

Context-dependent Semantic Parsing for Time Expressions

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University of Washington

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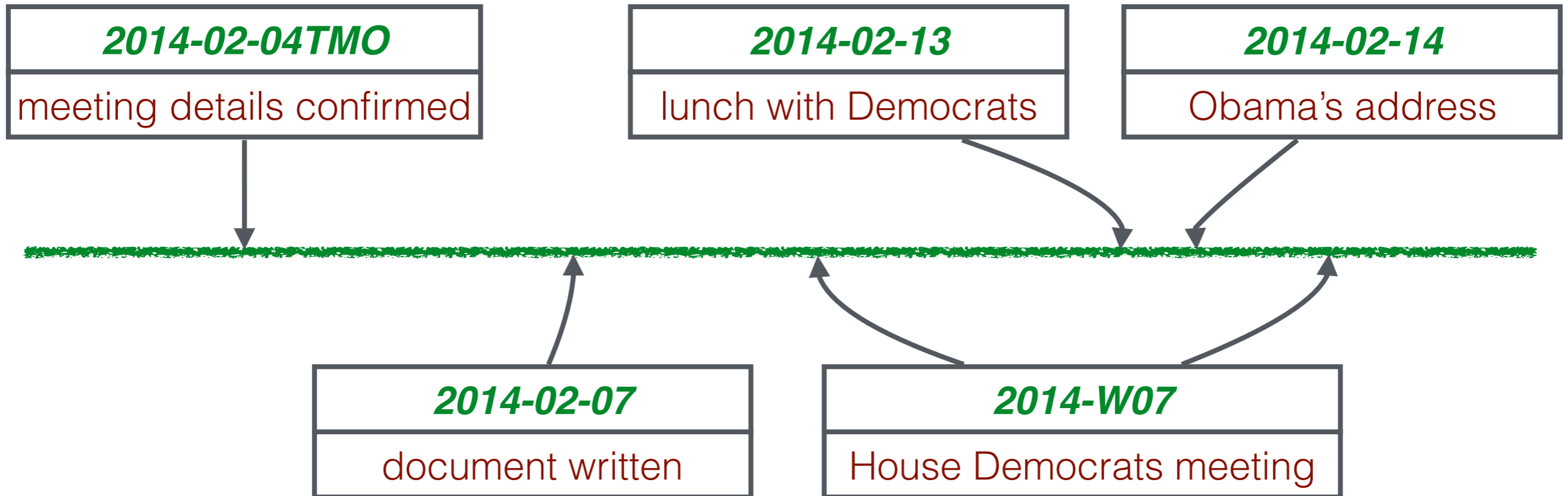
February 7th, 2014 — Obama, Biden to address House Democrats next week

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Temporal Analysis

February 7th, 2014 – Obama, Biden to address House Democrats next week

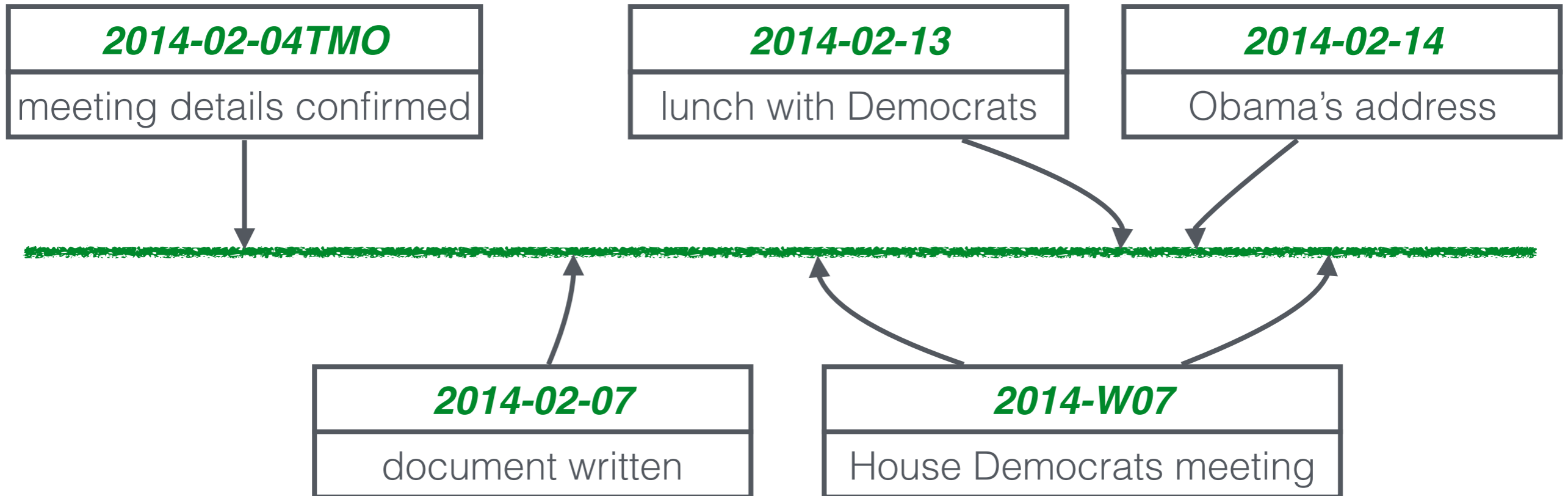
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Extracting Time Expressions

2014-02-07

2014-W07

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2014-02-14

2014-02-13

2014-02-04TMO

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2014-02-14

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Two Tasks

1. Detection - Find mentions of time expressions
2. Resolution - Given a mention, determine its time value

Resolution

Time expression

Resolved value

February 1990



1990-02

5 months



P5M

Thursday



2014-02-26

two days earlier



2014-02-24

that week



2012-W10

Resolution

Time expression

Resolved value

February 1990



1990-02

5 months



P5M

Thursday



2014-02-26

two days earlier



2014-02-24

that week



2012-W10



Key challenge: context-dependence

Outline

- ▶ Task
- ▶ Challenges
- ▶ Approach
- ▶ Experimental results

Challenge #1

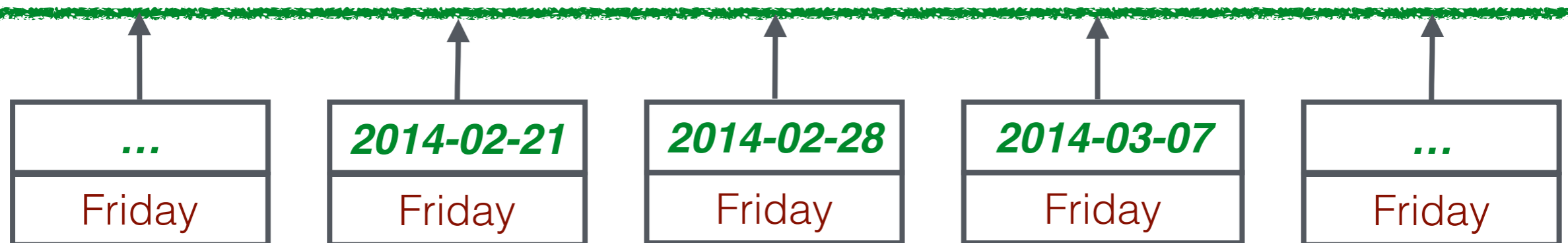
Context-dependence

- ▶ We will leave on **Friday**.
- ▶ We left on **Friday**.

Challenge #1

Context-dependence

- ▶ We will leave on **Friday**.
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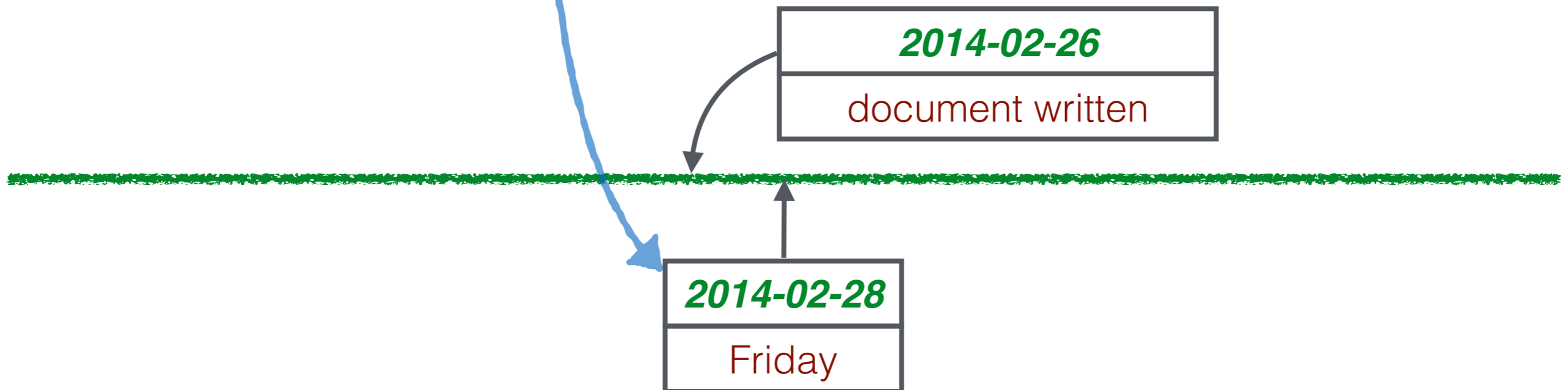


Challenge #1

Context-dependence

Contextual cue

- ▶ We **will leave** on **Friday**.
- ▶ We left on **Friday**.

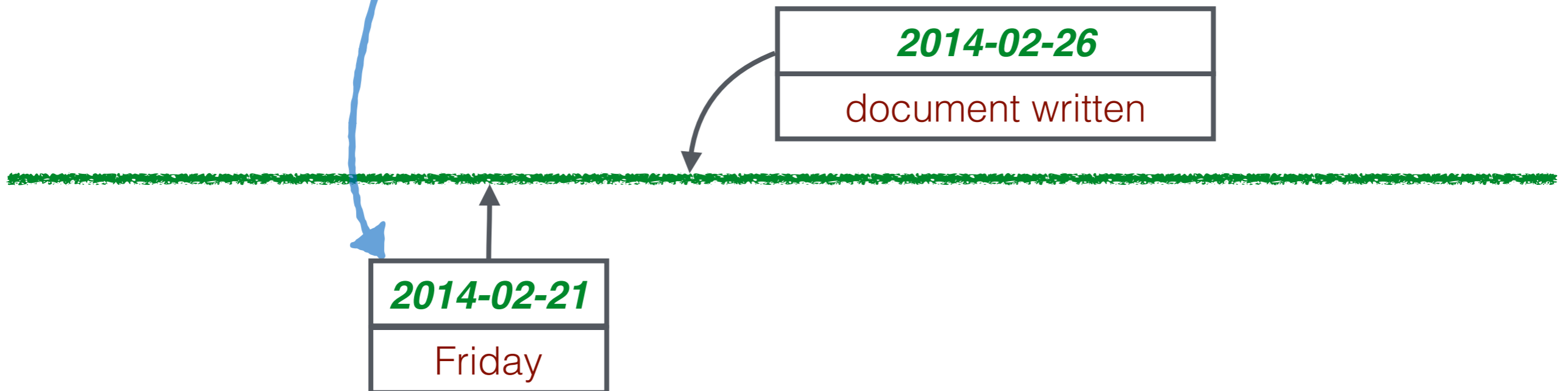


Challenge #1

Context-dependence

Contextual cue

- ▶ We will leave on Friday.
- ▶ We left on Friday.



Challenge #1

Context-dependence

1831-09

Charles Darwin had been told that the Beagle was expected to sail about the end of September 1831, but fitting out took longer... On 10 January Darwin tried out a plankton net he had devised to be towed behind the ship - only the second recorded use of such a net. Next day, he noted the great number of animals collected far from land and wrote "Many of these creatures so low in the scale of nature are most exquisite in their forms & rich colours. It creates a feeling of wonder that so much beauty should be apparently created for such little purpose." Six days later they made their first landing at Porto Praya on the volcanic island of St. Jago in the Cape Verde Islands.

Challenge #1

Context-dependence

1831-09

1832-01-10

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1832-01-17

1832-01-11

Challenge #2

Compositional Structure

- ▶ Let's schedule the meeting for a week after tomorrow.
- ▶ His vacation begins on the 2nd Friday of this month.

Challenge #2

Compositional Structure

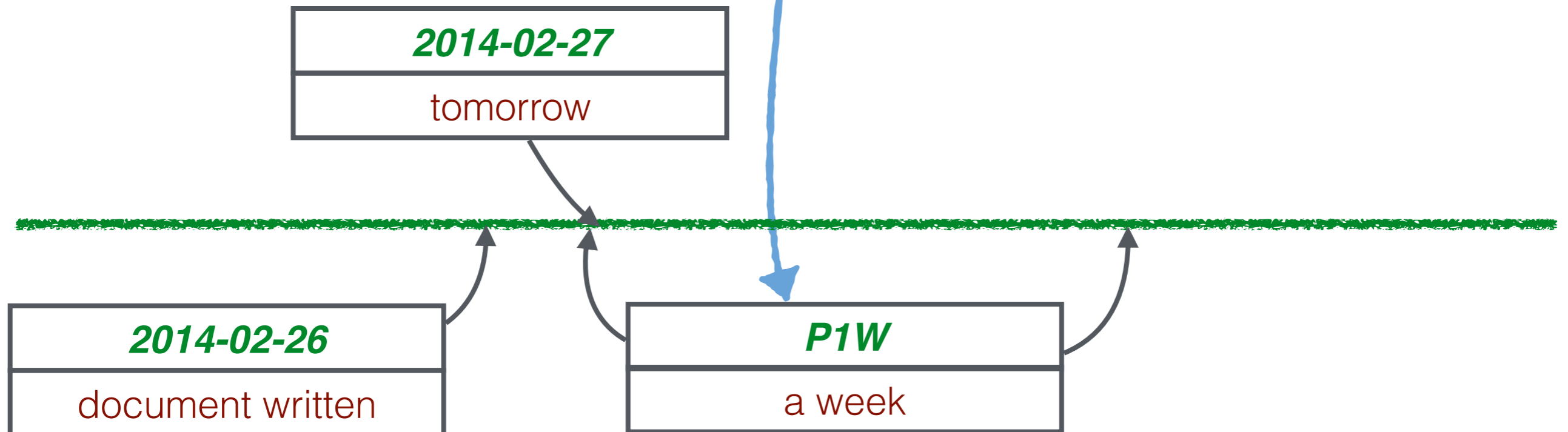
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Challenge #2

Compositional Structure

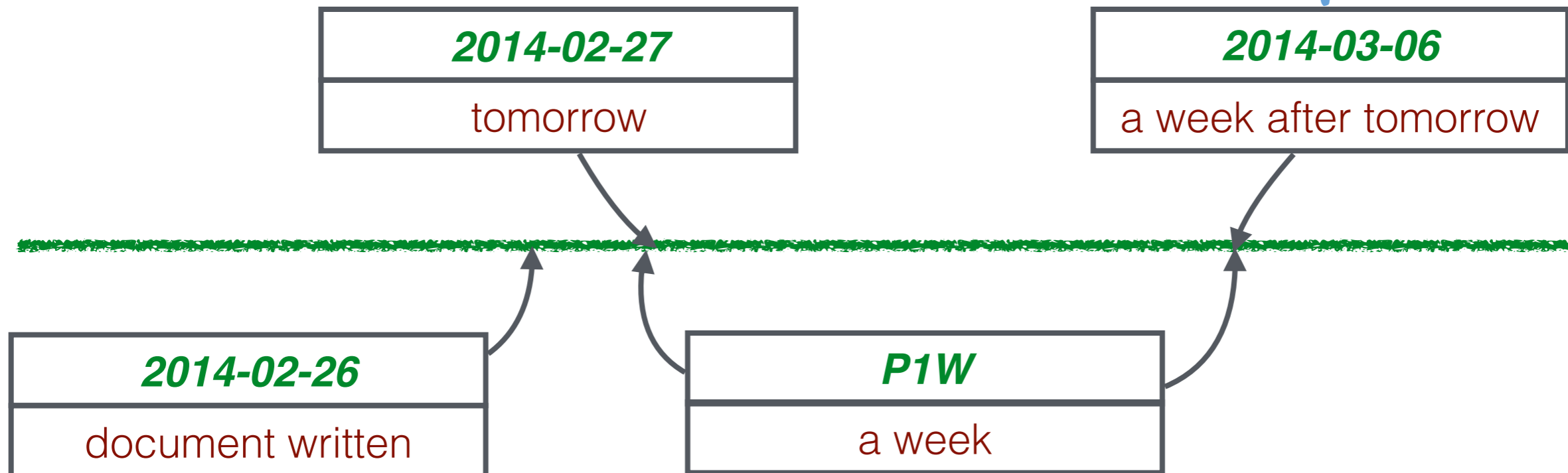
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Challenge #2

Compositional Structure

- ▶ Let's schedule the meeting for a week after tomorrow.
- ▶ His vacation begins on the 2nd Friday of this month.



Challenge #3

Lexical Ambiguity

- ▶ Jim doesn't return until the fall.
- ▶ He took the fall for this scandal.
- ▶ The reports were delayed for a period.
- ▶ This sentence has a period at the end.



Approach

Obama, Biden to address House Democrats next week

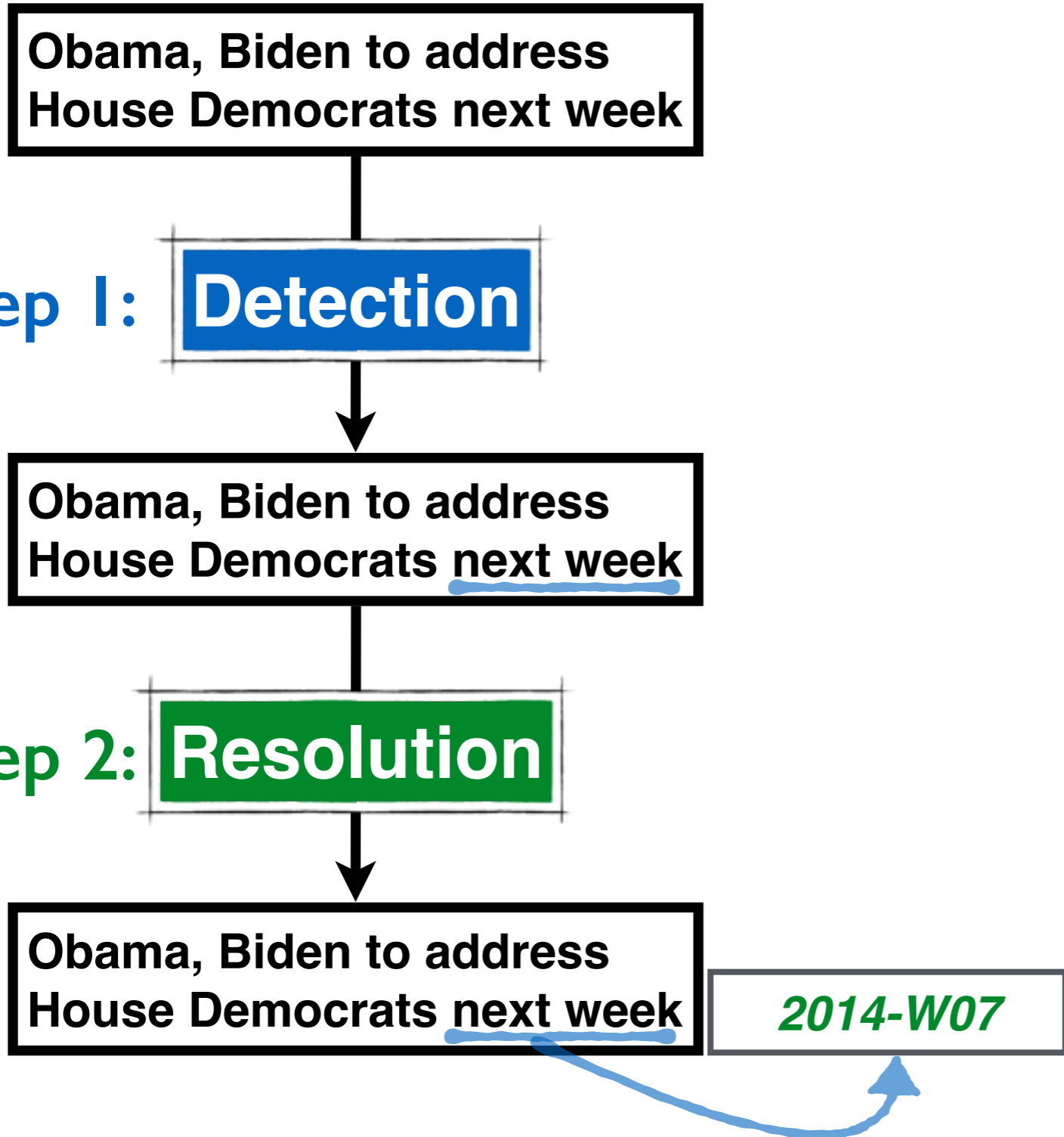
Step 1: **Detection**

Obama, Biden to address House Democrats next week

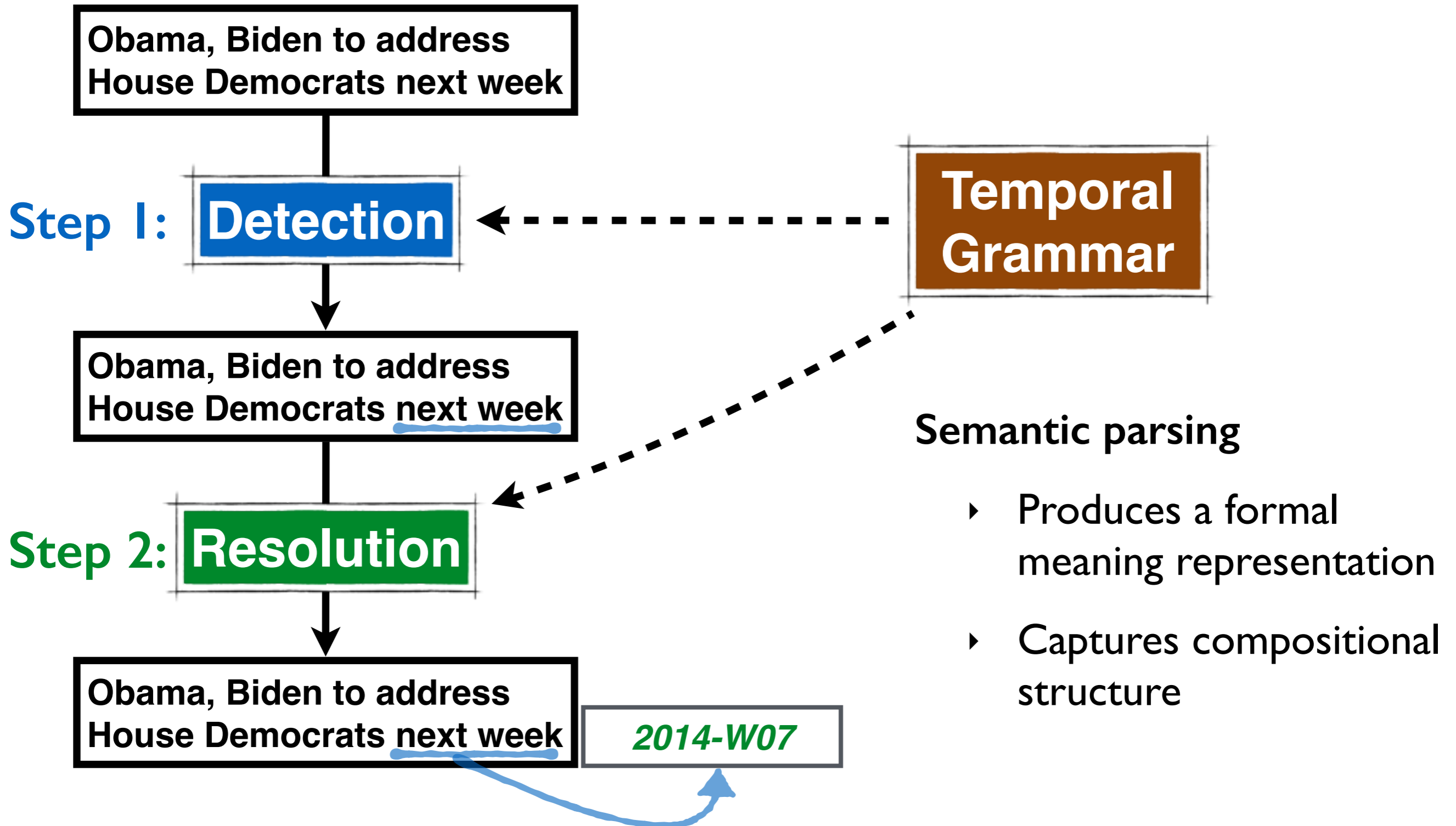
Step 2: **Resolution**

Obama, Biden to address House Democrats next week

2014-W07



Approach



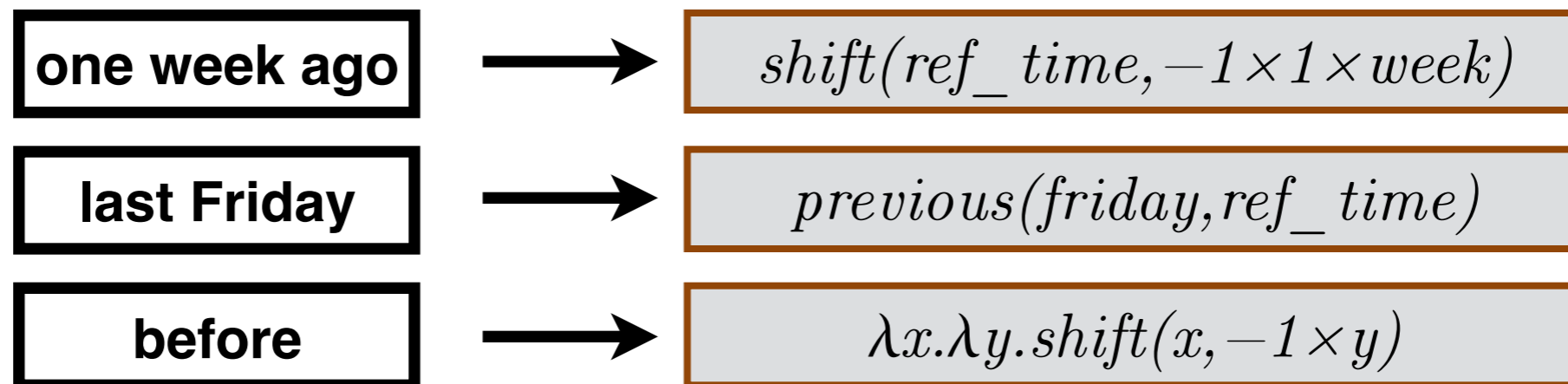
Representing Time

λ -calculus

Semantic types:

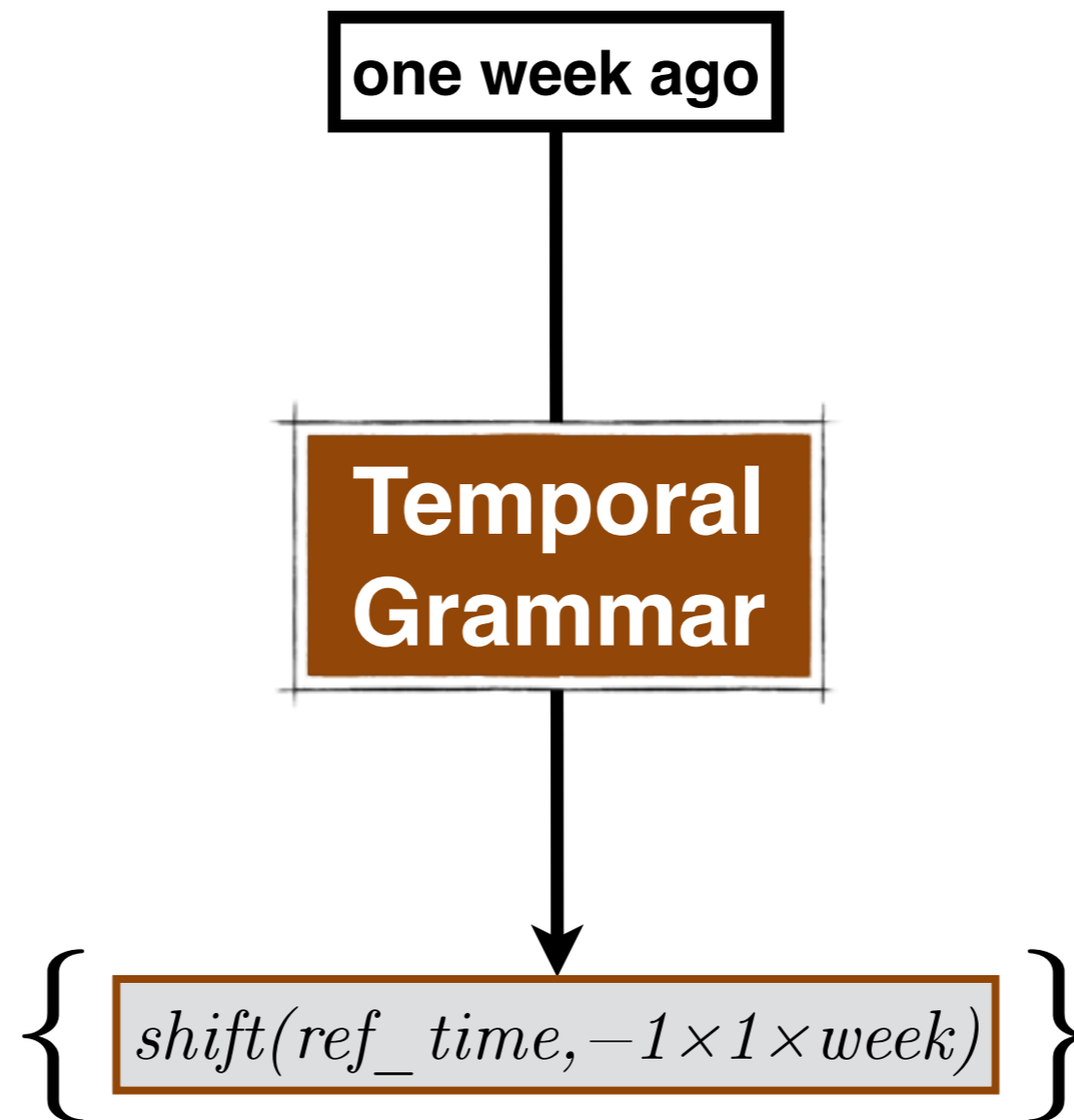
- ▶ Durations, ranges, sequences, approximate references, numeral, and functions
- ▶ Similar to the representation from Angeli et al. (2012)

Examples:



Combinatory Categorical Grammar

(The schedule was posted one week ago.)



Combinatory Categorical Grammar

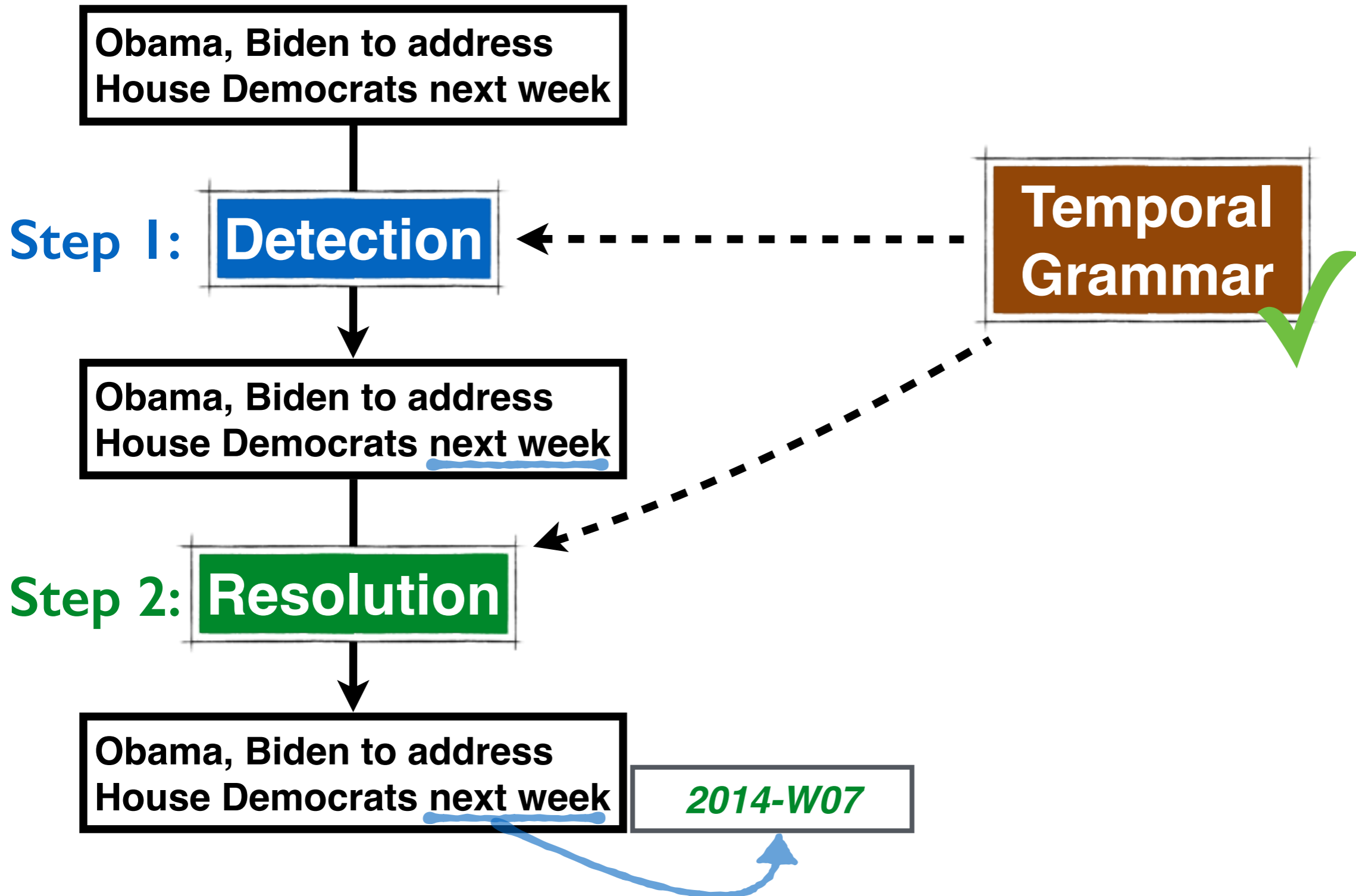
lexical entries	{	$\frac{\text{one}}{C}$	$\frac{\text{week}}{N}$	$\frac{\text{ago}}{NP \backslash NP}$	$\lambda x. shift(ref_time, -1 \times x)$
combine	{	$\frac{\frac{N/N}{\lambda x. 1 \times x}}{N} \rightarrow$			
		$\frac{1 \times week}{NP}$			
final meaning	{	$\frac{NP}{shift(ref_time, -1 \times 1 \times week)}$			



Temporal Grammar

- ▶ Hand-engineered lexicon
 - ▶ Time expressions have a closed-classed vocabulary
 - ▶ Easy to design a high quality grammar
- ▶ Examples
 - ▶ Units of times: **week, month, year, etc.**
 - ▶ Named times: **Monday, July, summer, 2014, etc.**
 - ▶ Function words: **next, after, recent, ago, etc.**

Approach



Detection

Obama, Biden to address
House Democrats next week

Detection

Obama, Biden to address
House Democrats next week

Detection

- ▶ Consider spans belonging to the temporal grammar
- ▶ Reject false positives with a binary classifier
- ▶ Prefer longer mentions

Return next year

Detection

- ▶ Consider spans belonging to the temporal grammar
- ▶ Reject false positives with a binary classifier
- ▶ Prefer longer mentions



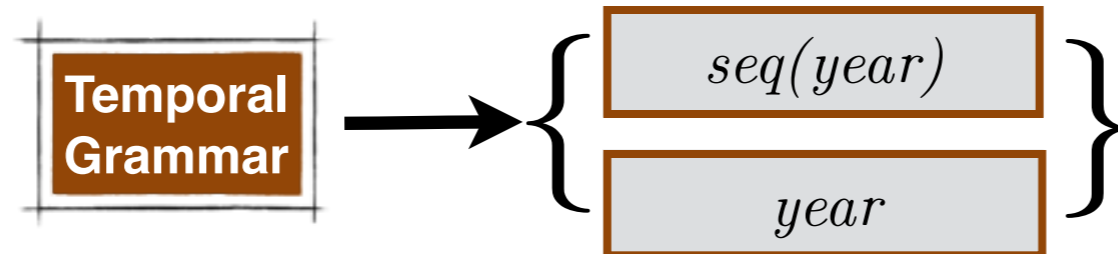
Return next year

Detection

- ▶ Consider spans belonging to the temporal grammar
- ▶ Reject false positives with a binary classifier
- ▶ Prefer longer mentions

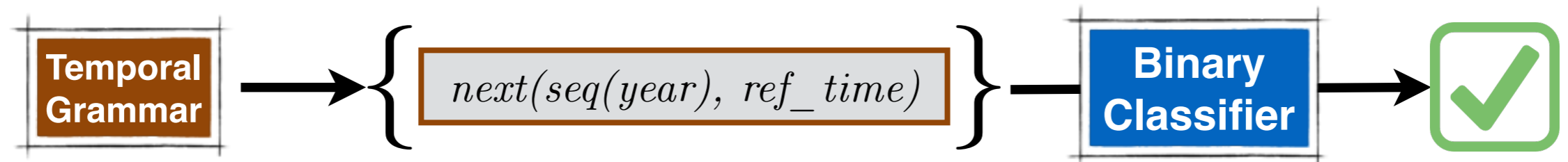


Return next year

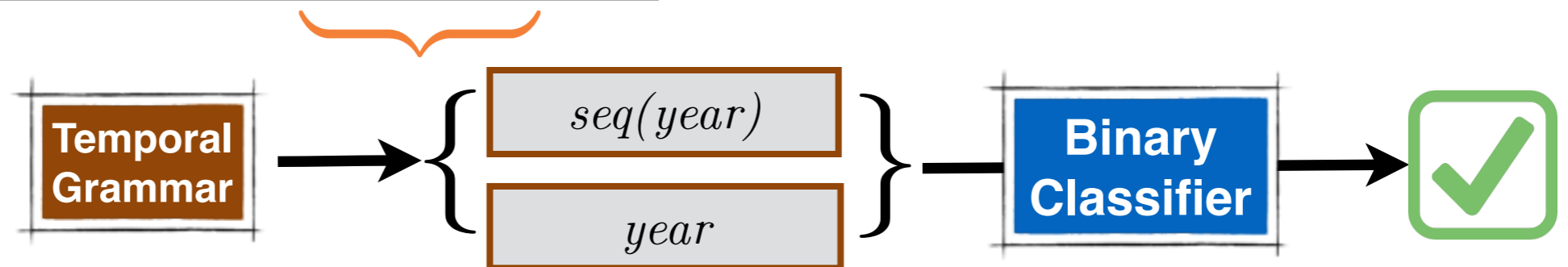


Detection

- ▶ Consider spans belonging to the temporal grammar
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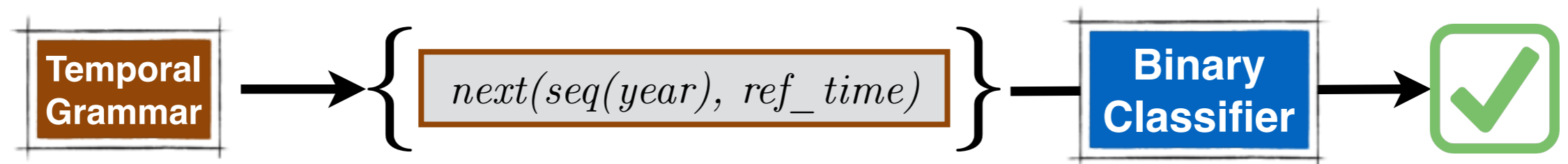


Return next year



Detection

- ▶ Consider spans belonging to the temporal grammar
- ▶ Reject false positives with a binary classifier
- ▶ Prefer longer mentions



Return next year

Detection

twenty four hour

(You get a **twenty four hour** extension.)

will have lunch

(John **will have lunch** with me.)

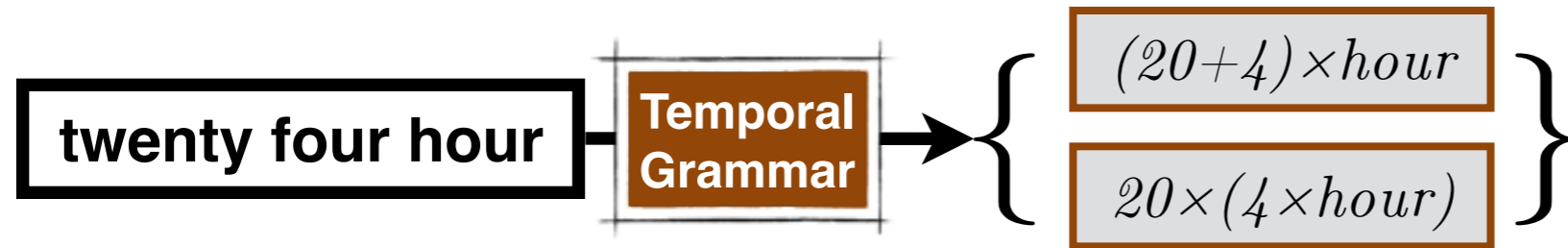
the fall

(He took **the fall** for this scandal.)

the fall

(Jim doesn't return until **the fall**.)

Detection



(You get a **twenty four hour** extension.)



(John will have lunch with me.)

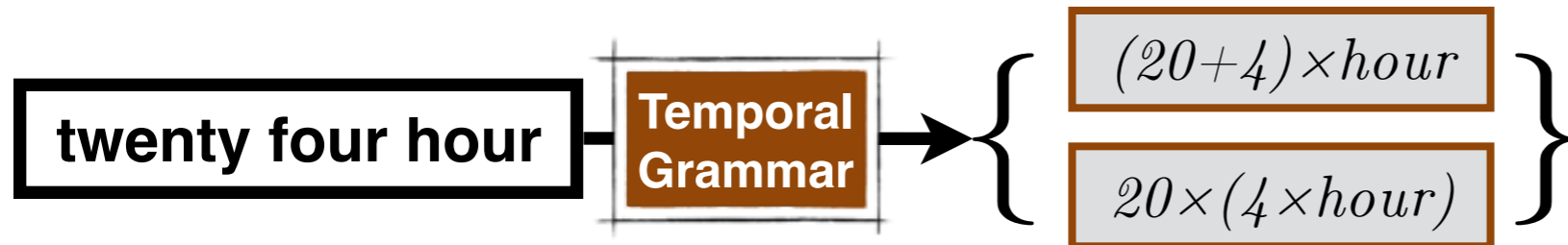


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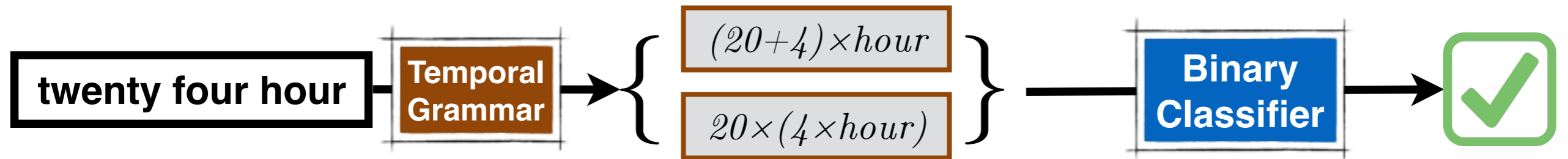


(He took **the fall** for this scandal.)



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Detection



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Detection: Learning

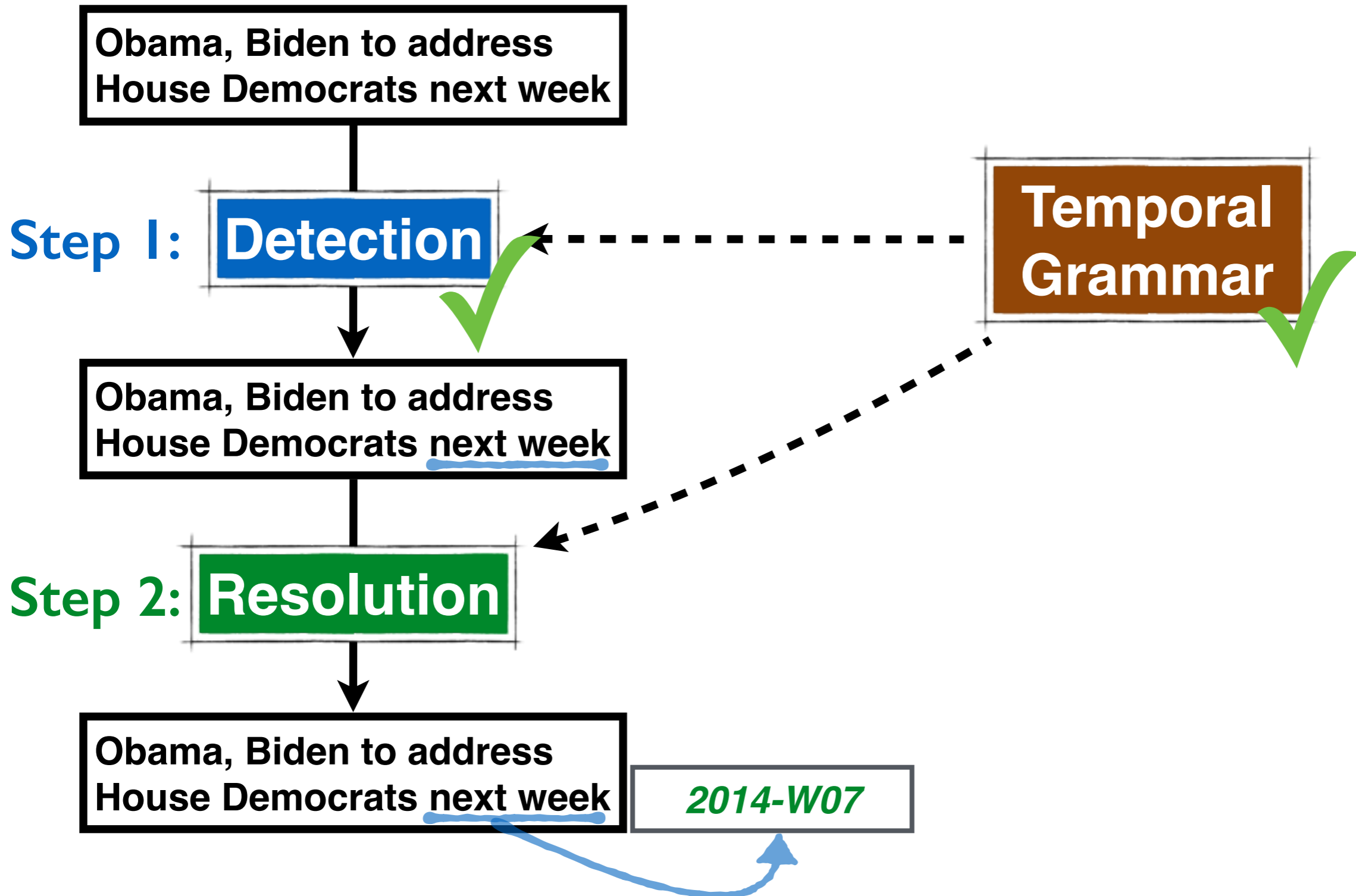
Model

- ▶ Logistic regression
- ▶ L1 regularization

Features

- ▶ Syntactic features
- ▶ Lexical features
- ▶ Context token indicators

Approach



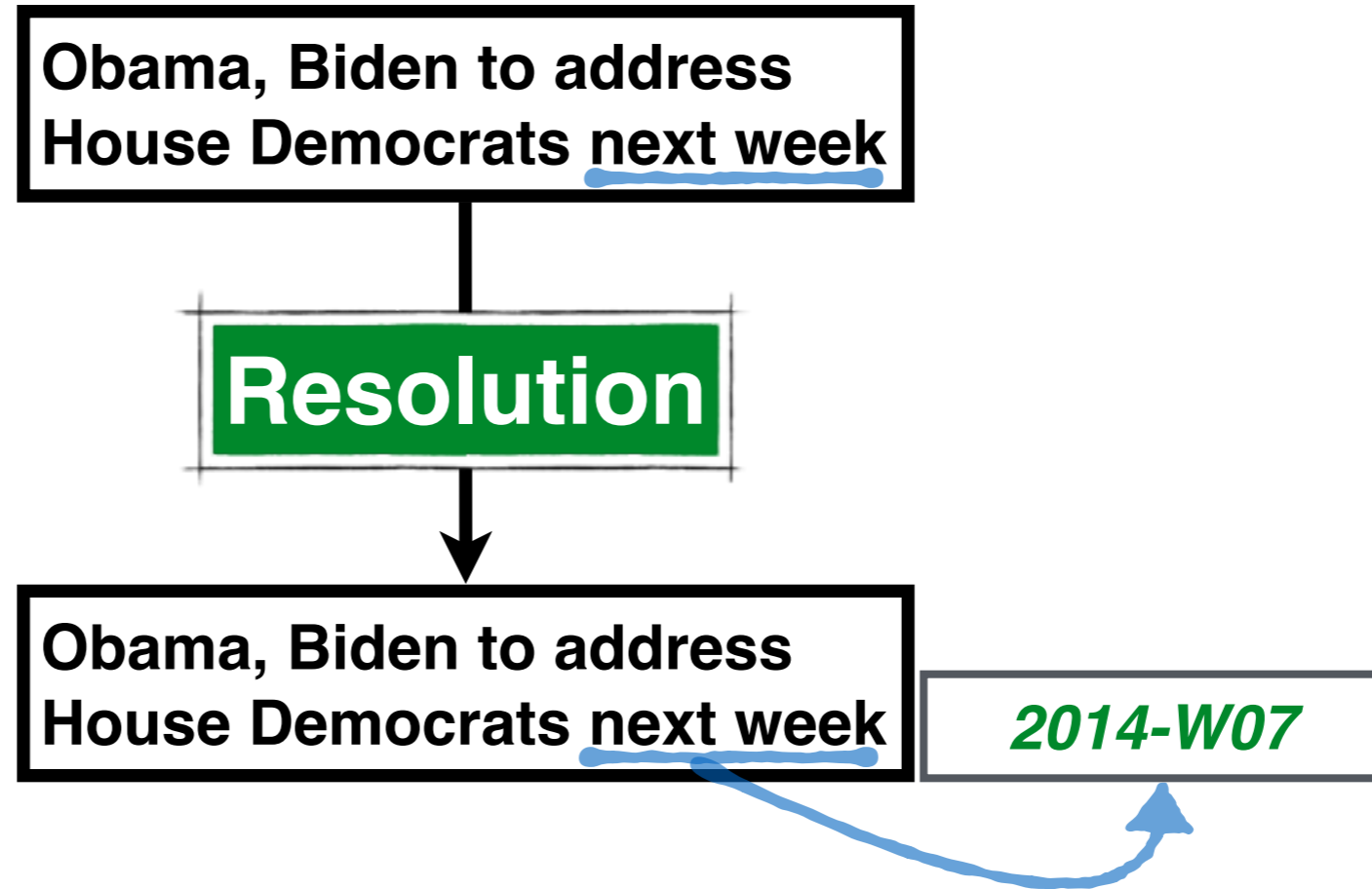
Resolution

Obama, Biden to address
House Democrats next week

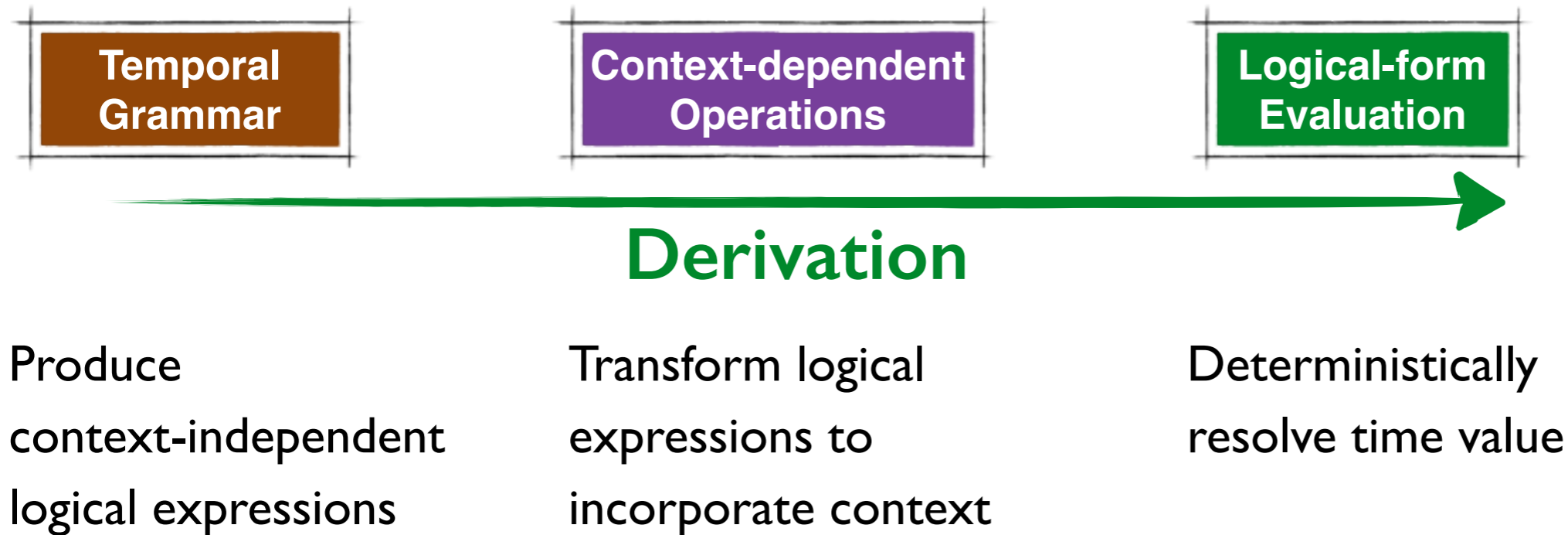
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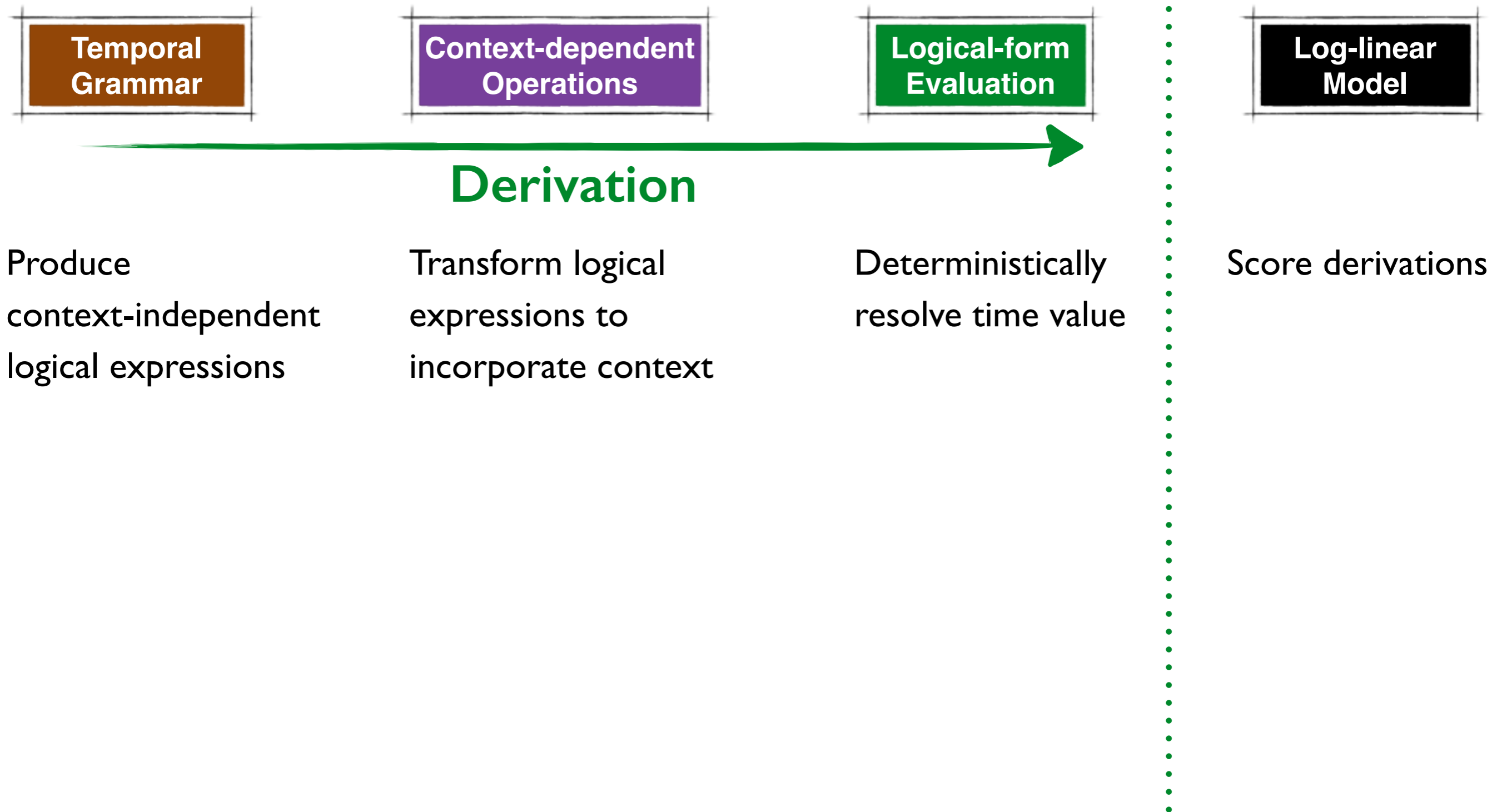
2014-W07



Resolution



Resolution



Resolution

Temporal
Grammar

(John arrived on **Friday**.)
[written 2014-02-05]

Friday



friday

Resolution

Temporal
Grammar

Context-dependent
Operations

(John arrived on **Friday**.)
[written 2014-02-05]

following(friday, ref_time)

Friday

friday

preceding(friday, ref_time)

friday

Resolution

Temporal
Grammar

Context-dependent
Operations

(John arrived on **Friday**.)
[written 2014-02-05]

Friday

friday

following(friday, ref_time)

following(friday, document_time)

following(friday, previous_time)

preceding(friday, ref_time)

preceding(friday, document_time)

preceding(friday, previous_time)

friday

Resolution

Temporal
Grammar

Context-dependent
Operations

(John arrived on **Friday**.)
[written 2014-02-05]

⋮

following(friday, document_time)

Friday

friday

following(friday, previous_time)

preceding(friday, document_time)

⋮

Resolution

Temporal
Grammar

Context-dependent
Operations

Logical-form
Evaluation

Derivation

(John arrived on **Friday**.)
[written 2014-02-05]

⋮

⋮

following(friday, document_time)

2014-02-07

Friday

friday

following(friday, previous_time)

2011-04-06

preceding(friday, document_time)

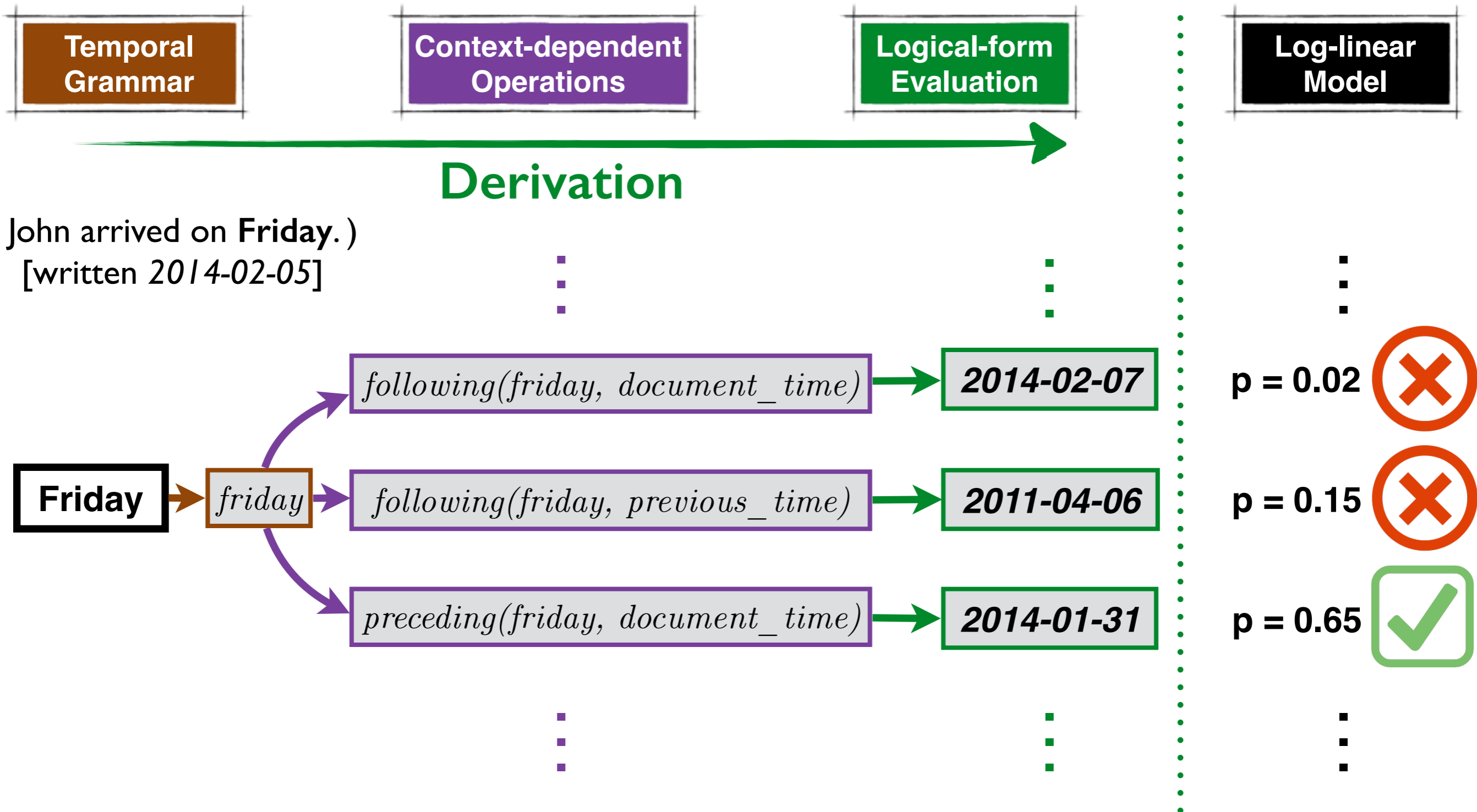
2014-01-31

⋮

⋮



Resolution



Temporal Grammar

Context-dependent Operations

Logical-form Evaluation

Log-linear Model

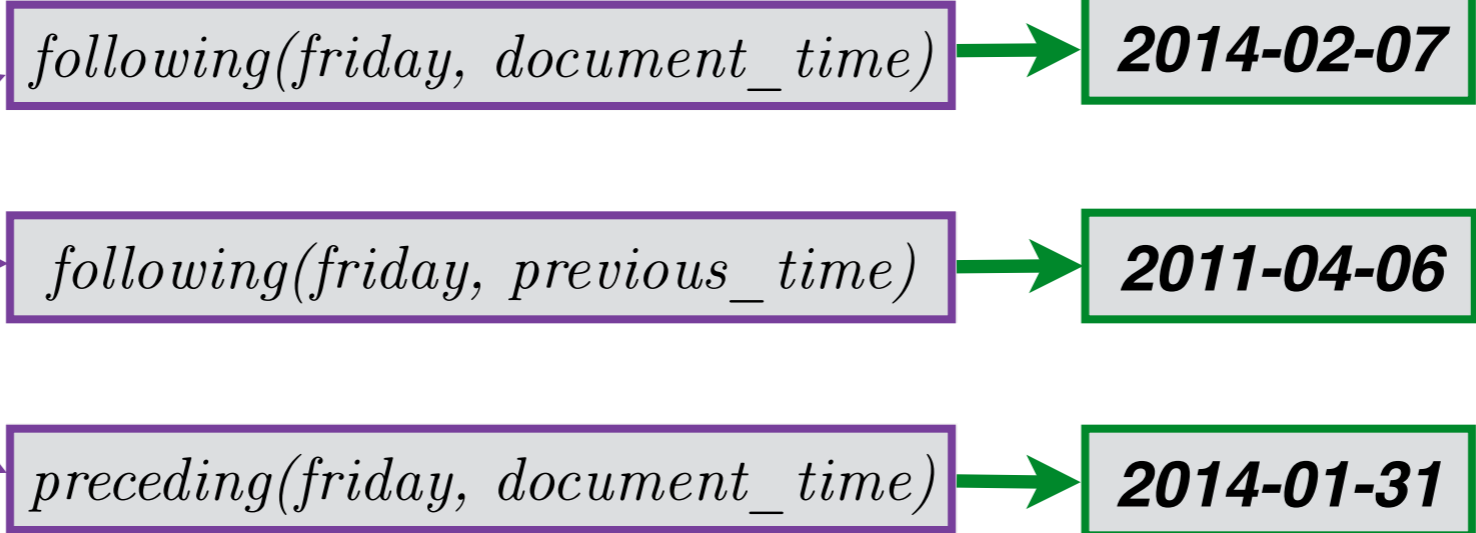
Derivation

(John arrived on Friday.)
[written 2014-02-05]

⋮

⋮

⋮



p = 0.02 ❌
p = 0.15 ❌
p = 0.65 ✅

⋮

⋮

⋮

Resolution: Learning

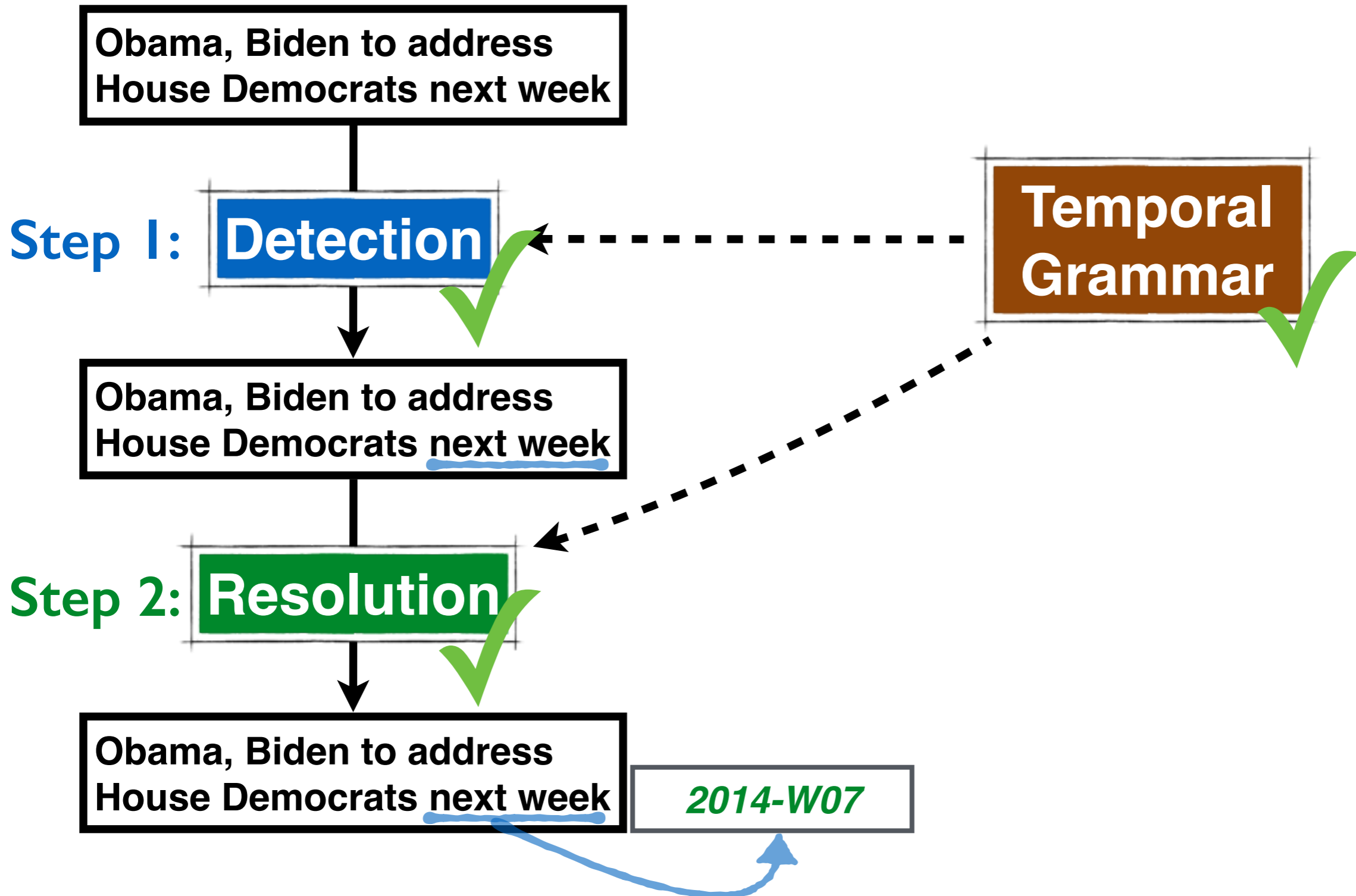
Model

- ▶ Log-linear model
- ▶ AdaGrad (Duchi et al., 2011)

Features

- ▶ Governor verb syntax
- ▶ Logical expression
- ▶ Context-dependent operations

Approach



Related Work

System	HeidelTime (Strotgen and Gertz, 2013)	SCFG (Bethard, 2013)	ParsingTime (Angeli et al., 2012)
Method	Rule-based	Semantic parsing	Semantic parsing
Detection	✓	✗	✗
Resolution	✓	✓	✓
Uses Context?	✓	✗	✗

Experimental Setup

Dataset

- ▶ TempEval-3
 - ▶ Newswire
- ▶ WikiWars
 - ▶ History articles

Metrics

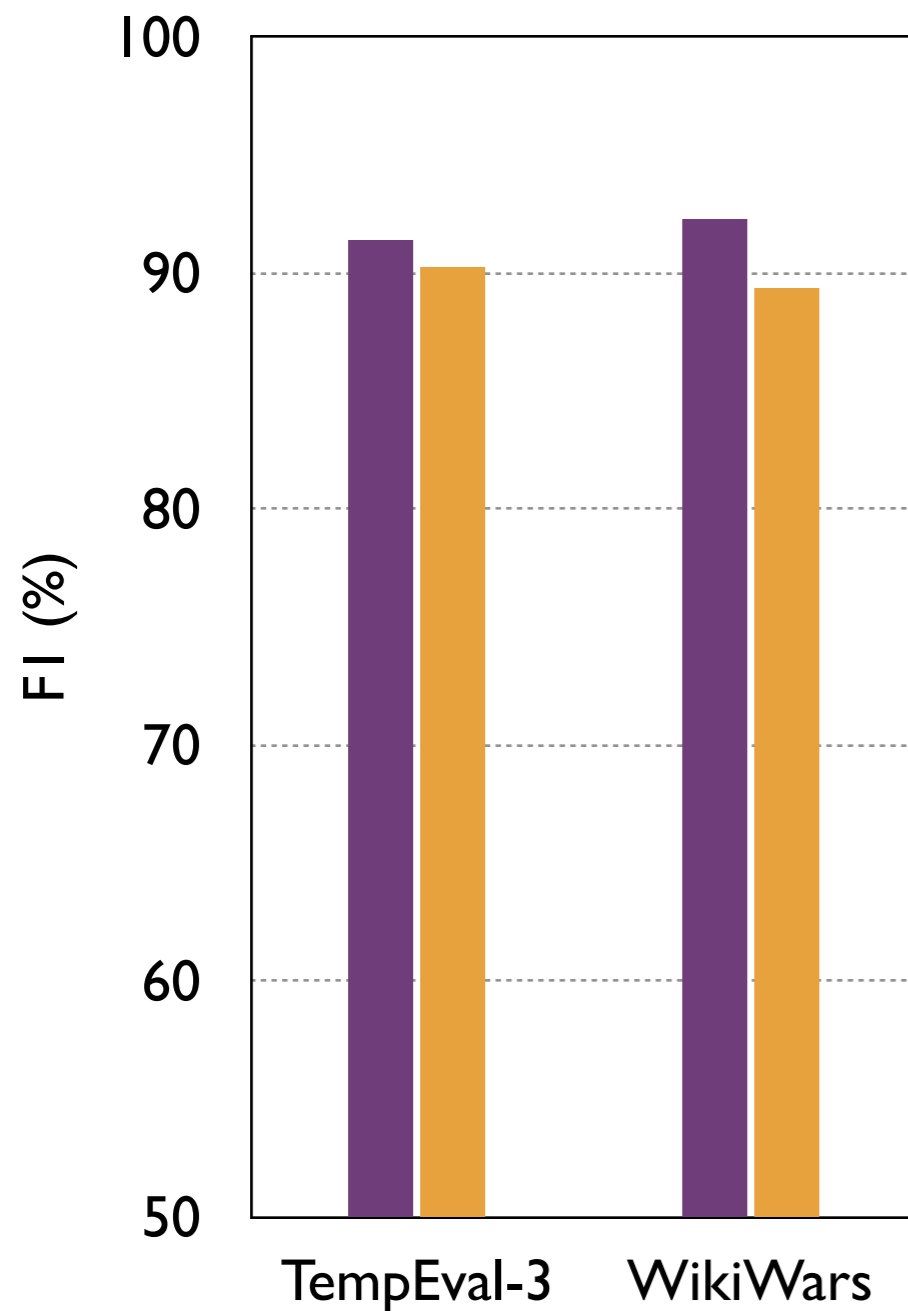
- ▶ Detection precision, recall, F1
- ▶ Resolution precision, recall, F1

Results

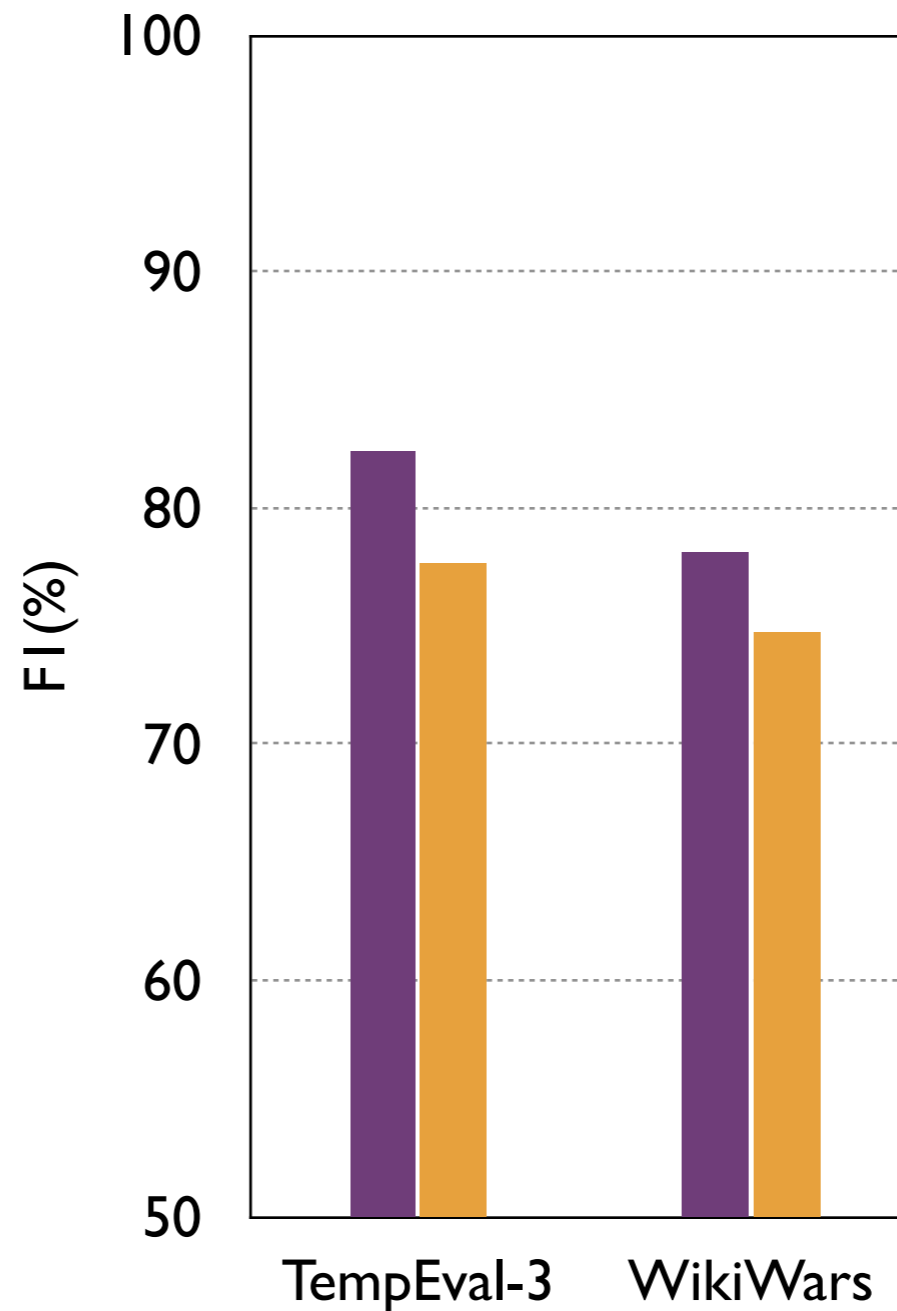
Our system

HeidelTime

Detection



Resolution



TempEval-3

- ▶ 21% error reduction

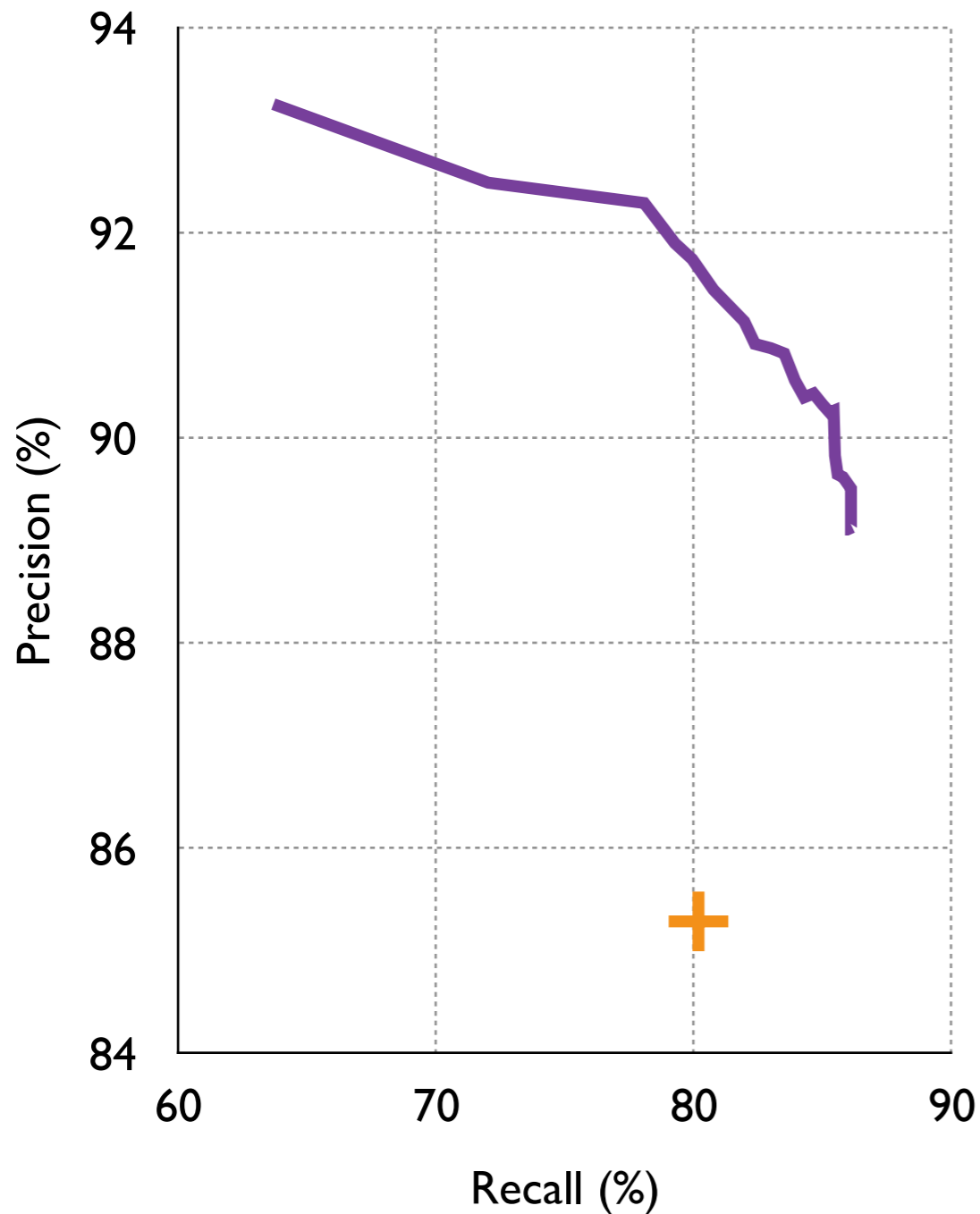
WikiWars

- ▶ 13% error reduction

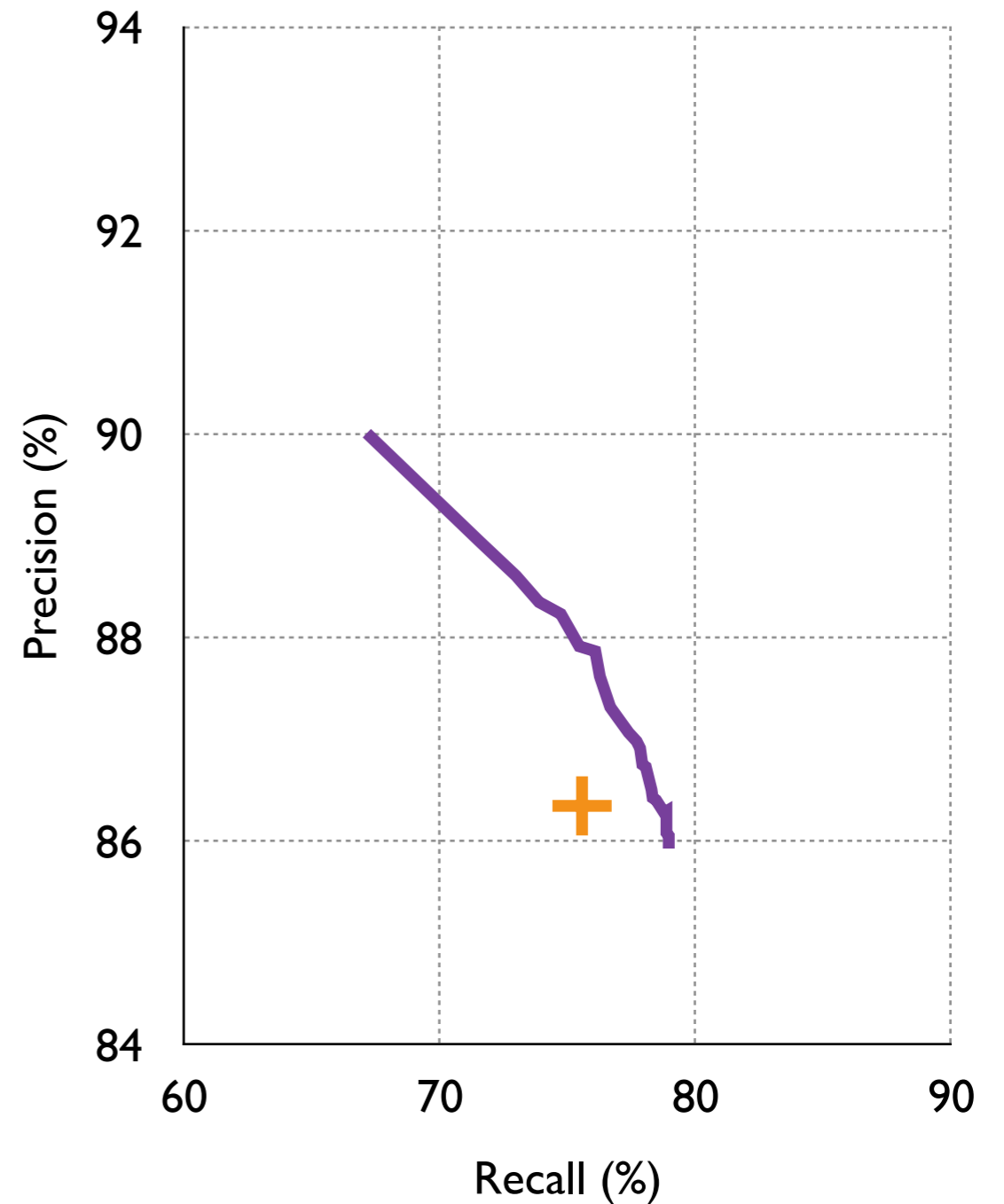
Precision vs. Recall

— Our system + HeidelTime

TempEval-3 (Dev)



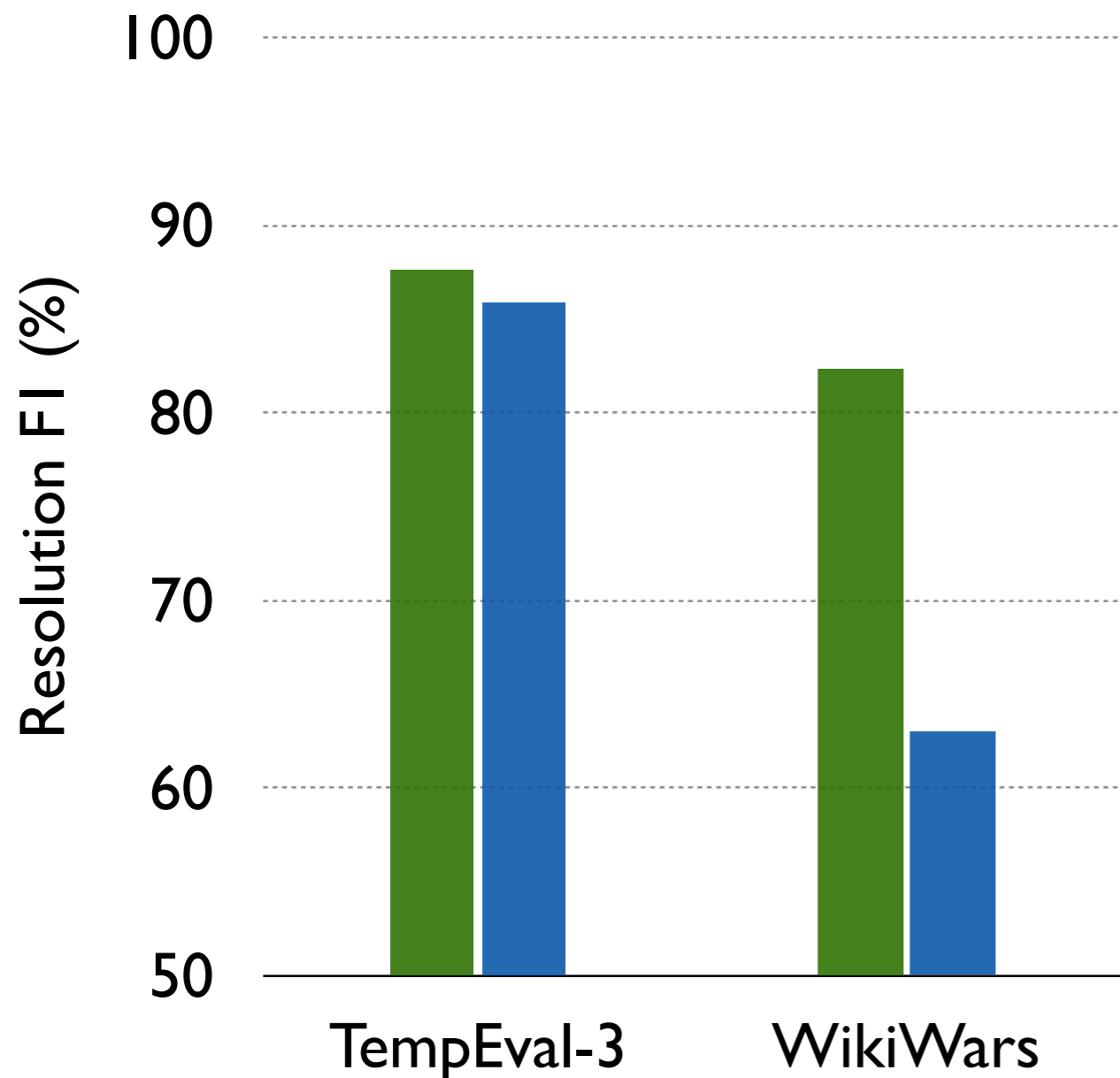
WikiWars (Dev)



Context Ablation

■ With context ■ Without context

Development Results



Resolution ablation

- ▶ Removed previous reference times
- ▶ Removed governor verb syntax

Context is more important in long history articles!

Example Error

The second attack led to retaliatory air strikes, prompting Congress to approve the resolution on 7 August 1964. An NSA publication declassified in 2005, however, revealed that there was no attack on 4 August.

1964-08-07

2005

2005-08-04

Future Work

- ▶ Joint modeling of times and events

The second attack led to retaliatory air strikes, prompting Congress to approve the resolution on 7 August 1964. An NSA publication declassified in 2005, however, revealed that there was no attack on 4 August.

1964-08-07

1964-08-04

2005

Future Work

- ▶ Joint modeling of times and events

The second attack led to retaliatory air strikes, prompting Congress to approve the resolution on 7 August 1964. An NSA publication declassified in 2005, however, revealed that there was no attack on 4 August.

1964-08-07

1964-08-04

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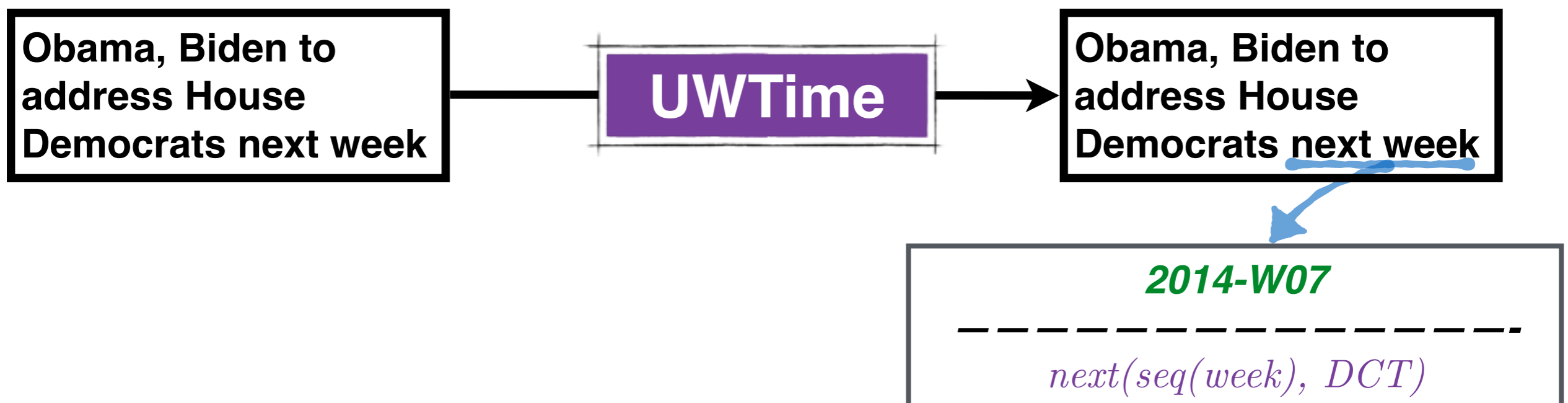
Contributions

- ▶ An end-to-end semantic parsing for time expressions
- ▶ Approach to consider contextual linguistic signals in a semantic parsing framework
- ▶ New state-of-the-art time expression extraction results

UWTime

- ▶ State-of-the-art time-extraction tool
- ▶ Implemented with UW Semantic Parsing Framework
- ▶ Demo and code at:

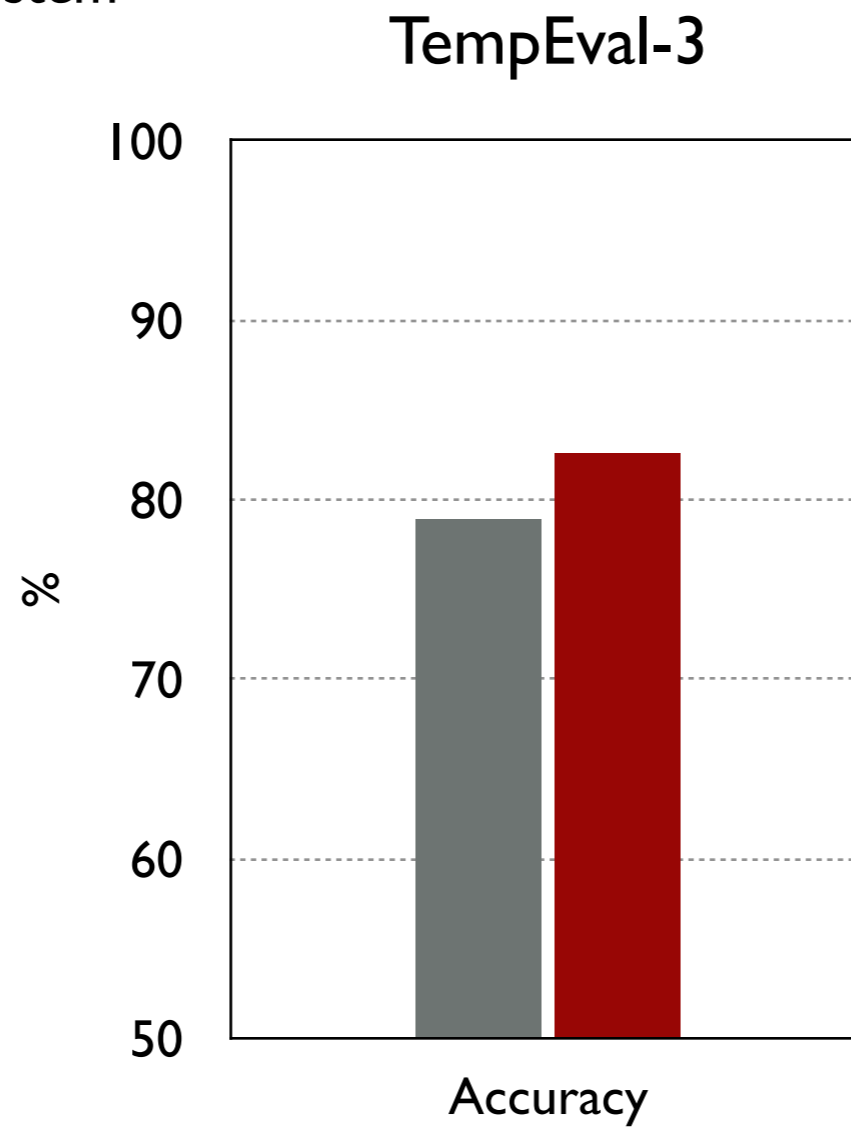
<http://lil.cs.washington.edu/uwtime>



Questions?

Results:

Resolution (given mentions)



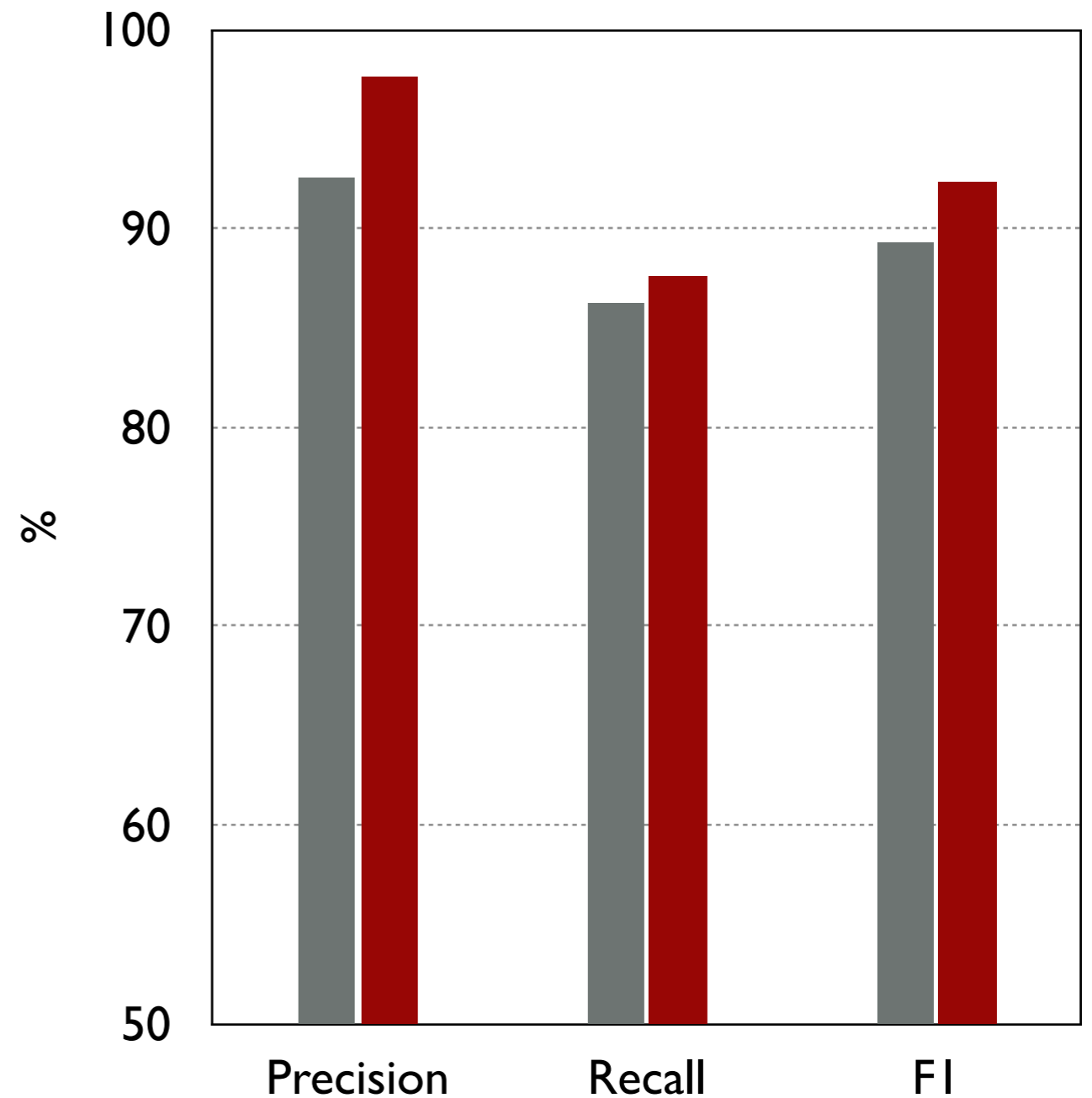
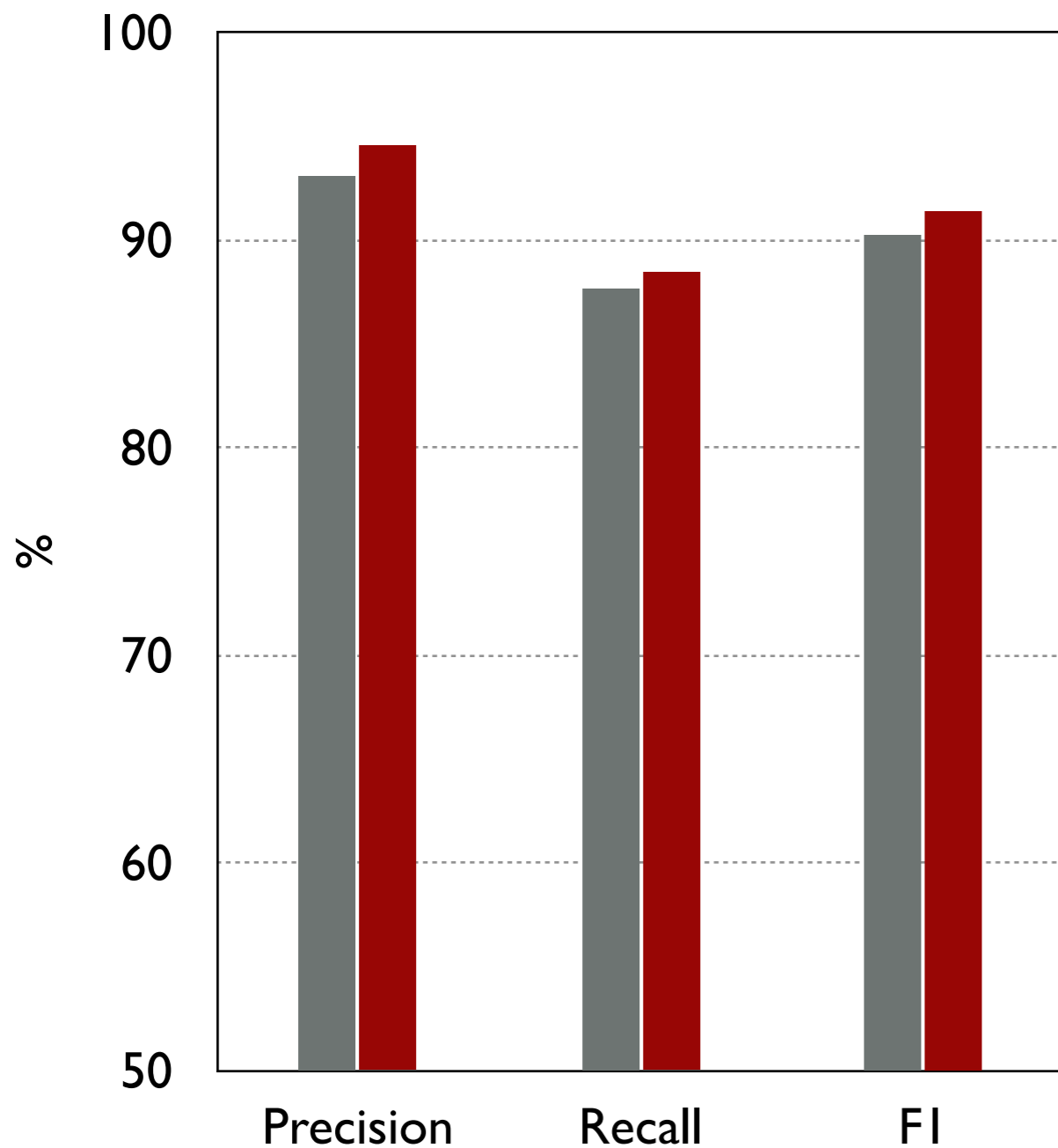
Results:

Relaxed Detection

HeidelTime
Our system

TempEval-3

WikiWars

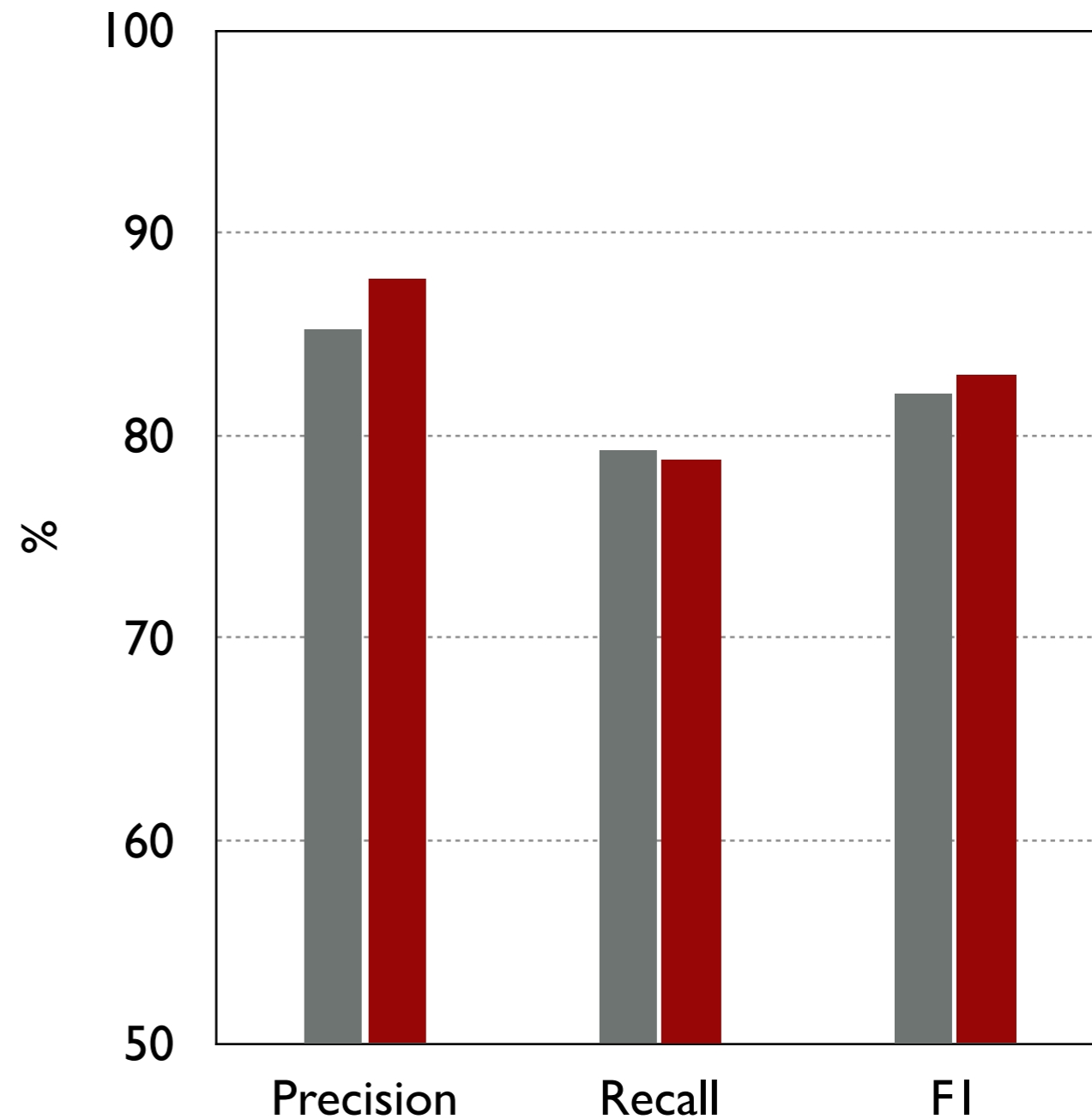
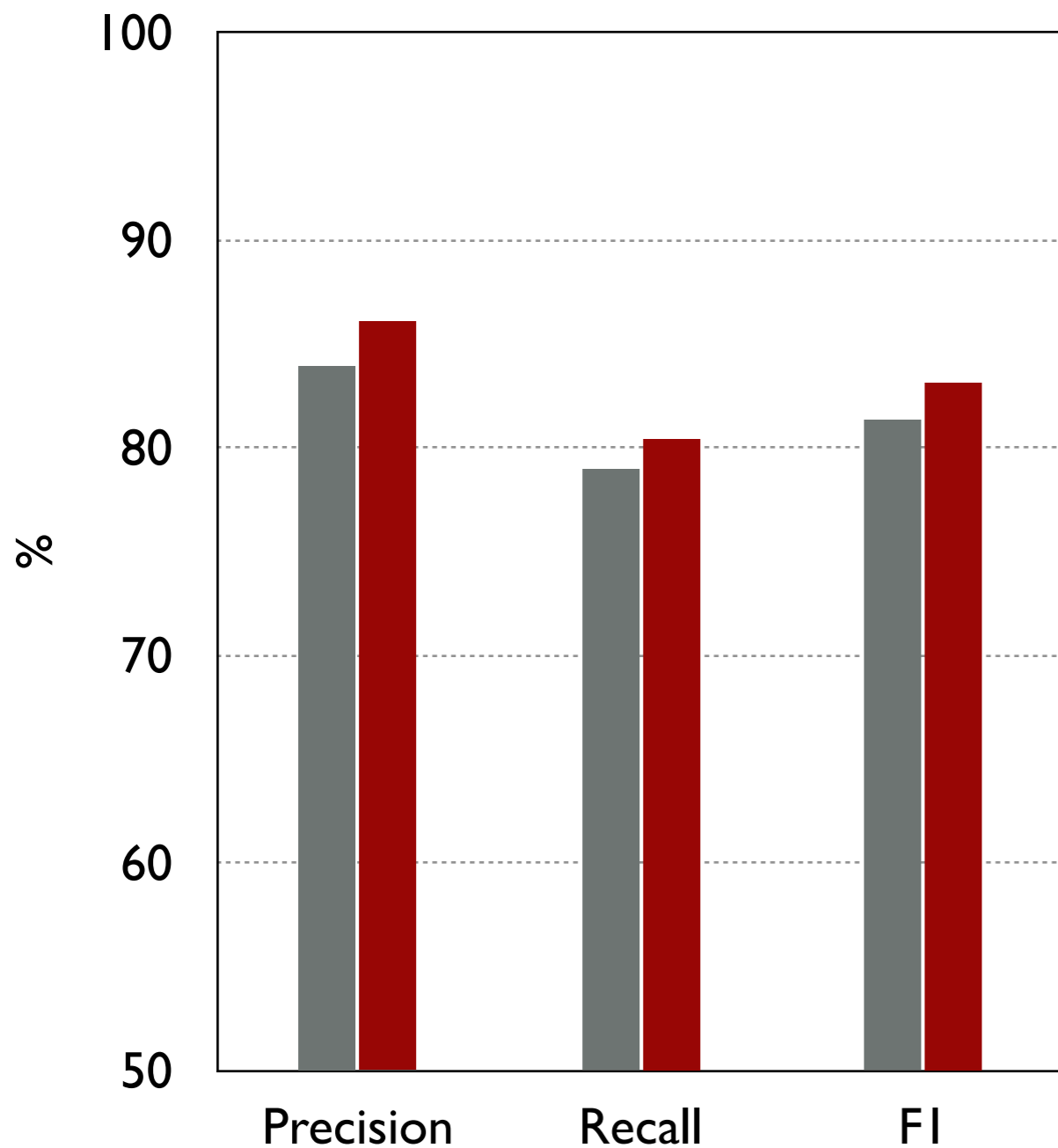


Results: Strict Detection

HeidelTime
Our system

TempEval-3

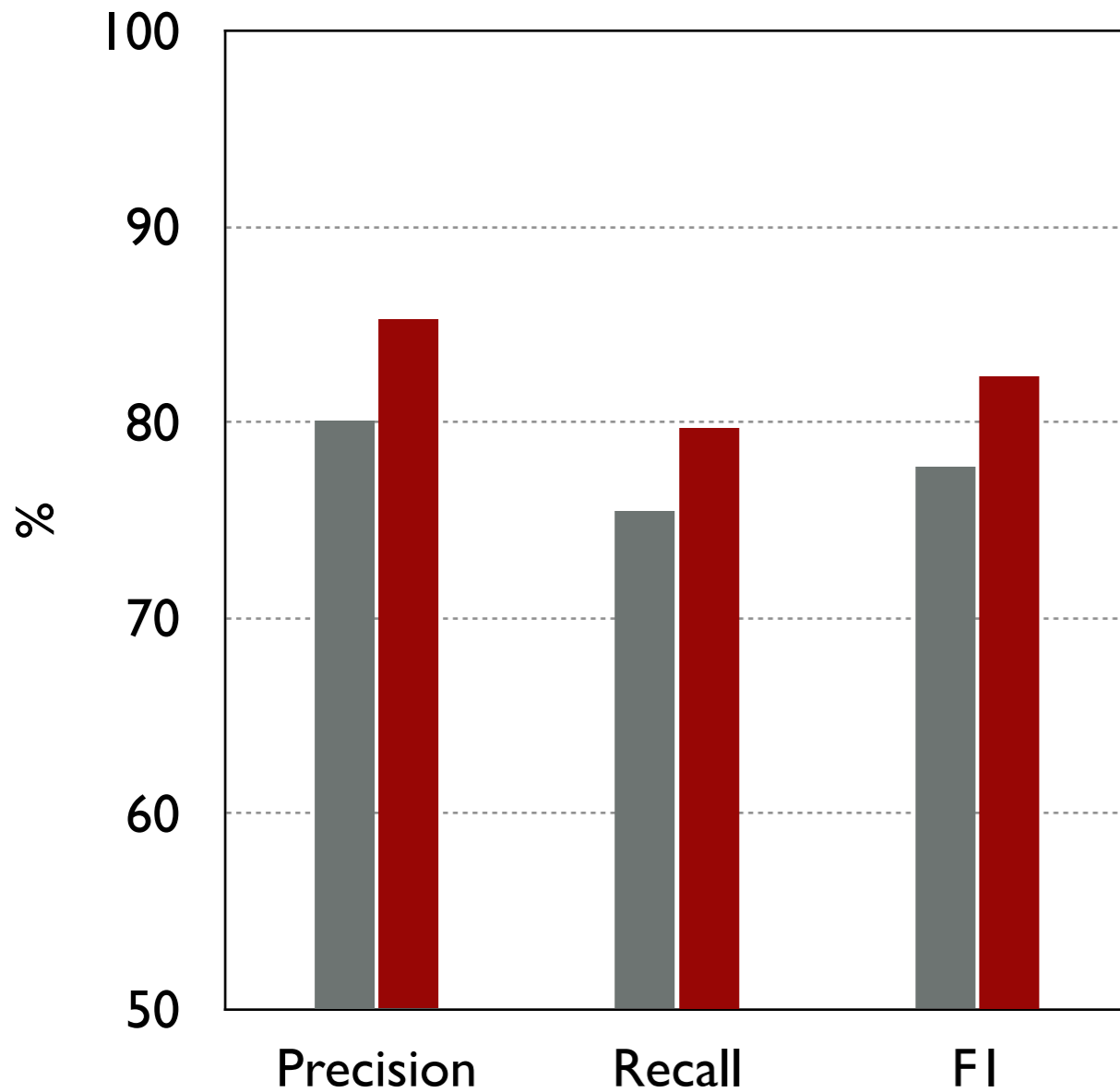
WikiWars



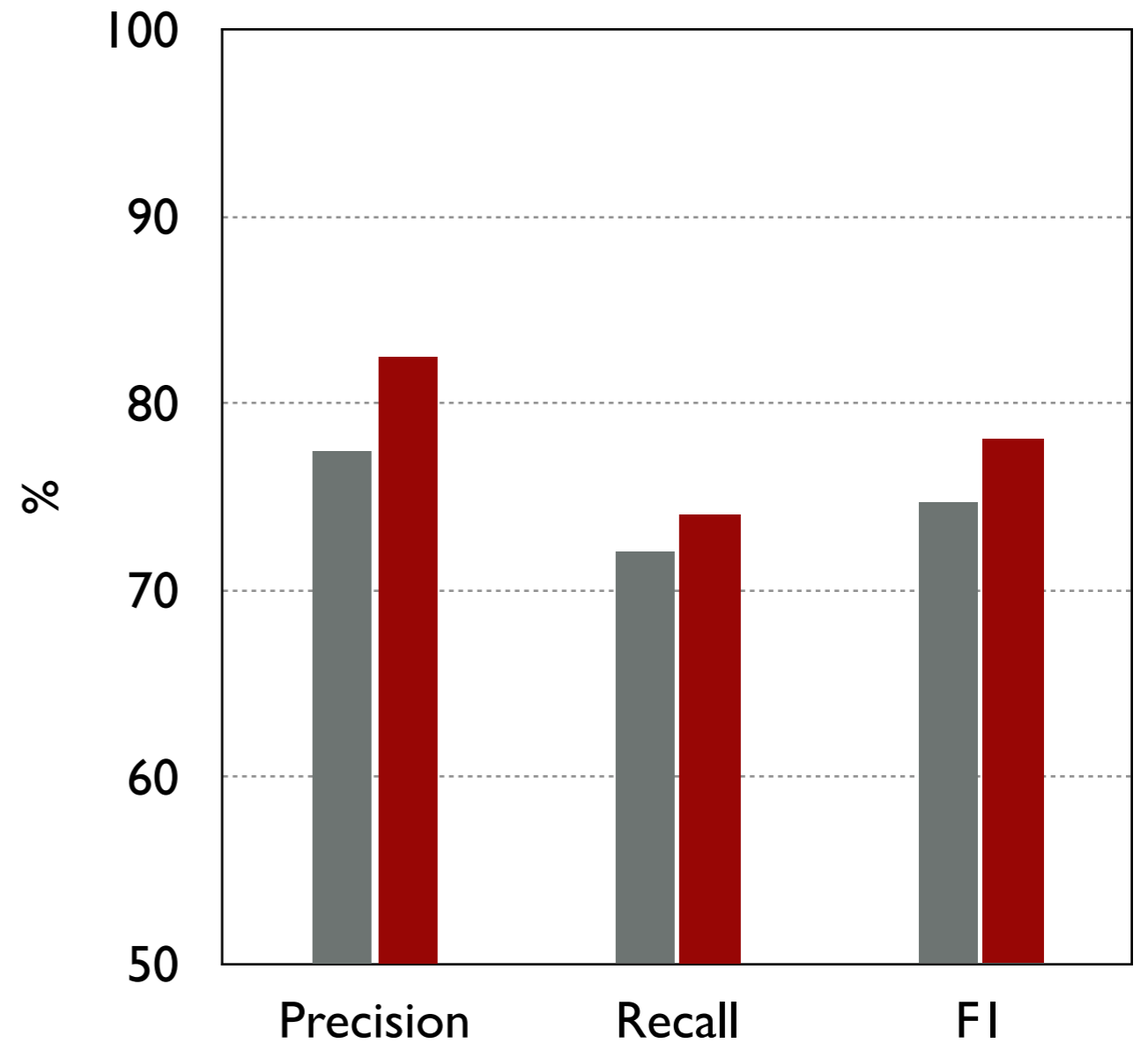
Results: Resolution

HeidelTime
Our system

TempEval-3



WikiWars



Datasets

Corpus	TempEval-3	WikiWars
Domain	Newswire text	History articles
Training Annotations	1822	2228
Testing Annotations	138	363

Evaluation Metrics

Detection Metrics

- ▶ True positive:
 - ▶ Predicted mention overlaps with gold mention
- ▶ Precision, recall, F1

Resolution Metrics (end-to-end)

- ▶ True positive:
 - ▶ Correctly detected and resolved
- ▶ Precision, recall, F1