors stated that the company would stop...”
  the company $\not\rightarrow$ General Motors

Error analysis

Time-anchoring

- Only timex occurring in the same sentence.

  “GM reported losing $4 billion in the fourth quarter of 2005”

  reported → fourth quarter of 2005

- Most of events do not have an explicit time-anchor.

  “This has been attributed to GM’s shrinking market share, which has been taken by Japanese manufacturers Toyota and Nissan. “

  attributed → ?
  shrinking → ?
  take → ?

Document level Time-anchoring (DLT)

- SemEval 2015 task 4 requires a quite complete time anchoring
- Explicit temporal relations are not enough
- **Hypothesis**: Temporal analysis must be performed at a document level in order to discover implicit temporal relations

  > Events of an entity tend to occur at the same time, except stated explicitly.

Document level Time-anchoring (DLT)

Algorithm

Starting from the annotation obtained by the NLP pipeline:

```
1:  eventList = sorted list of events of an entity
2:  for event in eventList do
3:      eAnchor = time anchor of event
4:      eTense = verb tense of event
5:      if eAnchor not NULL then
6:          defaultAnchor[eTense] = eAnchor
7:      else if defaultAnchor[eTense] not NULL then
8:          eAnchor = defaultAnchor[eTense]
9:      else
10:         eAnchor = DCT
11:         defaultAnchor[eTense] = DCT
12:     end if
13: end for
```

Document level Time-anchoring (DLT)

Example of document-level time-anchoring

Apple Computer CEO and co-founder **Steve Jobs** gave his annual opening keynote to the World Wide Developers Conference (WWDC) at Moscone Center in San Francisco, California on **Monday**...

Moving on, **Jobs** announced that there have been 2 million copies of **Tiger** sold in the **6 weeks** that it has been available....

Steve announced that **Mac OS X Leopard** would be released in **2007** ....

- Explicit time-anchors

  gave $\rightarrow$ *Monday*
  sold $\rightarrow$ *6 weeks*
  released $\rightarrow$ *2007*

Document level Time-anchoring (DLT)

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Steve announced that **Mac OS X Leopard** would be released in **2007** ....

- Implicit time-anchors

  announced $\rightarrow$ *Monday*
  announced $\rightarrow$ *Monday*

Results on the SemEval-2015 task

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OC_SPINOZA_VU	-	-	7.12
WHUNLP_1	14.59	5.37	7.85
BTE	**26.42**	4.44	7.60
DLT	20.67	**10.95**	**14.31**

- **BTE**: explicit time-anchors; similar results as best SemEval systems
- **DLT**: implicit time-anchors; outperforms BTE

Results on the SemEval-2015 task

System	P	R	F1
BTE	**26.42**	4.44	7.60
DLT	20.67	10.95	**14.31**
BTE$_{caevo}$	17.56	4.86	7.61
DLT$_{caevo}$	17.02	**12.09**	14.13

- Results not biased by the time-relation extractor

  BTE$_{caevo}$ and **DLT**$_{caevo}$: using CAEVO for extracting time-relations.

Conclusion

Task

- First task focusing on cross-document ordering of events
- Challenging task
- Open issues for future research:
  - Representation of durative events in the timeline

System

- We have proved that capturing implicit time-anchoring obtains the best results.
- Things to be improved
  - Entity disambiguation
  - Coreference resolution

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