

# Incrementally Predicting Syntax and Semantics

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## 1 Introduction

## 2 Incremental Semantic Role Labeling

- Incremental Parsing
- Semantic Lexicon
- Incremental Role Propagation

## 3 Results

- Incremental Semantic Role Labeling
- Semantic Roles improve Incremental Parsing

# Human Language Processing

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- (1) a. The old **man** the boat.
- b. The **prime** number few.
- c. I convinced **her children** are noisy.
- d. We painted the wall **with cracks**.

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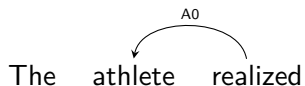
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Let's look at this example in more detail.



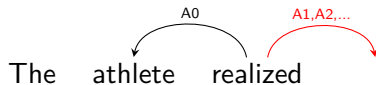
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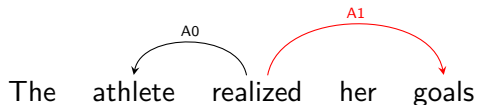


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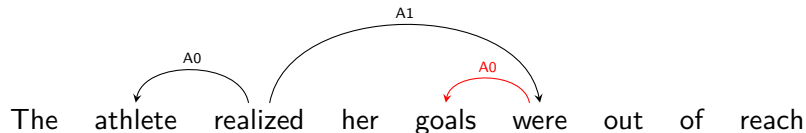


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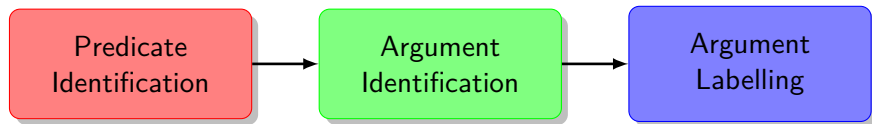
We can now define the task of **incremental semantic role labeling** (iSRL):

- determine semantic role labels as the input unfolds;
- given a sentence prefix and its partial syntactic structure:
  - 1 **identify** arguments and predicates;
  - 2 assign correct role **labels**;
- assign possibly **incomplete** semantic roles.

# Non-incremental SRL

There is a large NLP literature on automatic semantic role labeling (e.g., Liu and Sarkar, 2007; Màrquez et al., 2008; Björkelund et al., 2009).

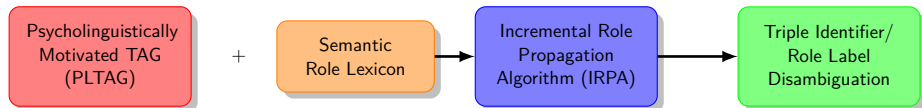
However, none of the existing approaches are incremental. They typically use a **pipeline architecture**:



# iSRL Model

Our model is built on top of an incremental syntactic parser.

We label the output of the parser directly. No need for separate predicate and argument identification step.



# Psycholinguistically Motivated TAG (PLTAG)

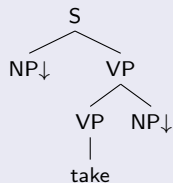
Psycholinguistically Motivated TAG (PLTAG, Demberg et al., 2013):

- variant of **tree-adjoining grammar**;
- supports parsing with **incremental**, fully **connected** structures;
- connectedness is achieved through **syntactic prediction**;
- PLTAG lexicon augmented with semantic roles for iSRL.

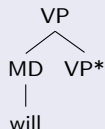
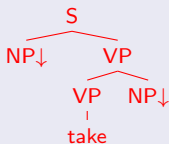
# Comparison with TAG

TAG derivations are not always incremental: *Banks will take measures.*

## Example



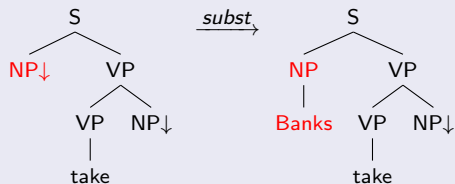
## Lexicon



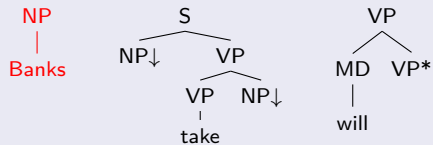
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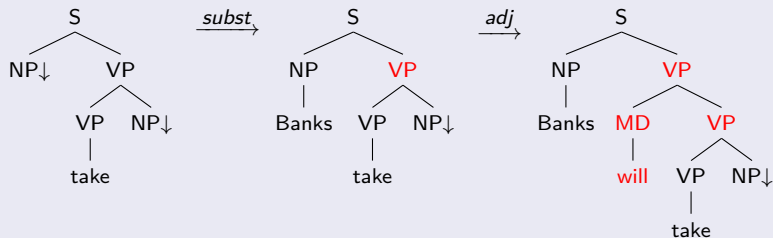
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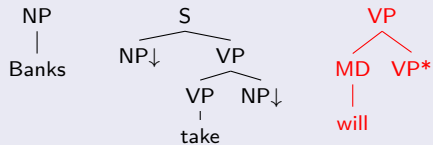
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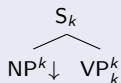
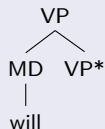
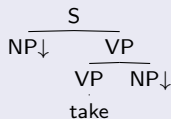
PLTAG derivation are always incremental and fully connected:

## Example

NP  
|  
Banks

## Lexicon

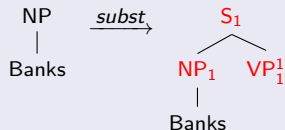
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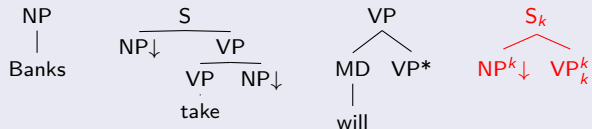
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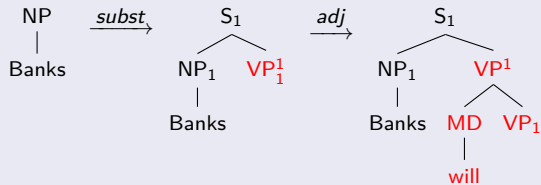
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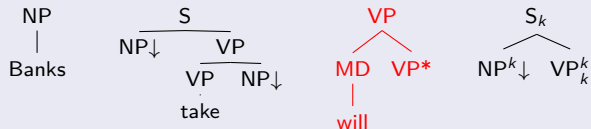
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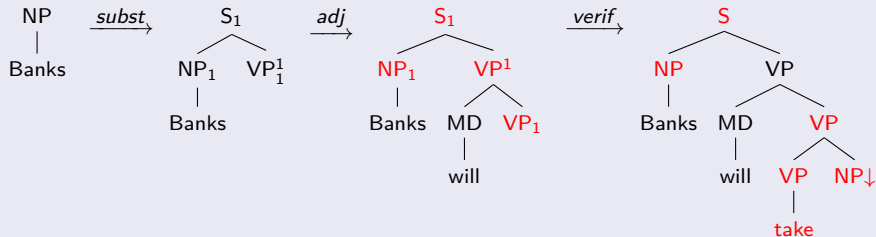
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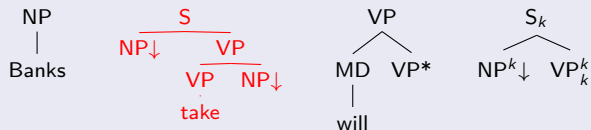
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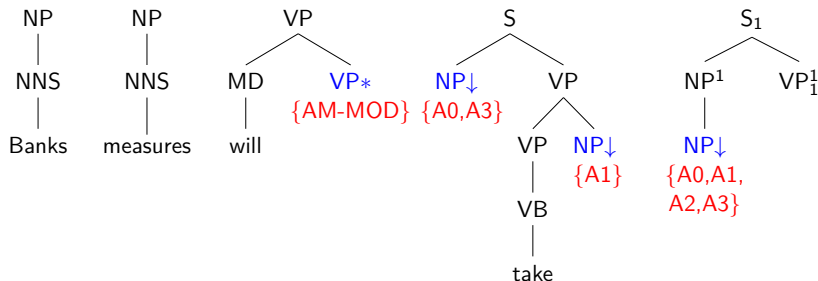


## Lexicon



# Semantic Lexicon

PLTAG semantic lexicon derived from PropBank (Palmer, 2005):

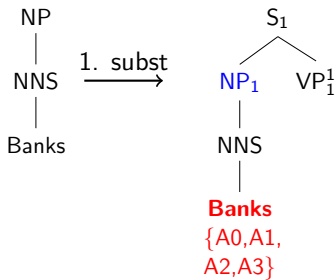


Only include semantic roles derived from verbal predicates.

# Incremental Role Propagation

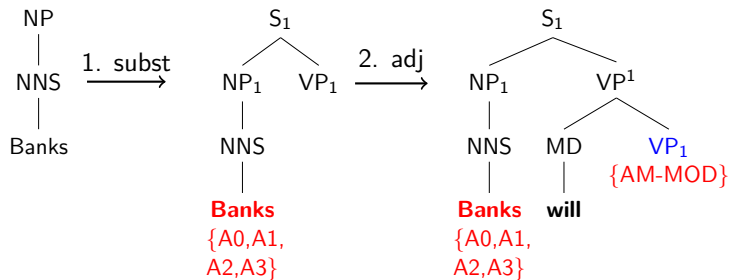
NP  
|  
NNS  
|  
Banks

# Incremental Role Propagation



1. NP  $\rightarrow$   $\langle \{A0, A1, A2, A3\}, \text{Banks}, \text{nil} \rangle$

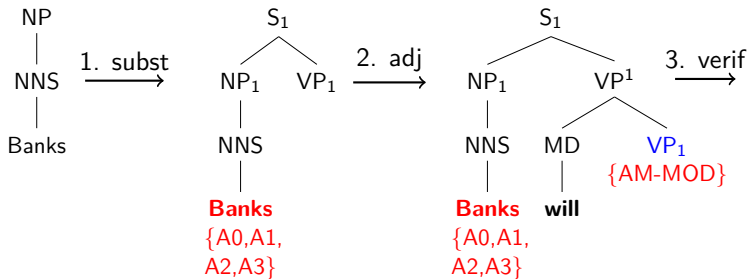
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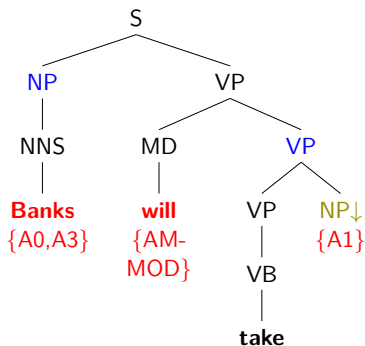
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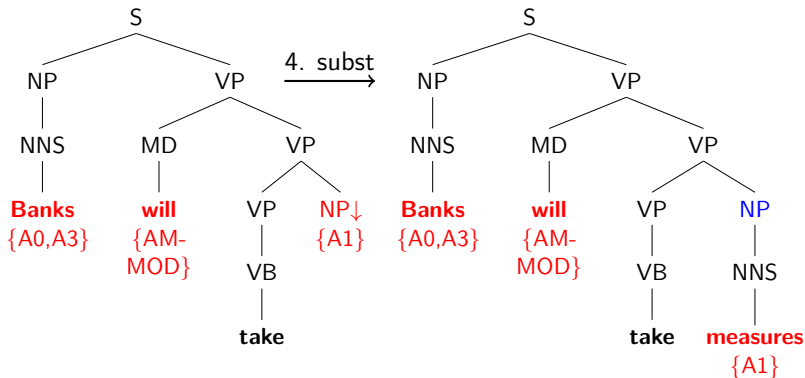
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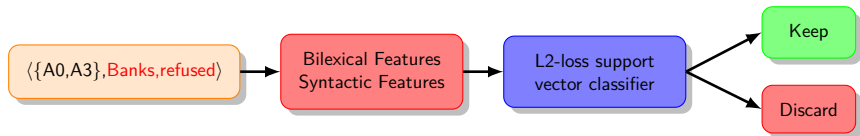
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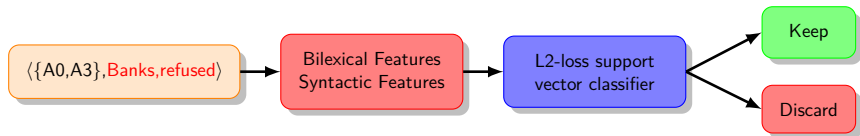
# Argument Identification; Role Label Disambiguation

Argument identification:

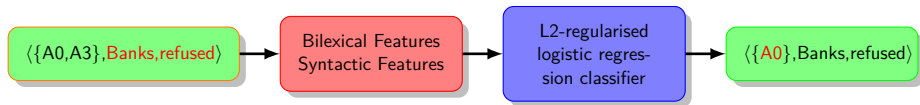


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# Results

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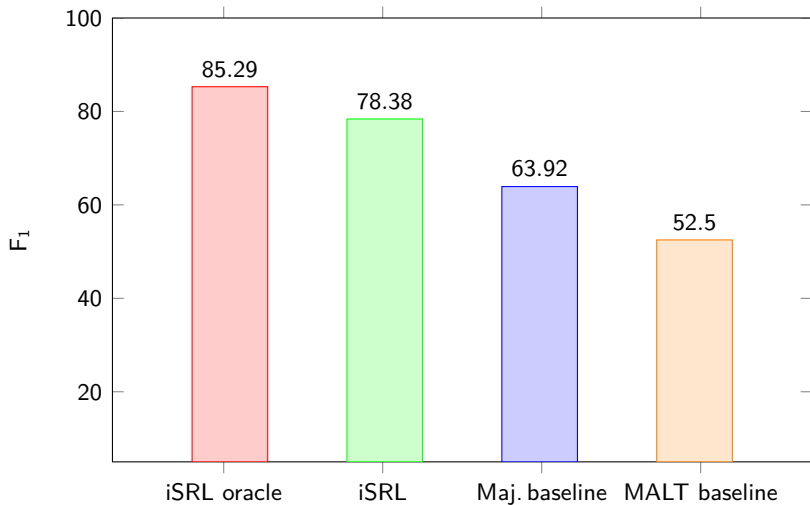
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## Model comparison:

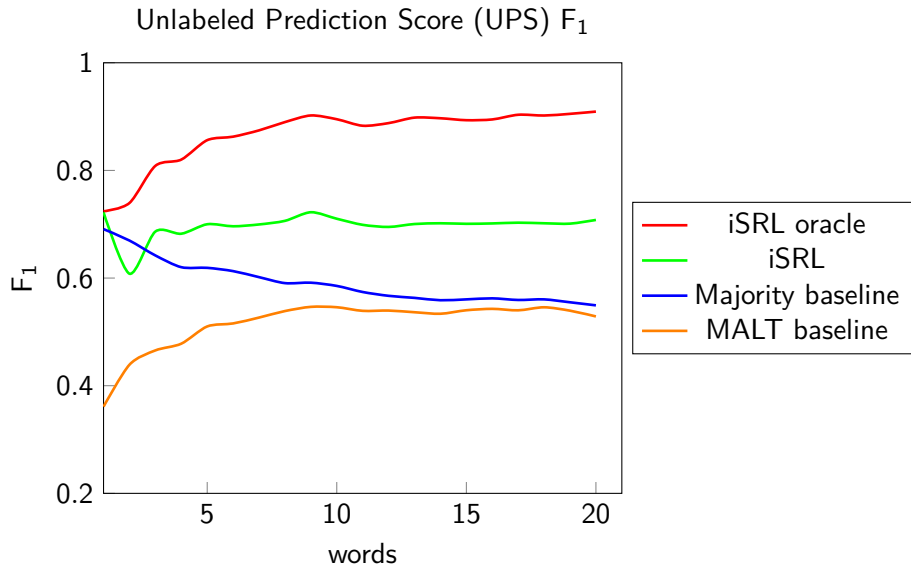
- iSRL oracle: gold semantic role labels;
- **iSRL**: all semantic role labels;
- majority baseline;
- MALT baseline.



# Results: Full Sentence

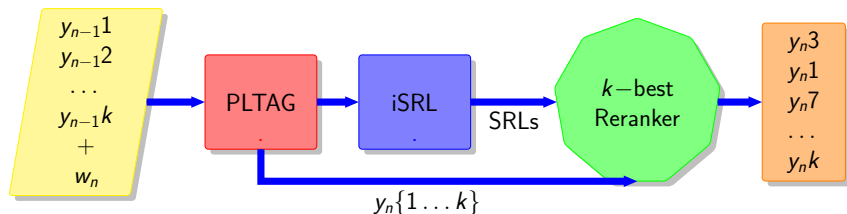


## Results: Incremental



# Parse Re-ranking with iSRL

We can now feed the output of the iSRL model back into the parser to improve parsing performance:



- For incoming word  $w_n$  compute new prefix tree  $y_n$ ;
- use PLTAG parser to attach  $w_n$  to  $y_{n-1}$ ;
- compute semantic roles for each possible  $y_n$ ;
- perform online **per word** reranking.

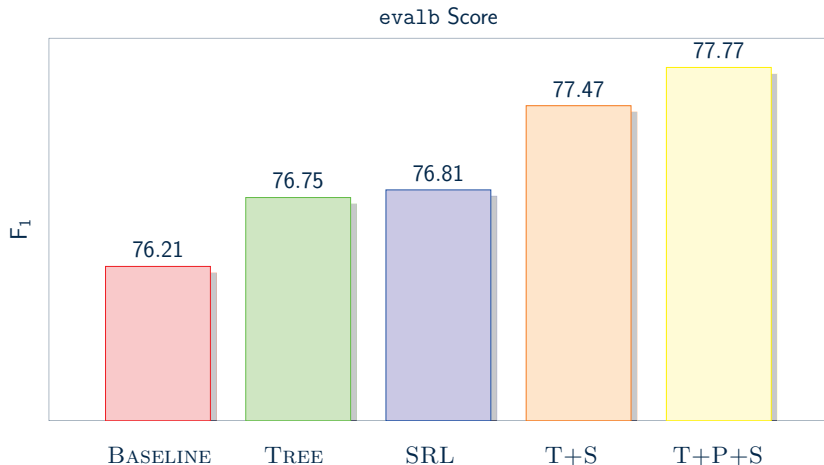
# Reranking Features

Features for parse reranking:

- baseline probability;
- PLTAG features: unigram, unigram+parent, bigram trees;
- tree features (Charniak and Johnson, 2005): right branching, coordination, heaviness, neighbors, word;
- SRL features:
  - complete SRL triples:  $\langle A0, \text{athlete}, \text{realized} \rangle$ ;
  - semantic frame:  $\langle \text{realized}, A0: \text{athlete}, A1: \text{were} \rangle$
  - back-off SRL triples:  $\langle -, \text{athlete}, \text{realized} \rangle$ ,  $\langle [A0], -, \text{realized} \rangle$ ,  $\langle [A0], \text{athlete}, - \rangle$ ;
  - predicate/argument/role: realized, athlete, A0.

# Results

- Train PLTAG,  $k$ -best reranker on WSJ sections 02–21;
- test on WSJ section 23 ( $\leq 40$  words).



# PLTAG with iSRL as a Psycholinguistic Model?

Good evidence for PLTAG as a psycholinguistic model:

- predicts reading times in the Dundee corpus (Demberg et al., 2013);
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PLTAG with iSRL as a potential model:

- first explicit implementation of incremental parsing with incremental semantic construction;
- makes architectural claims: **autonomous syntax** (without re-ranking), **syntax-first** with revision (with re-ranking);
- can be interfaced with distributional semantics models.

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Current limitations:

- no formal evaluation on human data;
- surprisal estimates can't be computed easily;
- plausibility of having three separate classifiers?



# Conclusions

- New task: incremental semantic role labeling;
- our model combines:
  - Psycholinguistically Motivated TAG (PLTAG);
  - semantic role lexicon;
  - incremental semantic role propagation algorithm;
  - argument identification, role disambiguation classifiers;
- performs well incrementally: predicts (in-)complete triples early in the sentence;
- incremental SRL improves parsing accuracy;
- download code from <https://github.com/sinantie/PLTAG>.

# Bonus Material: PLTAG

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- Standard TAG lexicon
- Predictive lexicon (PLTAG)

## Operations:

- Substitution
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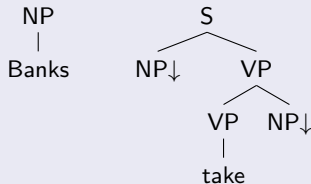
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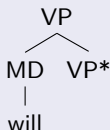
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## Example

*Initial Tree:*



*Auxiliary Tree:*



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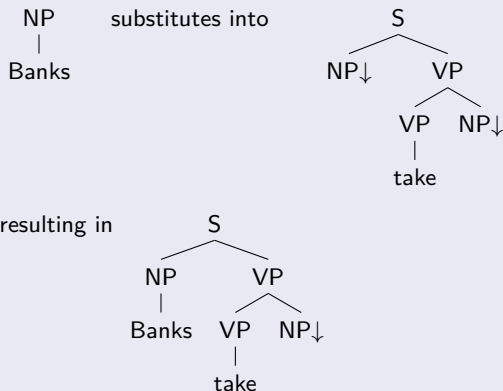
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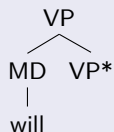
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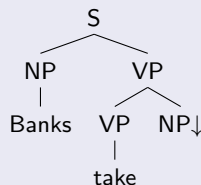
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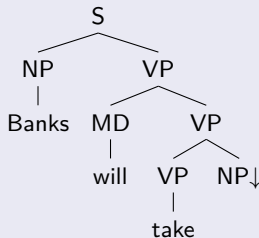
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adjoins to



resulting in



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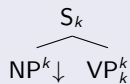
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## Example

*Prediction Tree:*



Index  $k$  marks predicted node.

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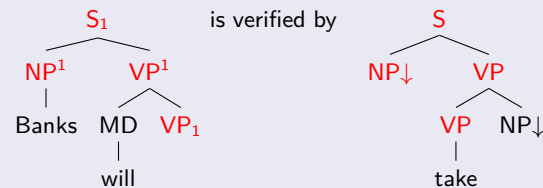
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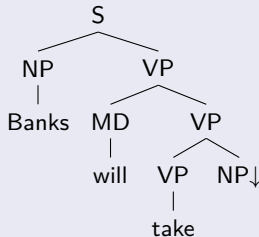
## Operations:

- Substitution
- Adjunction
- **Verification (PLTAG)**

## Example



resulting in



All nodes indexed with  $k$  have to be verified.