

# ISO-TIMEML: AN INTERNATIONAL STANDARD FOR SEMANTIC ANNOTATION

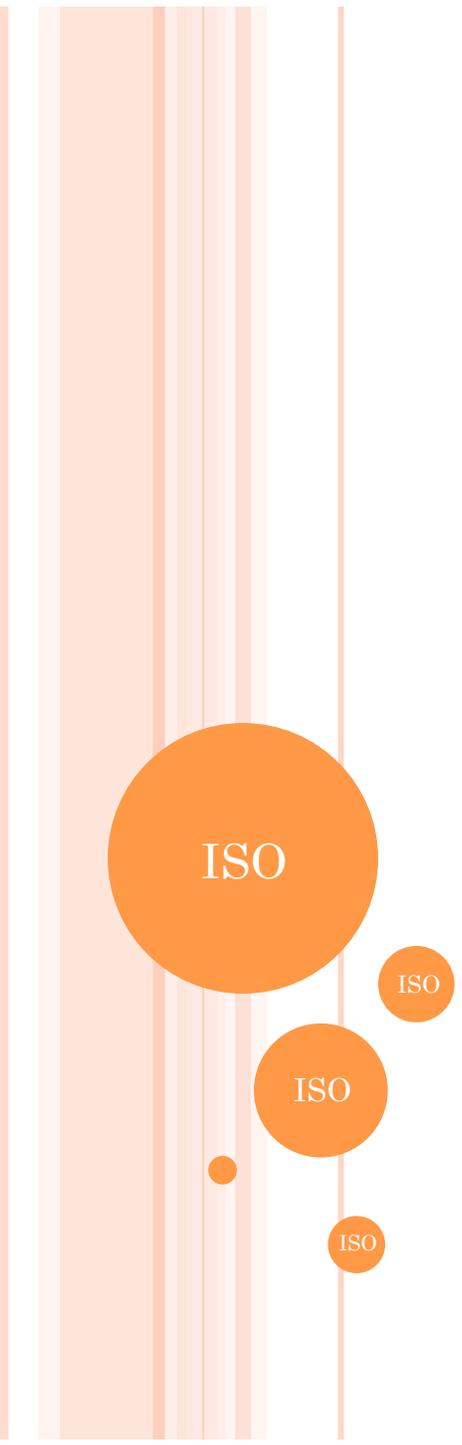
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# OUTLINE

- Motivation for event and temporal markup in language
- Basics of TimeML
- Problems with TimeML
- Enhancements in ISO-TimeML



## MOTIVATION FOR TIME AND EVENT MARKUP

- Natural language is filled with references to past and future events, as well as planned activities and goals;
- Without a robust ability to identify and temporally situate events of interest from language, the real importance of the information can be missed;
- A Robust Annotation standard can help leverage this information from natural language text.



## TEMPORAL AWARENESS IN REAL TEXT

- The bridge **collapsed** **during the storm** but **after** traffic was **rerouted** to the Bay Bridge.
- President Roosevelt **died** in April 1945 **before**
  - the war **ended**. (*event happened*)
  - he **dropped** the bomb. (*event didn't happen*)
- The CEO **plans** to **retire next month**.
- **Last week** Bill was **running** the marathon when he **twisted** his ankle. Someone had **tripped** him. He **fell** and didn't **finish** the race.



# CURRENT TIME ANALYSIS TECHNOLOGY

## ○ Document Time Linking

- Find the document creation time and link that to all events in the text;

## ○ Local Time Stamping

- find an event and a “local temporal expression”, and link it to that time;



## DOCUMENT TIME STAMPING

April 25, 2010

- President Obama **paid tribute** Sunday to 29 workers **killed** in an explosion at a West Virginia coal mine earlier this month, **saying** they **died** "in pursuit of the American dream." The **blast** at the Upper Big Branch Mine was the worst U.S. mine disaster in nearly 40 years. Obama **ordered** a **review** earlier this month and **blamed** mine officials for lax **regulation**.



## DOCUMENT TIME STAMPING:

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## DOCUMENT TIME STAMPING: FOR REAL

April 25, 2010

- President Obama **paid tribute** **Sunday** to 29 workers **killed** in an explosion at a West Virginia coal mine **earlier this month**, **saying** they **died** "in pursuit of the American dream." The **blast** at the Upper Big Branch Mine was the worst U.S. mine disaster in nearly 40 years. Obama **ordered** a **review** **earlier this month** and **blamed** mine officials for lax **regulation**.



## TIME STAMPING: THE GOOD, BAD, ...

- ☺ Set up a **meeting on Tuesday** with EMC.  

- ☺ Franklin **arrives tomorrow** from London.  

- ☹ Franklin **arrives** on **the afternoon** flight from London **tomorrow**.  

- ☹ ☹ Most people **drive today** while talking on the phone.  




# TEMPORAL AWARENESS CHALLENGE

- Identification of all important events in a text
- Actual temporal ordering and time anchoring of these events to temporal expressions.



## ISO-TIMEML ENABLES TEMPORAL PARSING

- A new generation of language analysis tools that are able to temporally organize events in terms of their ordering and time of occurrence
- These tools can be integrated with visualization, summarization, question answering, and link analysis systems to help analyze large event-rich information spaces.



## ISO-TIMEML PROVIDES ELEMENTS TO:

- Find all events and times in newswire text
- Link events to the document time and to local times
- Order event relative to other events
- Ensure consistency of the the temporal relations



# TEMPORAL PARSING TECHNOLOGIES

- Build temporal representations of events in document collections;
- Track people and the events they participated in;
- Answer questions about when events occur.



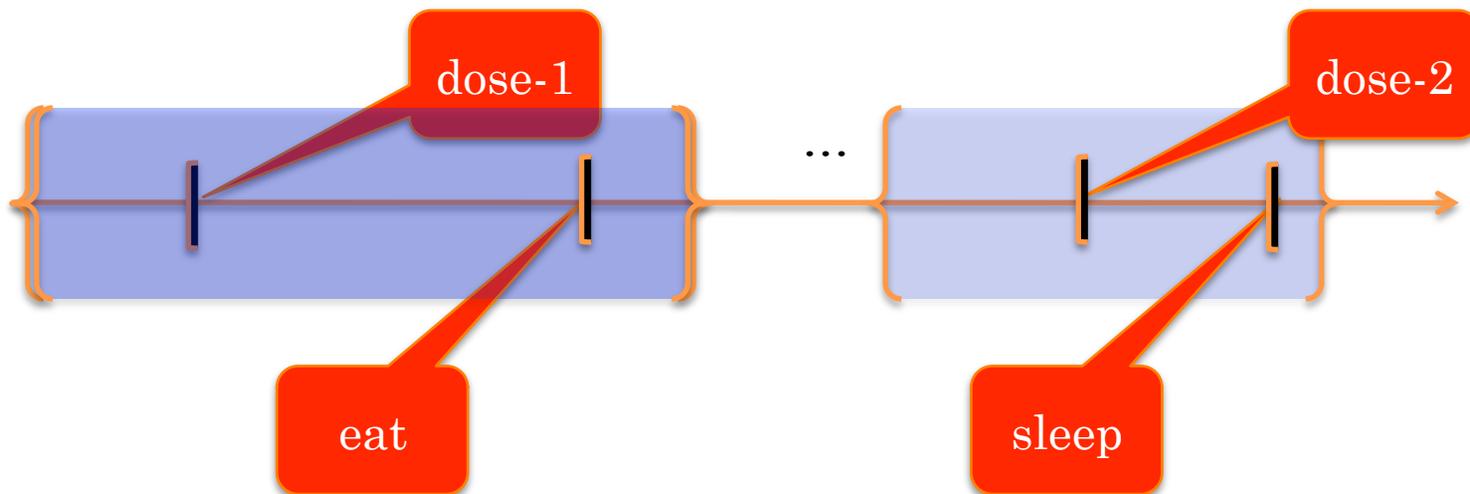
## APPLICATIONS IMPACTED

- Health Care, Bioinformatics, Insurance
- Object Tracking
- Search and Categorization
- Trend Analysis and Prediction



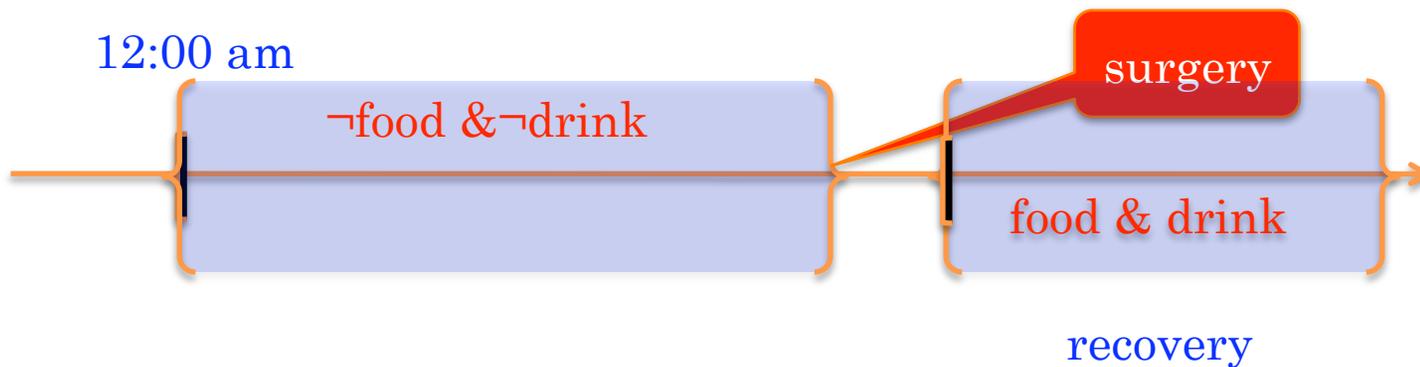
# TEMPORAL AWARENESS

- Take your 1<sup>st</sup> dose of levaquin in the morning before any food, 2<sup>nd</sup> dose before sleep.



# TEMPORAL AWARENESS

- No food or drink after midnight before surgery, until you are in recovery.



# DIFFERENT NOTIONS OF EVENTS

- **Topic**: “well-defined subject” for searching
  - document- or collection-level
- **Template**: structure with slots for participant named entities
  - document-level
- **Mention**: linguistic expression that expresses an underlying event
  - phrase-level (verb/noun)



# EVENTS AS TEMPLATES

**Wall Street Journal, 06/15/88 MAXICARE HEALTH PLANS INC and UNIVERSAL HEALTH SERVICES INC have dissolved a joint venture which provided health services.**

```
<TEMPLATE-8806150049-1> :=
  DOC NR: 8806150049
  CONTENT: <TIE_UP_RELATIONSHIP-8806150049-1>
  DATE TEMPLATE COMPLETED: 311292
  EXTRACTION TIME: 0
<TIE_UP_RELATIONSHIP-8806150049-1> :=
  TIE-UP STATUS: DISSOLVED
  ENTITY: <ENTITY-8806150049-1>
    <ENTITY-8806150049-2>
  JOINT VENTURE CO: <ENTITY-8806150049-3>
  OWNERSHIP: <OWNERSHIP-8806150049-1>
    <OWNERSHIP-8806150049-2>
  ACTIVITY: <ACTIVITY-8806150049-1>
<ENTITY-8806150049-1> :=
  NAME: Maxicare Health Plans INC
  ALIASES: "Maxicare"
  LOCATION: Los Angeles (CITY 4) California (PROVINCE 1) United States (COUNTRY)
  TYPE: COMPANY
  ENTITY RELATIONSHIP: <ENTITY_RELATIONSHIP-8806150049-1>
<ENTITY-8806150049-2> :=
  NAME: Universal Health Services INC
  ALIASES: "Universal Health"
  LOCATION: King of Prussia (CITY) Pennsylvania (PROVINCE 1) United States (COUNTRY)
  TYPE: COMPANY
  ENTITY RELATIONSHIP: <ENTITY_RELATIONSHIP-8806150049-1>
<ACTIVITY-8806150049-1> :=
  INDUSTRY: <INDUSTRY-8806150049-1>
  ACTIVITY-SITE: (<FACILITY-8806150049-1> <ENTITY-8806150049-3>)
<INDUSTRY-8806150049-1> :=
  INDUSTRY-TYPE: SERVICE
  PRODUCT/SERVICE: (80 "a joint venture Nevada health maintenance [organization]"
```

Systems can fill such templates

at ~ 60% accuracy from news (MUC evals)



# ACE EVENT TYPES

<b>Types:</b>
Destruction/Damage (BRK)
Creation/Improvement (MAK)
Transfer of Possession or Control (GIV)
Movement (MOV)
Interaction of Agents (INT)

# ACE Event Roles

Role	Description
Agent	The cause of the event
Object	The entity acted upon by the event
Source	The original location (for MOV or GIV only)
Target	The resultant location (for MOV or GIV only)
Time	The time of the event
Location	The location of the event
Other	Other event participants

# EVENTS IN TIMEML

- **Mention**: linguistic expression that expresses an underlying event
  - Phrase-level (verb/noun)
- Since they correspond to surface mentions, easier to annotate and recognize
  - Accuracy is > 88% (ARDA AQUAINT (TARSQI))
- Like templates
  - they are linked to times
- Unlike templates
  - the times are *resolved*
    - 87% accuracy in time resolution (TERN evals: [timex2.mitre.org](http://timex2.mitre.org))
    - the links involve temporal relations
  - the events are temporally ordered
  - the links also involve other logical relations (subordinating and aspectual)



# FEATURES OF ISO-TIMEML

- Identifies temporal expressions;
  - **Dates, times**
  - **Temporal Functions:** three years ago
  - **Anchors to events and other temporal expressions:** three years after the Gulf War
- Identifies signals determining interpretation of temporal expressions;
  - **Temporal Prepositions:** for, during, on, at;
  - **Temporal Connectives:** before, after, while.
- Identifies event expressions;
  - **tensed verbs;** has left, was captured, will resign;
  - **stative adjectives;** sunken, stalled, on board;
  - **event nominals;** merger, Military Operation, Gulf War;
- Creates dependencies between events and times:
  - **Anchoring;** John left on Monday.
  - **Orderings;** The party happened after midnight.
  - **Embedding;** John said Mary left.



# ISO-TIMEML TAGS

- **<TIMEX3>**
  - Used to mark up explicit temporal expressions, such as times, dates, durations, etc. It is modeled on the TIDES TIMEX2 tag.
- **<EVENT>**
  - Used to annotate those elements in a text that mark the semantic events described by it. Events are typically verbs, although event nominals, such as "crash" in "...killed by the crash", are also annotated as events.
- **<TLINK>**
  - One of the three TimeML link tags. Link tags encode the various relations that exist between the temporal elements of a document. A TLINK is a temporal link. It represents the relation between two temporal elements.
- **<SLINK>**
  - A subordination link that is used for contexts involving modality, evidentials, and factives. An SLINK is used in cases where an event instance subordinates another event instance type.
- **<ALINK>**
  - An aspectual link, it indicates an aspectual connection between two events. In some ways, it is like a cross between TLINK and SLINK in that it indicates both a relation between two temporal elements, as well as aspectual subordination.
- **<ARGLINK>**
  - A link establishing a relationship between an event and each of its participants. ARGLINK uses the entity ID and binds it to the event.



# TIMEML:

## ANNOTATION OF TEMPORAL ENTITIES

- **Temporal expressions: <TIMEX3>**
  - **Times:** *3 o'clock, mid-morning.*
  - **Dates:**
    - Fully Specified: *June 11, 1989; Summer, 2002.*
    - Underspecified: *Monday, next month, two days ago.*
  - **Durations:** *three months, two years.*
  - **Sets:** *every month, each Tuesday.*
- **Event expressions: <EVENT>**
  - **Expressions denoting events** that participate in the narrative of a given document, and which can be temporally ordered.
  - Event-related **grammatical features:**
    - **Tense:** past, present, past, etc.
    - **Aspect:** progressive, perfective, perfective-progressive.
    - **Polarity:** positive, negative.
    - **Modality:** *would, could, may, etc.*
    - **Class:** occurrence, state, aspectual, intensional, etc.



# TIMEML:

## ANNOTATION OF TEMPORAL RELATIONS

### ○ Temporal links: <TLINK>

- Anchoring of Events to Times
- Ordering of Events
- 13 temporal relations (based on Allen's relations), among which:
  - **Simultaneous**
  - **Before** (e.g., *For most of the murders, suspects have already been arrested*)
  - **After**
  - **Immediately before** (e.g., *All passengers died when the plane crashed into the mountain*)
  - **Immediately after.**
  - **Including** (e.g., *John arrived in Boston last Thursday*)
  - Etc.

### ○ Aspectual links: <ALINK> Phases of an event

- **Initiation:** *John started to read.*
- **Culmination:** *John finished assembling the table.*
- **Termination:** *John stopped talking.*
- **Continuation:** *John kept talking.*



# TIMEML:

## ANNOTATION OF TEMPORAL RELATIONS

### ○ Subordinating links <SLINK>

- Events that syntactically subordinate other events
- Providing information about the factual nature of the embedded event:

**Factive:** The embedded event is presupposed or entailed as factual.

*John forgot that he was in Boston last year.*

*Mary regrets that she didn't marry John.*

**Counterfactive:** The embedded event is presupposed as non-factual:

*John forgot to buy some wine.*

*John prevented the divorce.*

**Evidential:** Introduced by REPORTING or PERCEPTION:

*John said he bought some wine.*

*Mary saw John carrying only beer.*

**Negative evidential:** Introduced by REPORTING events conveying negative polarity:

*John denied he bought only beer.*

**Modal:** Expressing different degrees of uncertainty, possibility, thought, etc.

*Analysts also suspect suppliers have fallen victim to their own success.*



## EXAMPLE: TEMPORAL EXPRESSIONS

AP-NR-08-15-90 1337EDT

Iraq's Saddam Hussein, facing U.S. and Arab troops at the Saudi border, **today** sought peace on another front by promising to withdraw from Iranian territory and release soldiers captured during the Iran-Iraq war. Also **today**, King Hussein of Jordan arrived in Washington seeking to mediate the Persian Gulf crisis. President Bush on **Tuesday** said the United States may extend its naval quarantine to Jordan's Red Sea port of Aqaba to shut off Iraq's last unhindered trade route.

In another mediation effort, the Soviet Union said **today** it had sent an envoy to the Middle East on a series of stops to include Baghdad. Soviet officials also said Soviet women, children and invalids would be allowed to leave Iraq.



## EXAMPLE: EVENTS

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## EXAMPLE:

### TLINKS, ANCHORING EVENT TO TIMEX

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## EXAMPLE:

# TLINKS, ORDERING EVENTS

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Iraq's Saddam Hussein, facing U.S. and Arab troops at the Saudi border, **today sought peace** on another front by promising to **withdraw** from Iranian territory and **release** soldiers **captured** during the Iran-Iraq **war**. Also **today**, King Hussein of Jordan **arrived** in Washington seeking to mediate the Persian Gulf crisis. President Bush on **Tuesday said** the United States may **extend** its naval **quarantine** to Jordan's Red Sea port of Aqaba to **shut** off Iraq's last unhindered trade route.

Past < Tuesday < Today < Indef Future

---

war(I,I)	say(Bush,S)	arrive(H,DC)	withdraw(Saddam)
capture(sold)		seek(Saddam,peace)	release(Saddam,soldiers)
			extend(US,quarantine)
			shut_off(US,trade_route)



## EXAMPLE:

### ALINKS, PHASES OF EVENTS

President Bush today **denounced** Saddam's ``ruinous policies of **war**," and **said** the United States is ``**striking a blow** for the principle that might does not **make** right."

In a **speech delivered** at the Pentagon, Bush **seemed** to **suggest** that American forces could **be** in the gulf region for some time.

``No one should **doubt** our **staying power** or **determination**," he **said**.

The U.S. military **buildup** in Saudi Arabia **continued** at fever pace, with Syrian troops now part of a multinational force **camped out** in the desert to **guard** the Saudi kingdom from any new **thrust** by Iraq.

In a letter to President Hashemi Rafsanjani of Iran, **read** by a broadcaster over Baghdad radio, Saddam **said** he will **begin withdrawing** troops from Iranian territory a week from tomorrow and **release** Iranian prisoners of war.



## EXAMPLE:

# SLINKS, FACTUAL NATURE OF EVENTS

AP-NR-08-15-90 1337EDT

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territory and **release** soldiers **captured**

during the Iran-Iraq **war**. Also today, King Hussein of Jordan **arrived** in Washington **seeking** to **mediate** the Persian Gulf **crisis**. President Bush on Tuesday **said** the United States may **extend** its naval **quarantine** to Jordan's Red Sea port of Aqaba to **shut off** Iraq's last **trade route**.

In another **mediation effort**, the Soviet Union **said** today it had **sent** an envoy to the Middle East on a series of **stops** to **include** Baghdad. Soviet officials also **said** Soviet women, children and invalids would be **allowed** to **leave** Iraq.

## EXAMPLE:

### SLINKS, REPORTED SPEECH

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In another **mediation effort**, the Soviet Union **said** today it had **sent** an envoy to the Middle East on a series of **stops** to **include** Baghdad. Soviet officials also **said** Soviet women, children and invalids would be **allowed** to **leave** Iraq.

## NEW FEATURES IN ISO-TIMEML

- Follow the abstract syntax/concrete syntax distinction
- Introduces Standoff Annotation;
- Introduces a Measurement function, MLINK
- Supports Temporal Quantification



# STANDOFF ANNOTATION IN ISO-TIMEML

- Conforms to following three ISO standards:
  - ISO 24610-1:2006 FSR
  - ISO DIS 24611 MAF, and
  - ISO DIS 24612 LAF
- Mia visited Seoul to look me up yesterday.

```
<maf xmlns:"http://www.iso.org/maf">  
<seg type="token" xml:id="token1">Mia</seg>  
<seg type="token" xml:id="token2">visited  
</seg>  
<seg type="token" xml:id="token3">Seoul  
</seg>  
<seg type="token" xml:id="token4">to</seg>  
<seg type="token" xml:id="token5">look  
</seg>
```



# OFFLINE ID THROUGH TEXT SPANS

```
<TIMEX3 xml:id="t0" type="DATE"
value="2009-10-20"
functionInDocument="CREATION_TIME"/>
<EVENT xml:id="e1" target="#token2"
class="OCCURRENCE" tense="PAST"/>
<EVENT xml:id="e2"
target="#range(#token5,#token7)"
class="OCCURRENCE"
tense="NONE" vForm="INFINITIVE"/>
<TIMEX3 xml:id="t1" type="DATE"
value="2009-10-19"/>
<TLINK target="#range(#e1,#t0)"
relType="BEFORE"/>
```



# MODELING EVENTS RELATIVE TO TIME:

- **ORDER:**

- The position of the interval relative to others :

- **MEASURE:**

- The size of the interval;

- **QUANTITY:**

- The number of intervals.



# EVENT ANCHORING

- John taught on Tuesday.
    - ▮ a. EVENT tag introduces a quantified event expression  $\implies \exists e_1[teach(e_1)]$ ;
    - ▮ b. TIMEX3 tag introduces the temporal expression  $\implies \exists t_2[tuesday(t_2)]$ ;
    - ▮ c. TLINK introduces the ordering relation  $\implies \lambda y \lambda x[\tau(x) \subseteq y]$ .
- 

- a.  $teach = e_1, tuesday = t_2$
- b.  $\exists e_1 \exists t_2 [teach(e_1) \wedge tuesday(t_2) \wedge \tau(e_1) \subseteq t_2]$



# EVENT ORDERING

- John taught before Mary arrived.

- EVENT tag introduces a quantified event expression  $\implies \exists e_1[teach(e_1)]$ ;
- EVENT tag introduces a quantified event expression  $\implies \exists e_2[arrive(e_2)]$ ;
- TLINK introduces the ordering relation  $\implies \lambda y \lambda x[\tau(x) < \tau(y)]$ .

- teach =  $e_1$ , arrive =  $e_2$
- $\exists e_1 \exists e_2[teach(e_1) \wedge arrive(e_2) \wedge \tau(e_1) < \tau(e_2)]$



# DURATIONS IN TIMEML

- John slept for two hours.

- Use TLINK:

```
<EVENT id="e1" pred="SLEEP"/>
```

```
<TIMEX3 id="t1" type="DURATION" value="P2H"/>
```

```
<TLINK eventID="e1" relatedToTime="t1" relType="SIMULTANEOUS"/>
```

a.  $\text{sleep} = e_1, t_1 = \text{"two hours"}$

b.  $\exists e_1 \exists t_1 [\text{sleep}(e_1) \wedge \text{two\_hours}(t_1) \wedge \tau(e_1) = t_1]$



# MEASURING EVENTS IN ISO-TIMEML

- John taught for three hours on Tuesday.
- Introduce MLINK:

```
<EVENT id="e1" pred="TEACH"/>
```

```
<TIMEX3 id="t2" type="DURATION" value="P3H"/>
```

```
<MLINK eventID="e1" relatedToTime="t2" />
```

a.  $teach = e_1, tuesday = t_2, m = [3, hour]$

b.  $\exists e_1 \exists t_2 [teach(e_1) \wedge \mu(\tau(e_1)) = m \wedge$   
 $m = [3, hour] \wedge tuesday(t_2) \wedge \tau(e_1) \subseteq t_2]$



## QUANTITY

- John taught every Monday in November.

- EVENT tag introduces a quantified event expression  $\implies \exists e_1[teach(e_1)]$ ;
- TIMEX3 tag introduces the temporal expression  $\implies \exists t_1[monday(t_1)]$ ;
- TIMEX3 tag introduces the temporal expression  $\implies \exists t_2[november(t_2)]$ ;
- TLINK introduces an ordering relation  $\implies \lambda y \lambda x[\tau(x) \subseteq y]$ ;



- $\forall t_1 \exists e_1 \exists t_2 [(Monday(t_1) \wedge November(t_2) \wedge t_1 \subseteq t_2) \rightarrow (teach(e_1) \wedge \tau(e_1) \subseteq t_1)]$



# SUMMARY OF ISO-TIMEML

- Enhances our ability to annotate temporal and event expressions in multiple languages
- Has an explicit semantics associated with the abstract syntactic specification
- Is already being tested against SemEval standards competitions.
- Integrated into the TTK (TARSQI Toolkit) at Brandeis
- Work Ahead:
  - Integration with predicate-argument markup
  - Model argument quantification (QNP)



THANK YOU!

[timeml.org](http://timeml.org)

