Paraphrase Recognition *via* Dissimilarity Significance Classification

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Paraphrase

Sentences that are “semantically equivalent” are a (Sentence-Level) Paraphrase.

- “It’s probably not the easiest time to take over the shuttle program,” he added, “but I look forward to the challenge.”
- “It is probably not the easiest time to come in and take over the shuttle program, but then again, I look forward to the challenge,” he said.

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Related Work

- Bag-of-words: Corley and Mihalcea, 2005
- Sequence of Tokens: Barzilay and Lee, 2003 (Multiple-Sequence Alignment)
- Syntactic Tree: Wu, 2005 (Inversion Transduction Grammar)

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Similarity

Motivation

- Paraphrase ($+pp$):
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- Non-Paraphrase ($-pp$):
  - The technology-laced Nasdaq Composite Index *added* 1.92 points, or 0.12 percent, at 1,647.94.
  - The technology-laced Nasdaq Composite Index *dipped* 0.08 of a point to 1,646.

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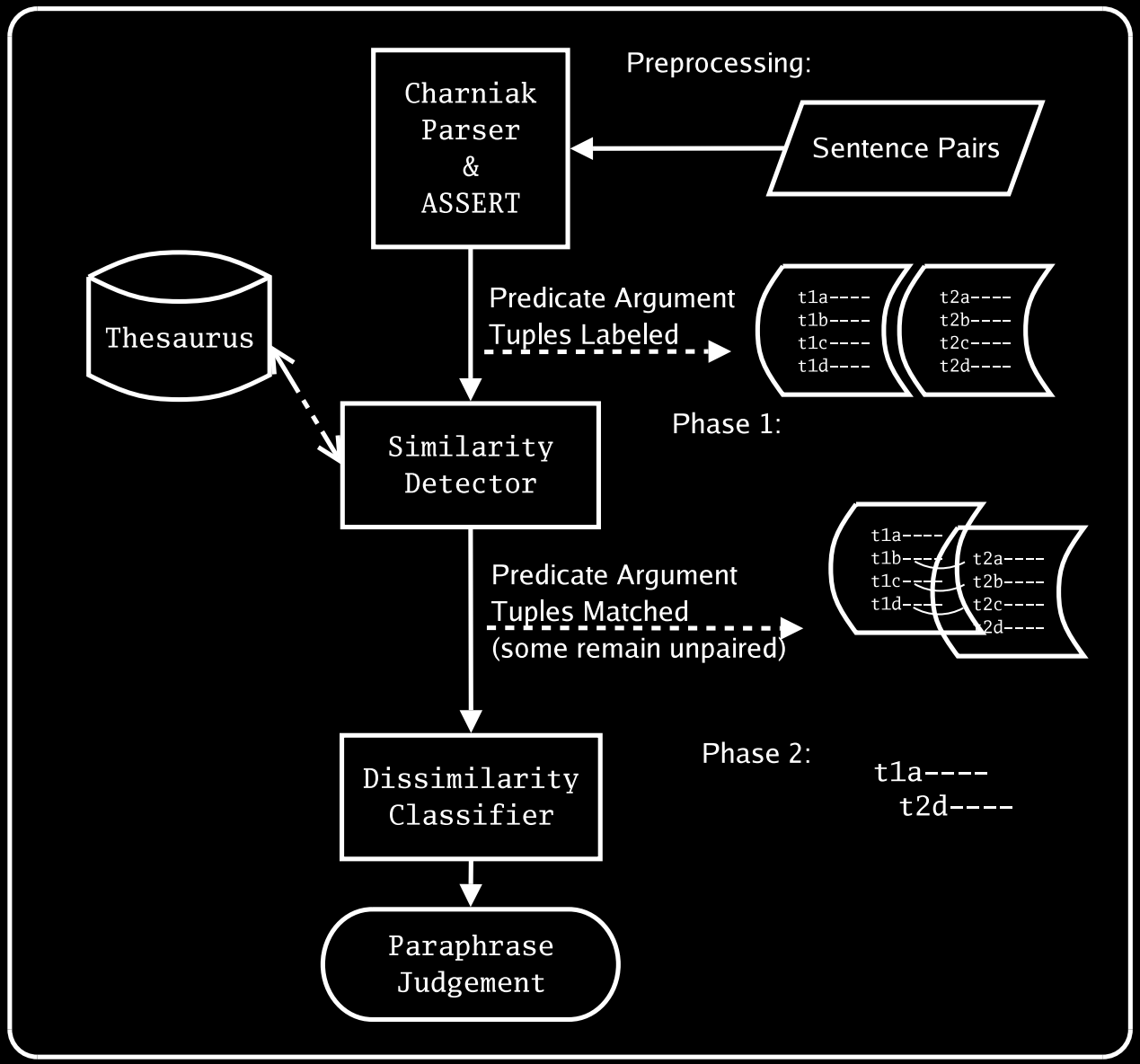
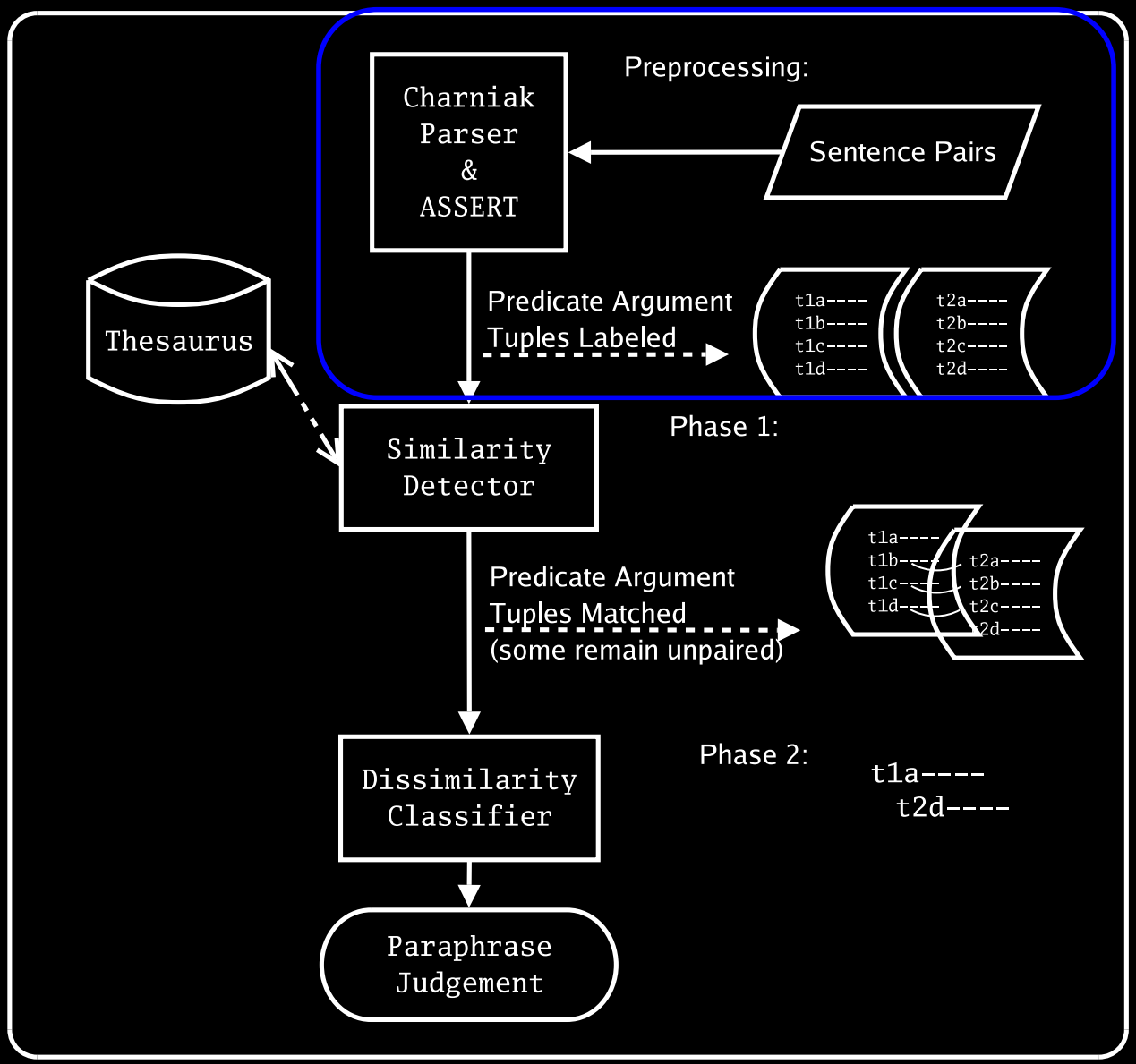
Outline

- Related Work
- Motivation
- Two-phase Framework
- Evaluation
- Discussion


Preprocessing:
Charniak Parser & ASSERT
Sentence Pairs
Thesaurus
Predicate Argument Tuples Labeled
t1a----
t1b----
t1c----
t1d----
t2a----
t2b----
t2c----
t2d----
Phase 1:
Similarity Detector
Predicate Argument Tuples Matched (some remain unpaired)
Phase 2:
Dissimilarity Classifier
t1a----
t2d----
Paraphrase Judgement



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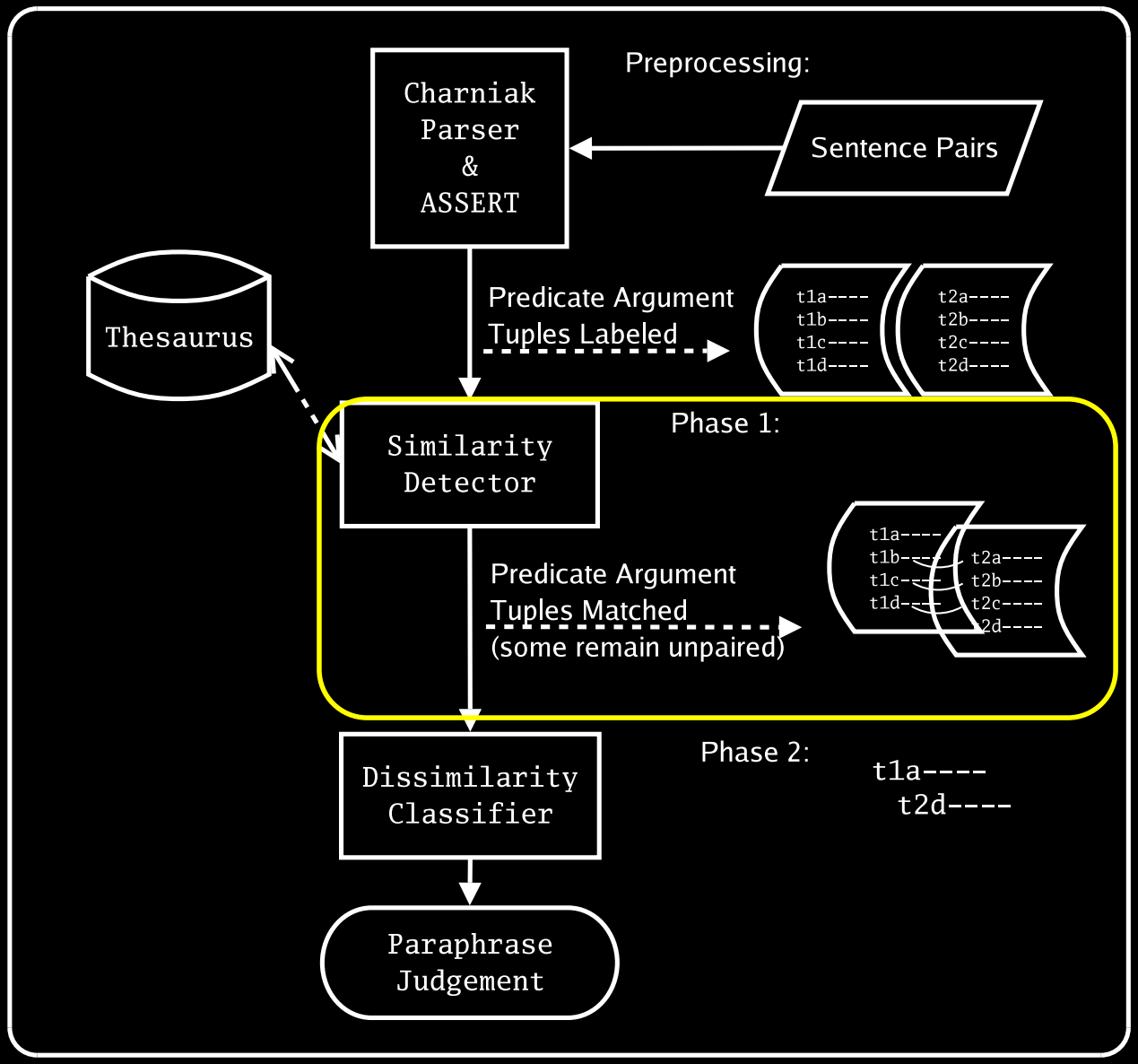

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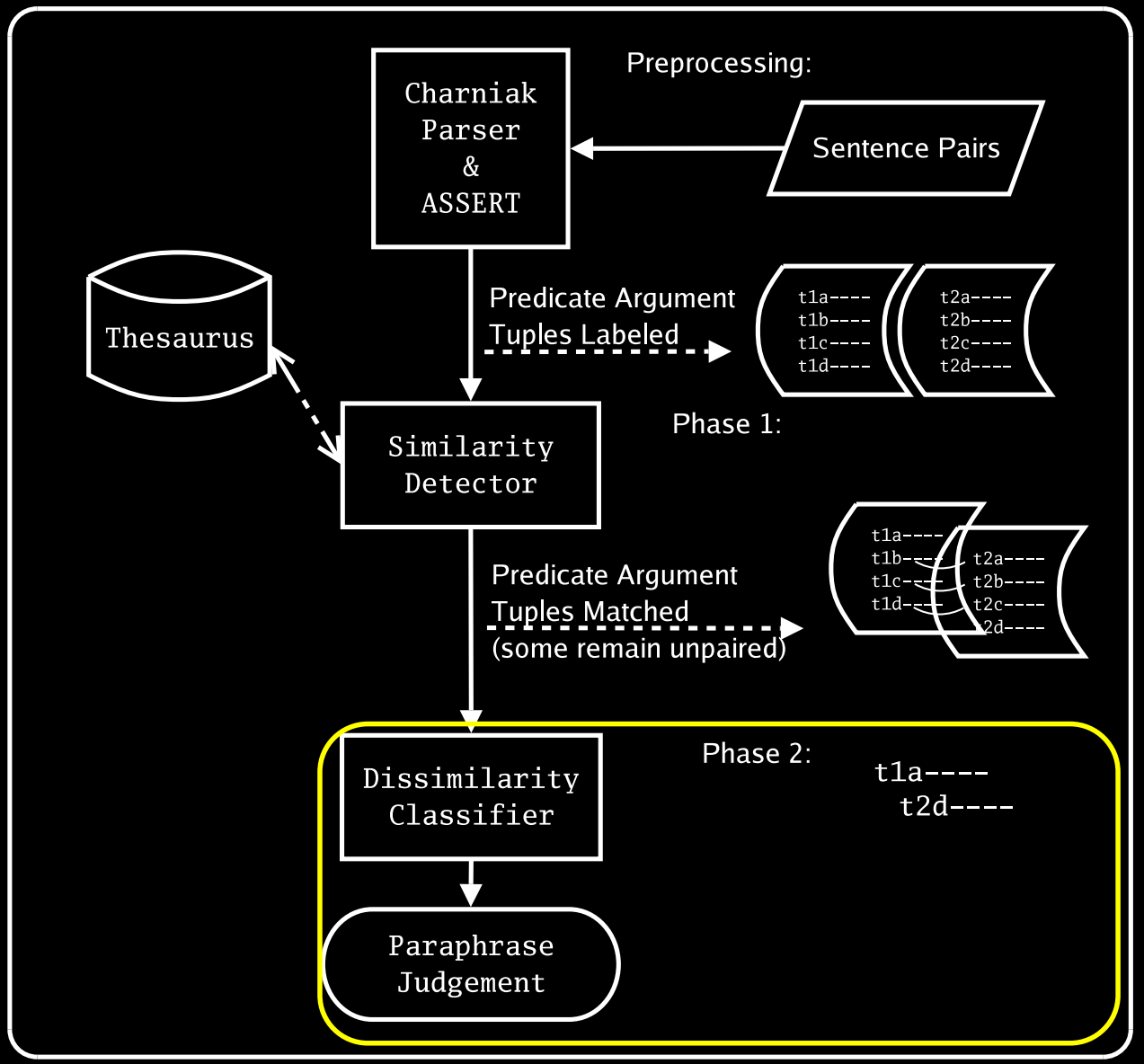
- 1. Phase 1: Similarity Detector



- 0. Preprocessing
- 1. Phase 1: Similarity Detector
- 2. Phase 2: Dissimilarity Significance Classifier

0. Preprocessor: Semantic Role Labeler

Authorities said a young man injured Richard Miller.

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Authorities said a young man injured Richard Miller.

- Authorities$_{ARG0}$ said$_{PREDICATE}$ a young man injured Richard Miller$_{ARG1}$
- Authorities said a young man$_{ARG0}$ injured$_{PREDICATE}$ Richard Miller$_{ARG1}$

1. Similarity Detector (SD)

- [**ARG1** The technology-laced Nasdaq Composite Index] [**TARGET** added] [**ARG2** 1.92 points or 0.12 percent] at 1,647.94
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Automatically annotated instances:

- *Insignificant Tuples* in paraphrasing sentence pairs where only one sentence has extra tuples;
- *Significant Tuples* in non-paraphrasing sentence pairs where only one sentence has only one extra tuple.

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Machine Learner : Support Vector Machine

- Linear Kernel

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Internal Features:

- *# numeric expressions*: 2
- *# named entities*: 1
- *# words*: 12
- *# semantic roles*: 4
- *similar to other tuples in the same sentence*: false

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Contextual Features:

- *hosting/opposing sentence length*: 13/14
- *# paired tuples*: 0
- *etc.*

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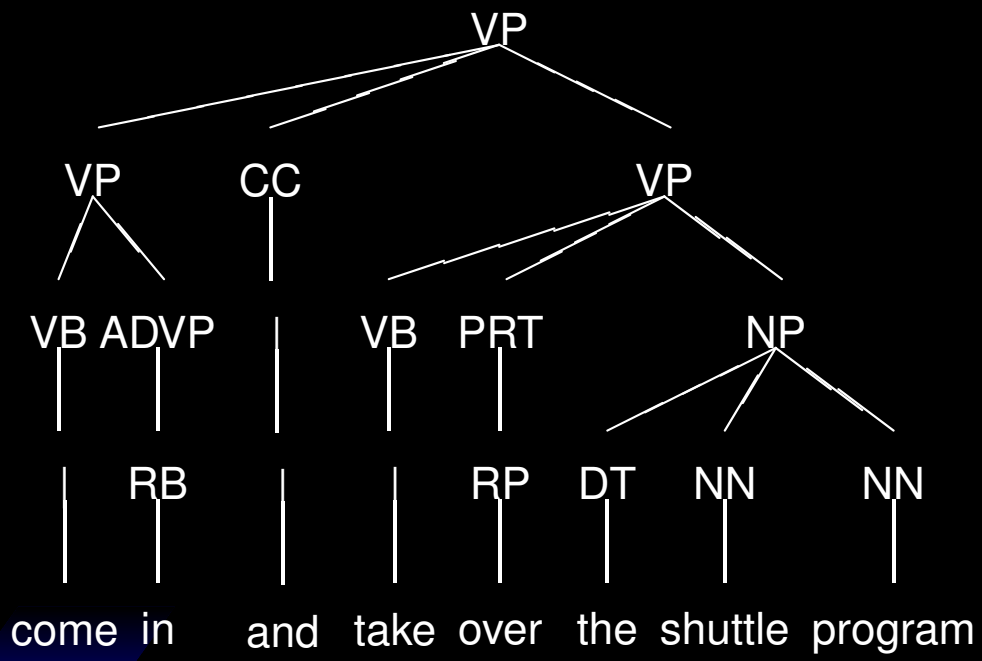
Features that show performance gain:

- lemma of the predicate;
- n-grams from Syntactic Parse Path.



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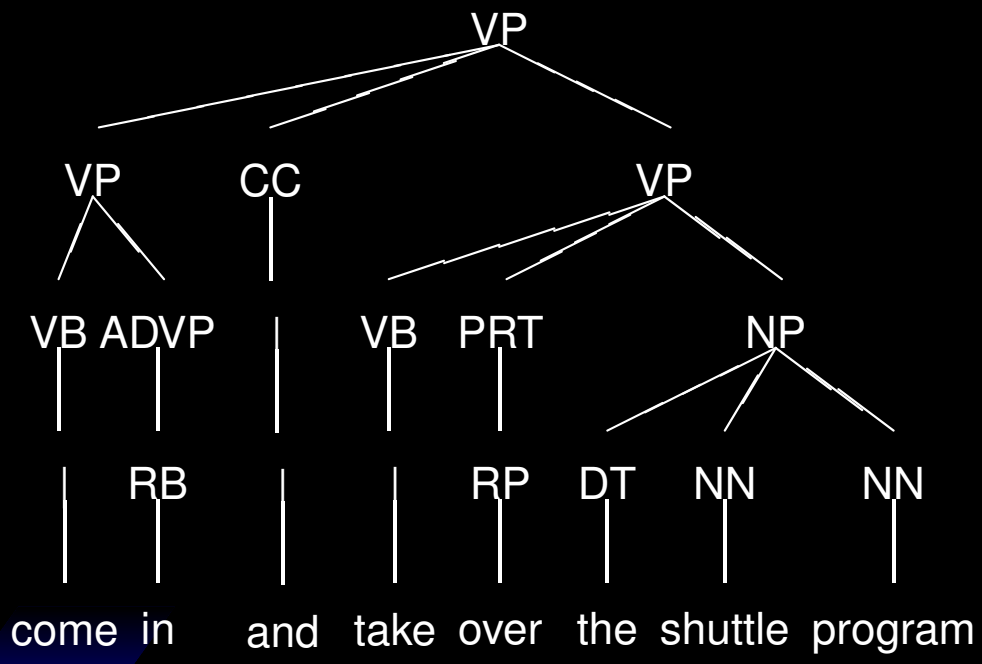

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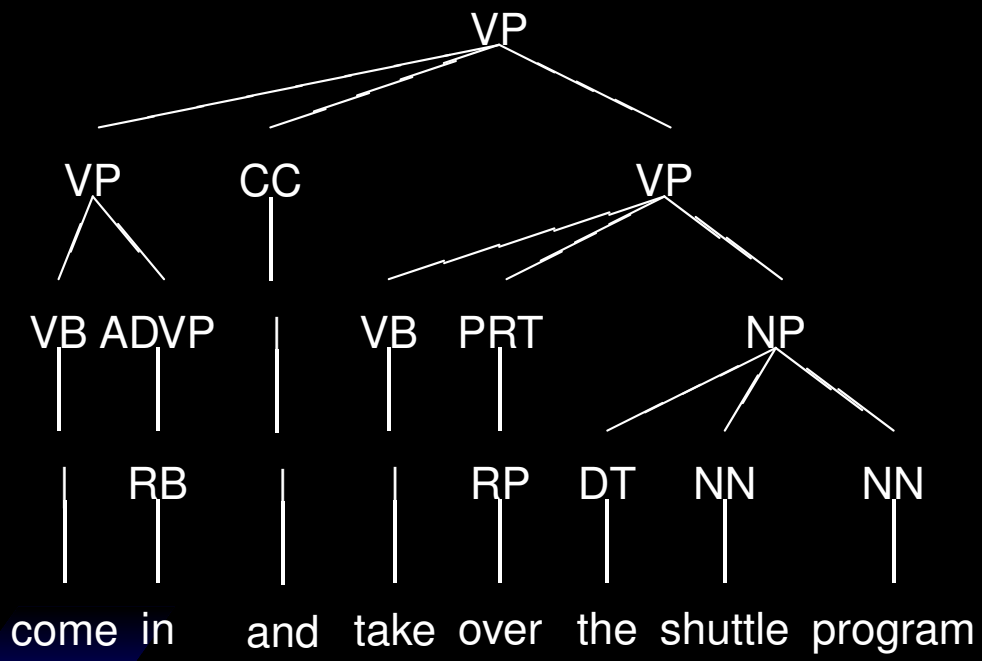

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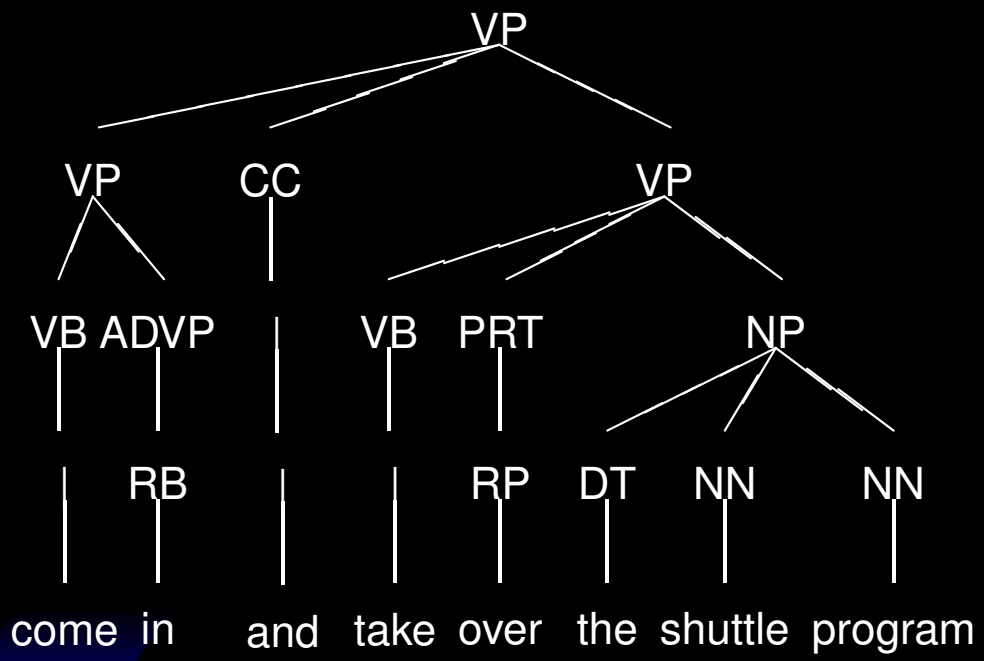

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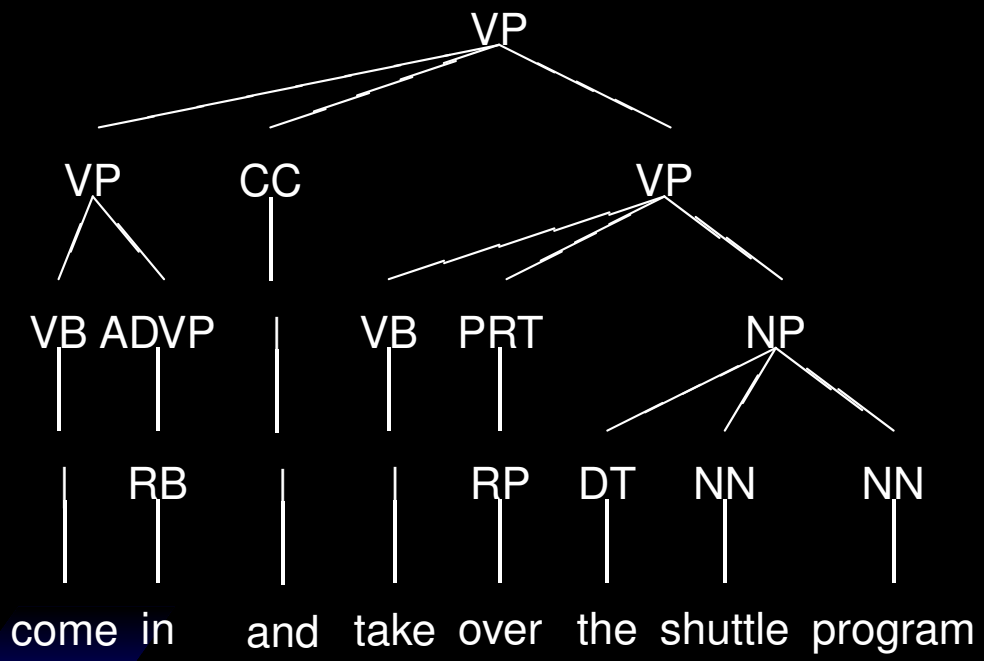

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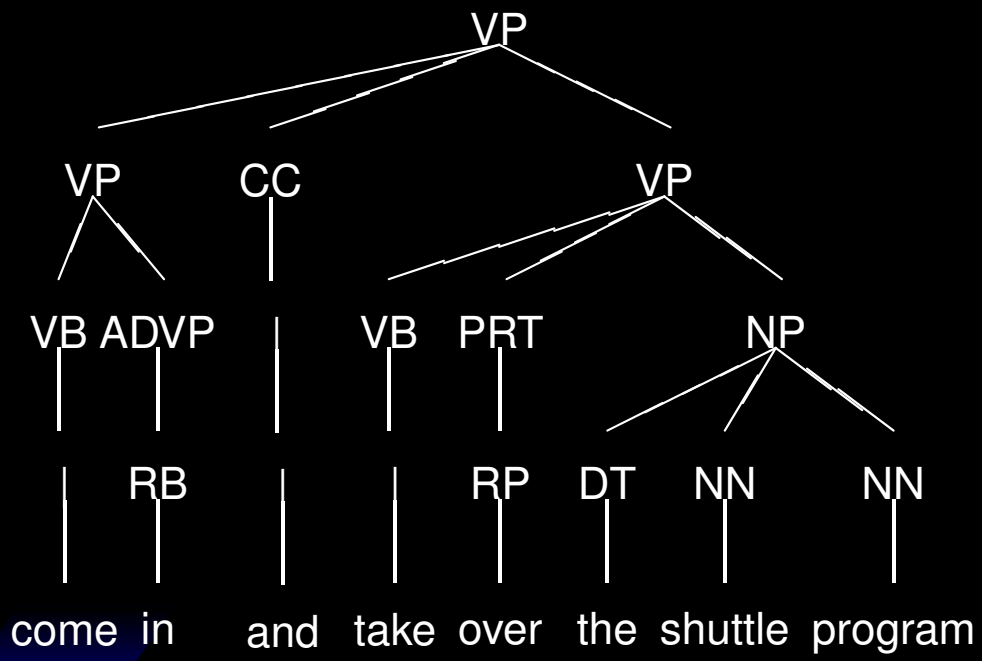

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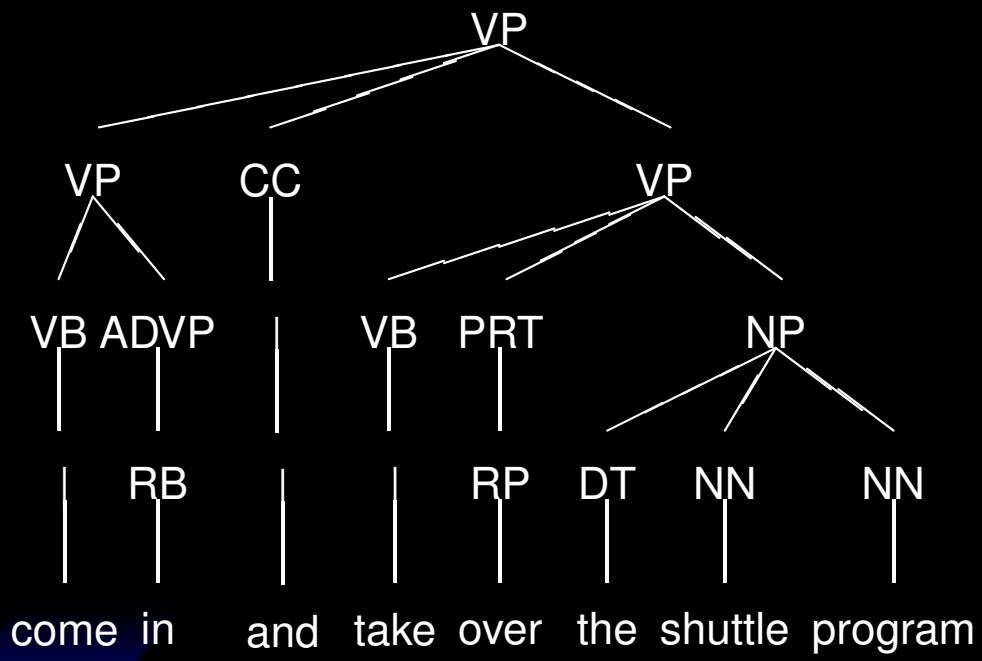

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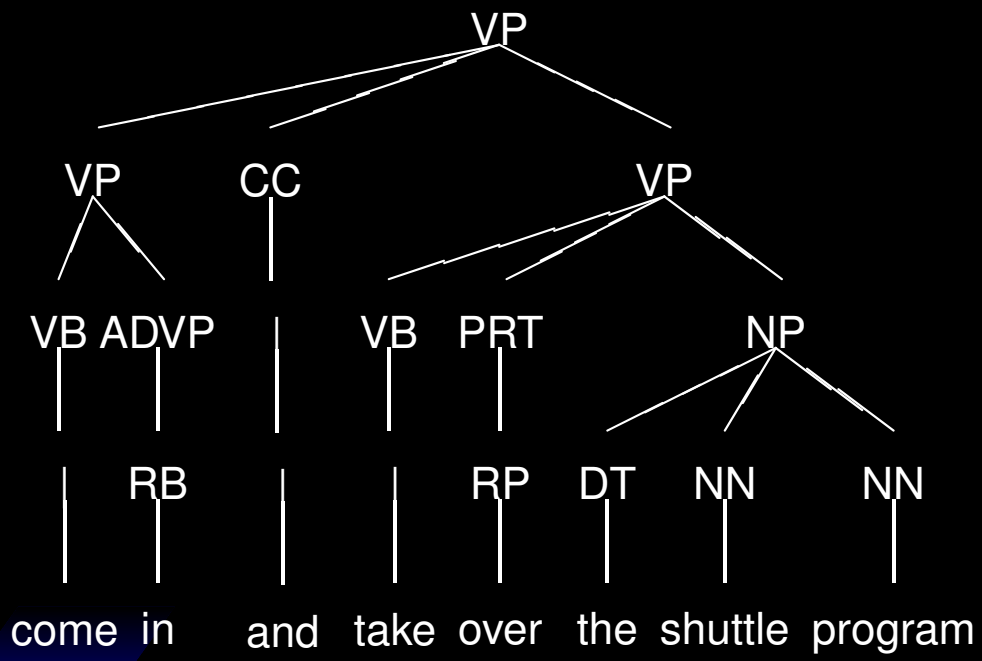

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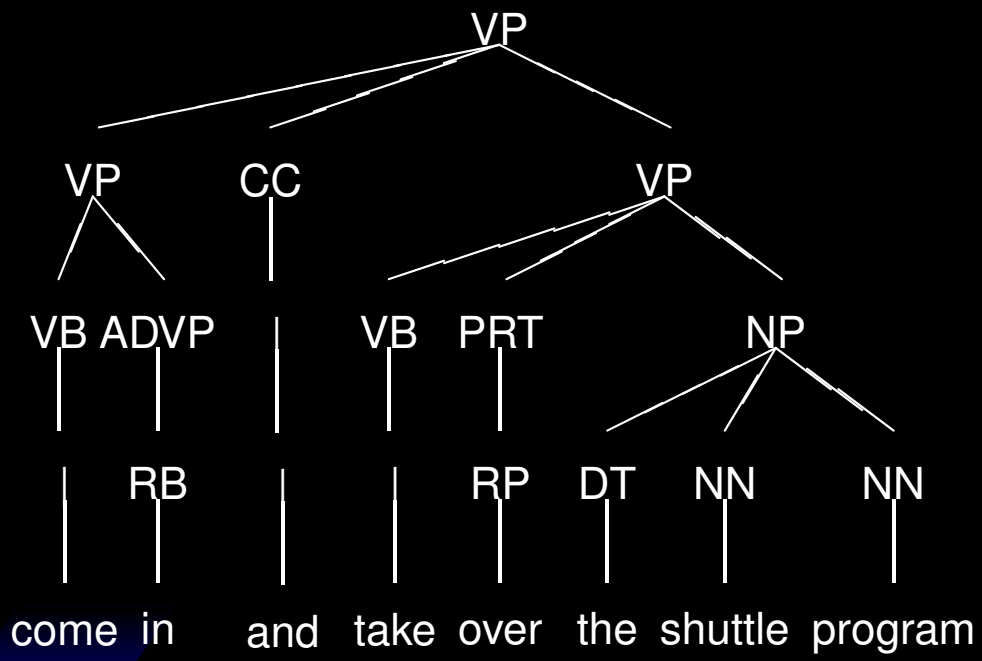

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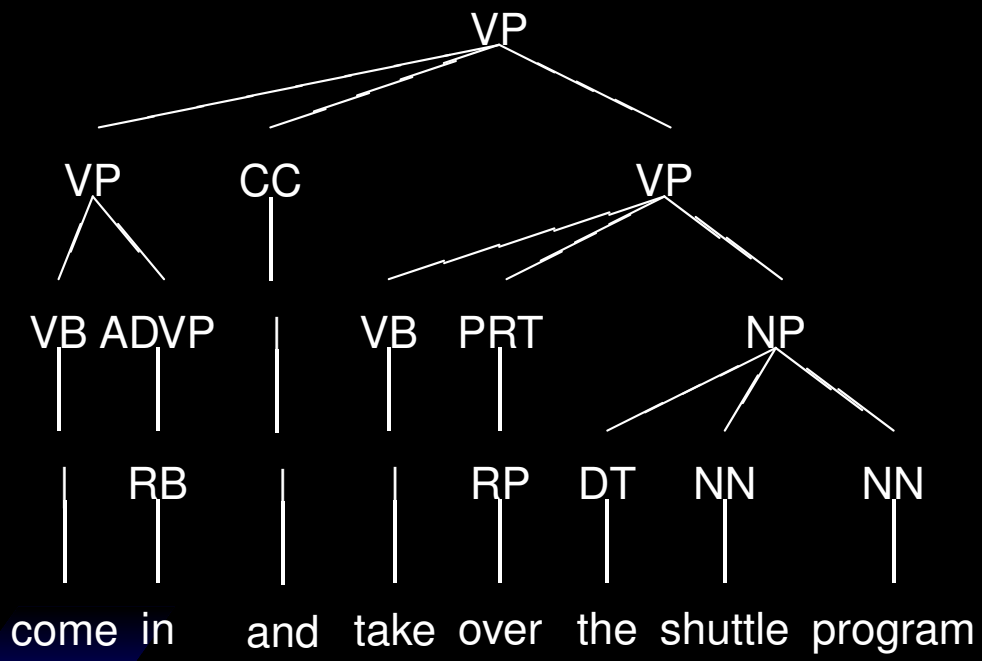

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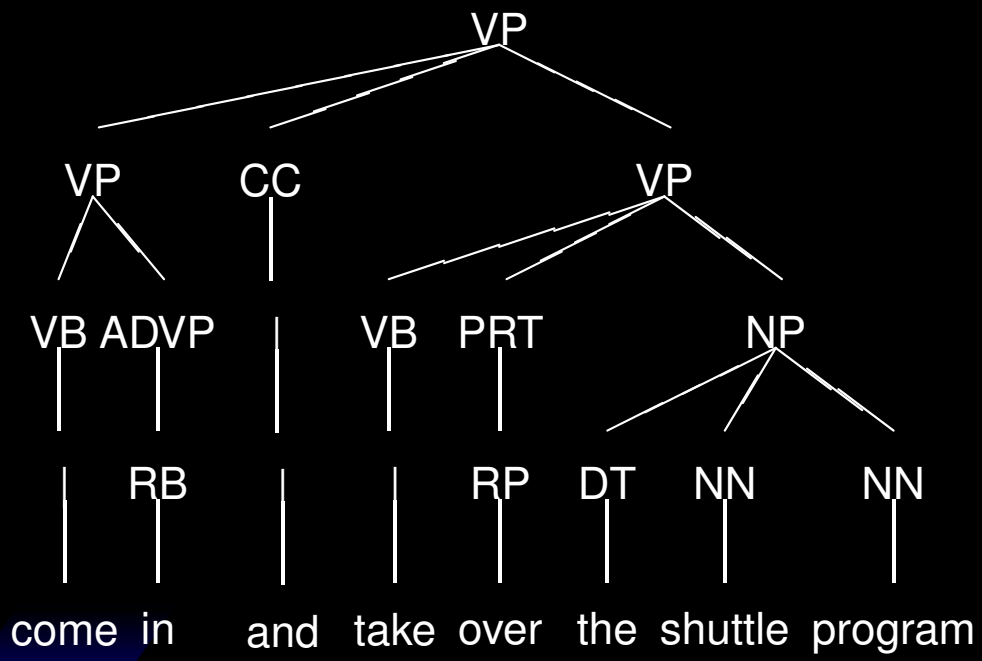

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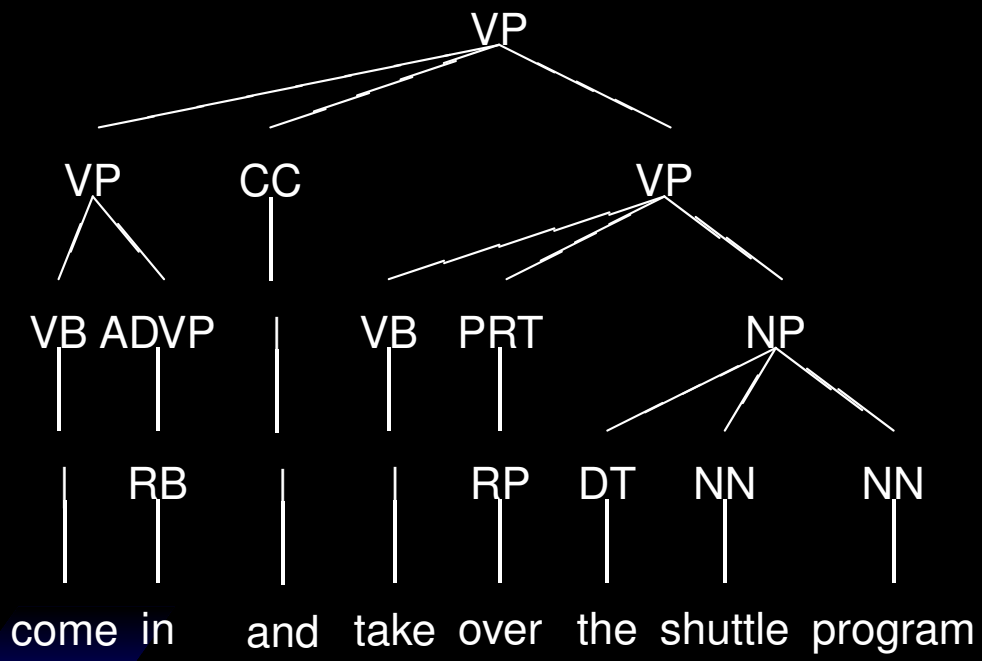

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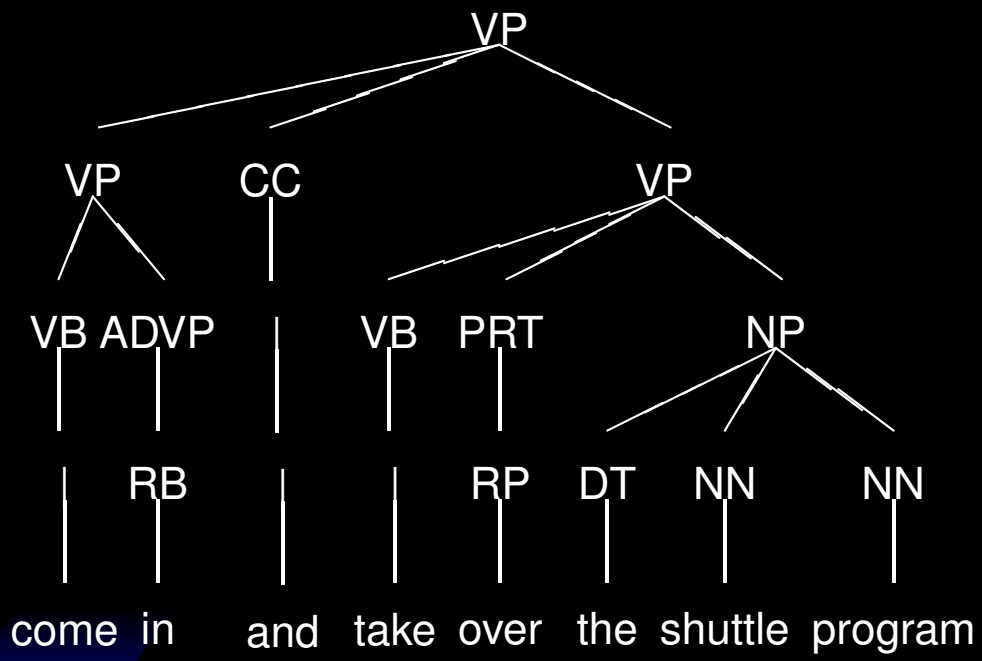

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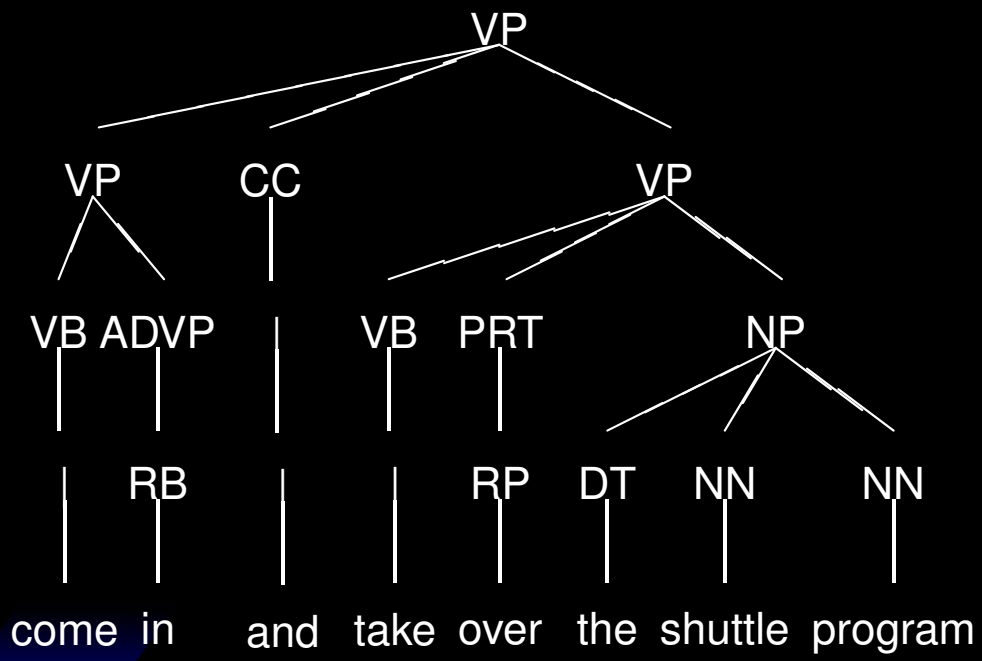

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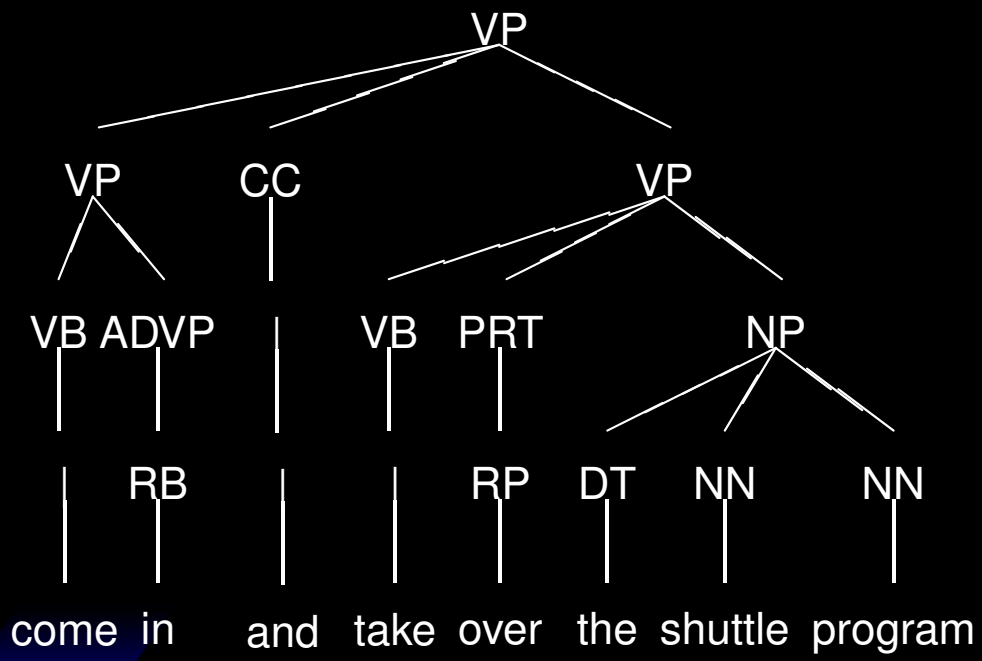

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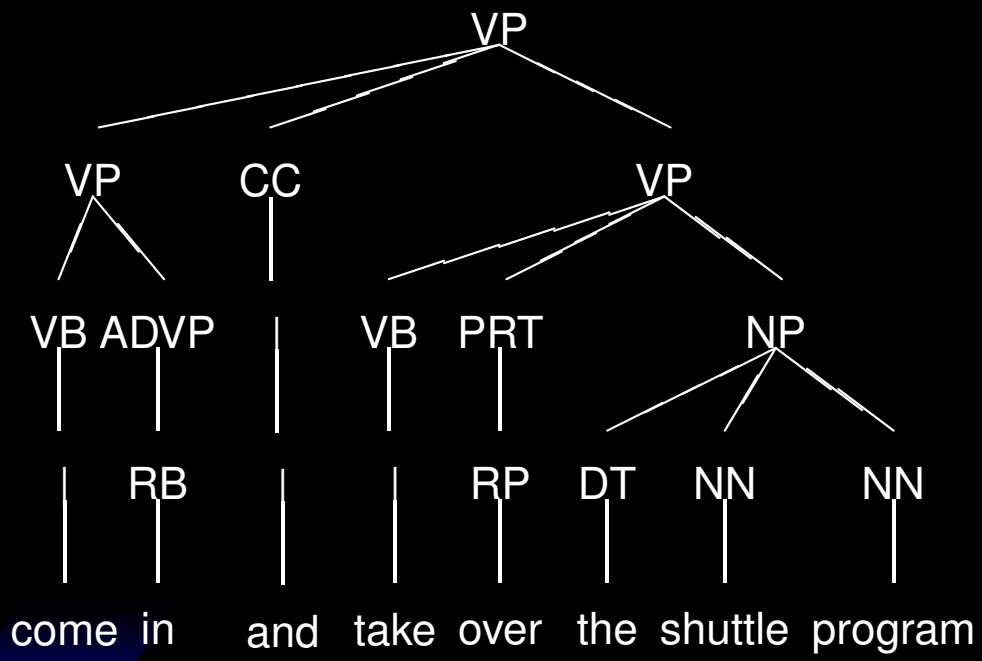

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  - $\downarrow VB$

Paraphrase Judgement

IF Sentence pairs with perfectly paired tuples

THEN Paraphrase

ELSE {

IF Sentence pairs with insignificant unpaired tuples

THEN Paraphrase

IF Sentence pairs with significant unpaired tuples

THEN Non-paraphrase

}

Outline

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Evaluation

- Goals of the evaluation: do they work?
  1. Similarity Detector (SD)
  2. Dissimilarity Classifier (DC)
  3. The whole PR system (SD + DC)

- Data Set: Microsoft Research Paraphrase Corpus
  - 4076 sentence pairs in training set (2753 $+pp$)
  - 1725 sentence pairs in test set (1147 $+pp$)

1. Similarity Detection

- Statistics for 200 further annotated sentence pairs in the test set (200set):

Description	total
# sentence pairs with tuple pairs (by SD)	**157**
# correctly paired (annotators agree)	**144**
# sentence pairs with missed tuple pairs (by annotators)	**31**

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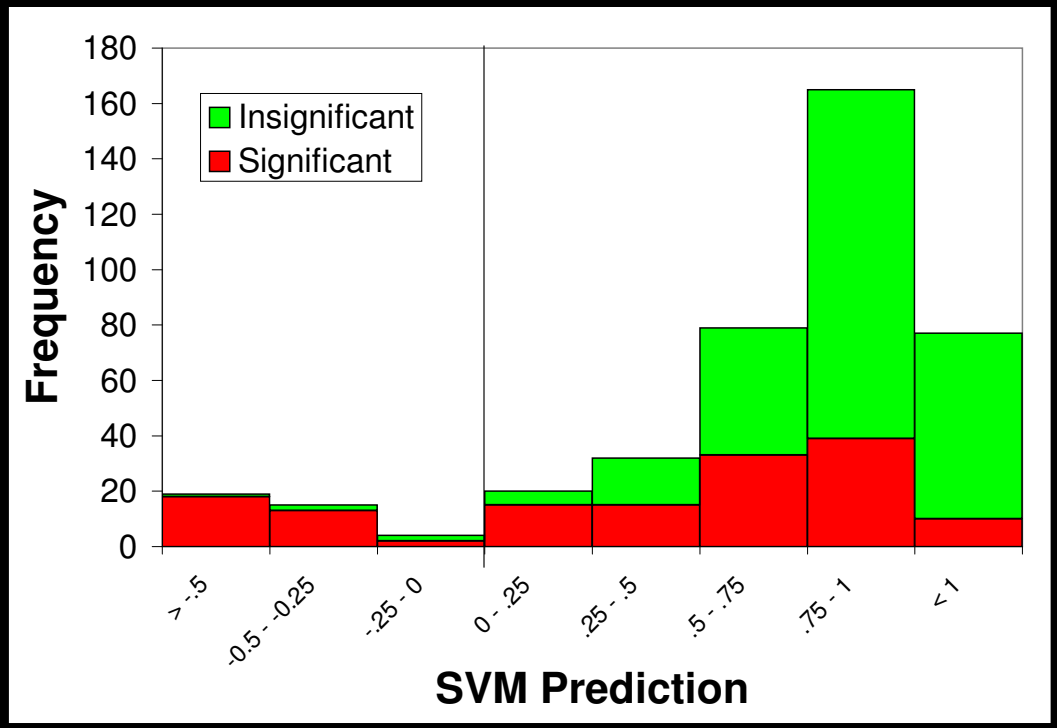
- $Precision = \frac{Positive_{true} \bigcap Positive_{system}}{Positive_{system}} = \frac{144}{157} = 92\%$
- $Recall = \frac{Positive_{true} \bigcap Positive_{system}}{Positive_{true}} = \frac{144}{144 + 31} = 82\%$

2. Dissimilarity Classification



significant	insignificant	
112	263	insignificant by classifier
33	5	significant by classifier

- insignificant tuples well captured
- significant tuples evenly distributed

3. Overall

The system's ability of pinpointing paraphrase barriers:

- In the 200set, 55 $-pp$ cases are correctly recognized;
- For 40 (73%), significant unpaired tuples are agreed to be the reason for non-paraphrasing by human.

Algorithm	Overall Performance (100% of Test set)			
	Acc	R	P	F1
Majority Classifier	66.5%	100%	66.5%	79.9%
SimFinder	72.9%	88.5%	75.1%	81.3%
CM05	71.5%	92.5%	72.3%	81.2%
Our System	72.0%	93.4%	72.5%	81.6%

Outline

- Related Work
- Motivation
- Two-phase Framework
- Evaluation
- Discussion

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
    Michael Hill, a Sun reporter who is a member of the Washington-Baltimore Newspaper Guild's bargaining committee, estimated meetings to last late Sunday.

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
  - (30%) A part of a coordination:
    Security lights have also been installed and police have swept the grounds for booby traps.

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
  - (30%) A part of a coordination:
  - (13%) A predicate of a modifying clause:
    Westermayer was 26 then, and a friend and former manager who knew she was unhappy in her job tipped her to another position.

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
  - (30%) A part of a coordination:
  - (13%) A predicate of a modifying clause:
  - (7%) An adjunct:
    While waiting for a bomb squad to arrive, the bomb exploded, killing Wells.

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
  - (30%) A part of a coordination:
  - (13%) A predicate of a modifying clause:
  - (7%) An adjunct:
  - (7%) An embedded sentence:
    Dean told reporters traveling on his 10-city "Sleepless Summer" tour that he considered campaigning in Texas a challenge.

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
  - (30%) A part of a coordination:
  - (13%) A predicate of a modifying clause:
  - (7%) An adjunct:
  - (7%) An embedded sentence:
  - (3%) Or factual content that conflicts with the opposing sentence:

    Total sales for the period declined 8.0 percent to USD1.99 billion from a year earlier.
    Wal-Mart said sales at stores open at least a year rose 4.6 percent from a year earlier.

Discussion & Future Work

- significant tuples appear as:
  - (40%) The nucleus of the sentence (often the matrix tuple):
  - (30%) A part of a coordination:
  - (13%) A predicate of a modifying clause:
  - (7%) An adjunct:
  - (7%) An embedded sentence:
  - (3%) Or factual content that conflicts with the opposing sentence:

Discussion & Future Work (Cont'd)

- Problematic cases
  - Non-literal language issues such as implicature, idiom, metaphor, *etc.* are not addressed in our current system:

    $+pp$

    Later in the day, a standoff developed between French soldiers and a Hema battlewagon that attempted to pass the UN compound.

    French soldiers later threatened to open fire on a Hema battlewagon that tried to pass near the UN compound.

Discussion & Future Work (Cont'd)

- Problematic cases
  - Non-literal language issues such as implicature, idiom, metaphor, *etc.* are not addressed in our current system;
  - A paraphrasing pair may exceed the system's threshold for syntactic difference:

    $+pp$

    With the exception of dancing, physical activity did not decrease the risk.
    Dancing was the only physical activity associated with a lower risk of dementia.

Discussion & Future Work (Cont'd)

- Problematic cases
  - Non-literal language issues such as implicature, idiom, metaphor, *etc.* are not addressed in our current system;
  - A paraphrasing pair may exceed the system's threshold for syntactic difference;
  - One or more unpaired tuples exist, but their significance is not inferred correctly:

    $+pp$

    Inhibited children tend to be timid with new people, objects, and situations, while uninhibited children spontaneously approach them.

    Simply put, shy individuals tend to be more timid with new people and situations.

Discussion & Future Work (Cont'd)

- Problematic cases
  - Non-literal language issues such as implicature, idiom, metaphor, *etc.* are not addressed in our current system;
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Conclusion

- Proposed a PR framework focusing on dissimilarity
  - Similarity Detector: Matches similar tuples and detects extra ones;
  - Dissimilarity Classifier: Judges whether extra tuples are significant.
- Implemented a system that shows:
  - what information makes the sentences non-paraphrasing;
  - high accuracy in matching similar tuples;
  - robust dissimilarity classification;
  - comparable overall PR performance.