

Parsing Algorithms

Human Language from a Computational Perspective
May 30, 2018

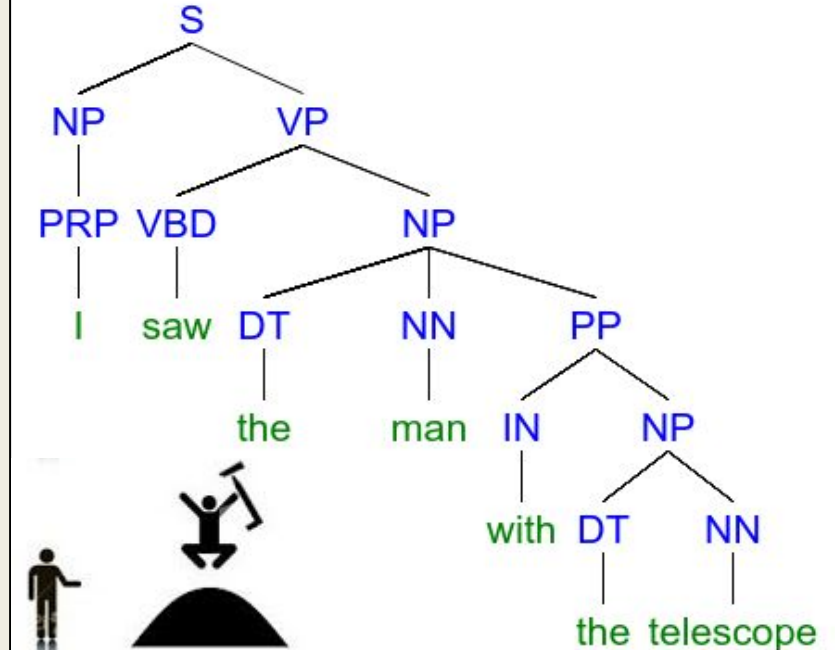
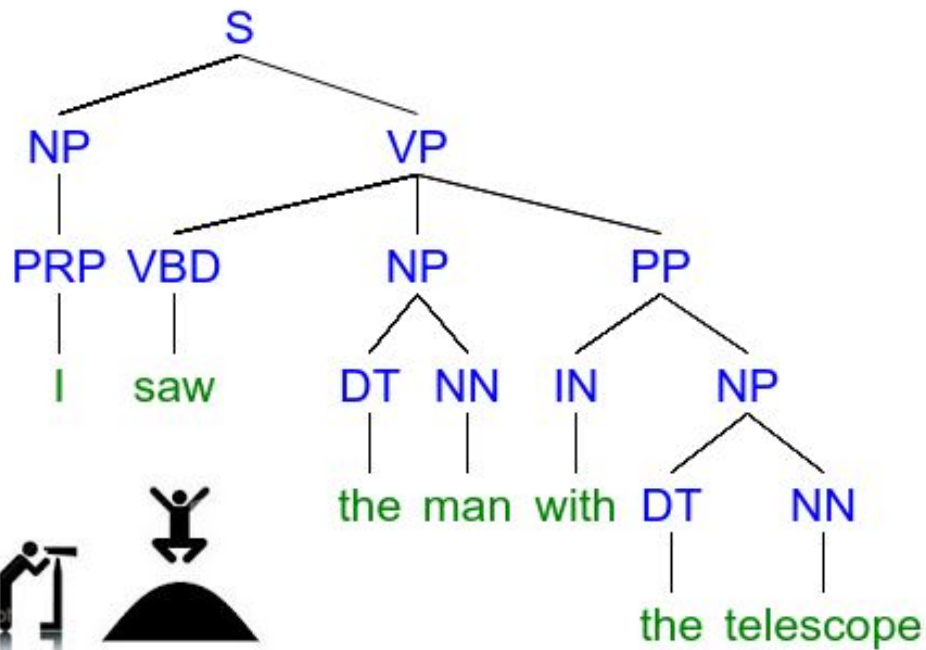
Data structures so far

- Lists [3, 16, 8, 0]

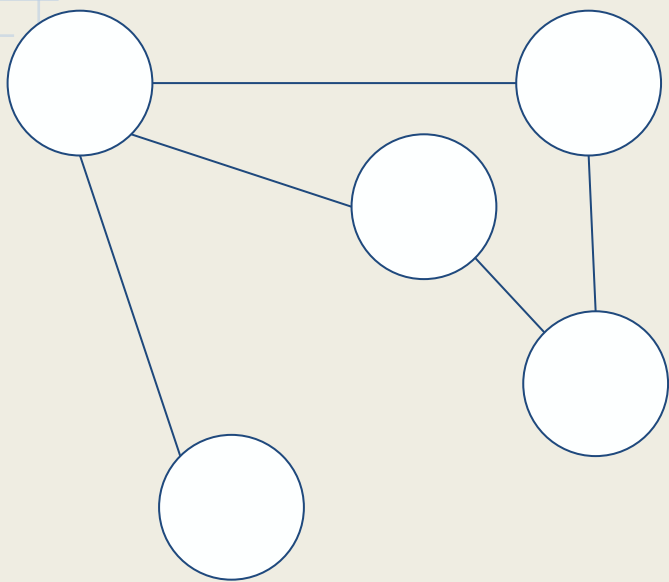
[HE, GAVE, HER, A, BOOK]

- Tables [THE: 462, FISH: 31, SEE: 9]

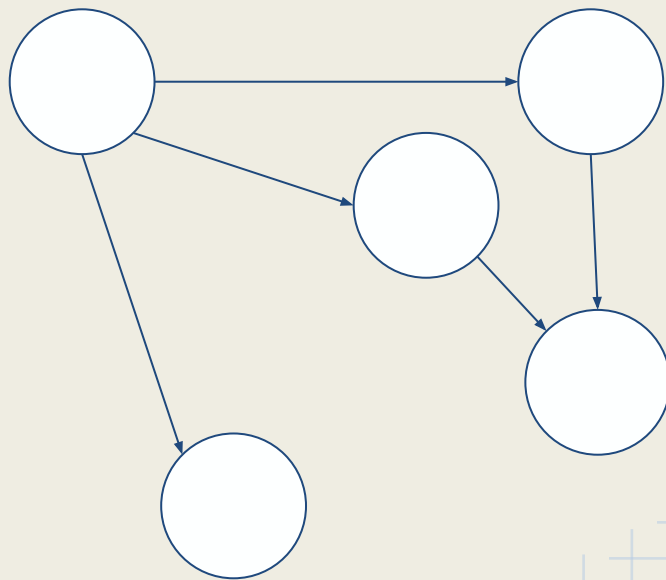
Reminder: phrase structure



Graphs

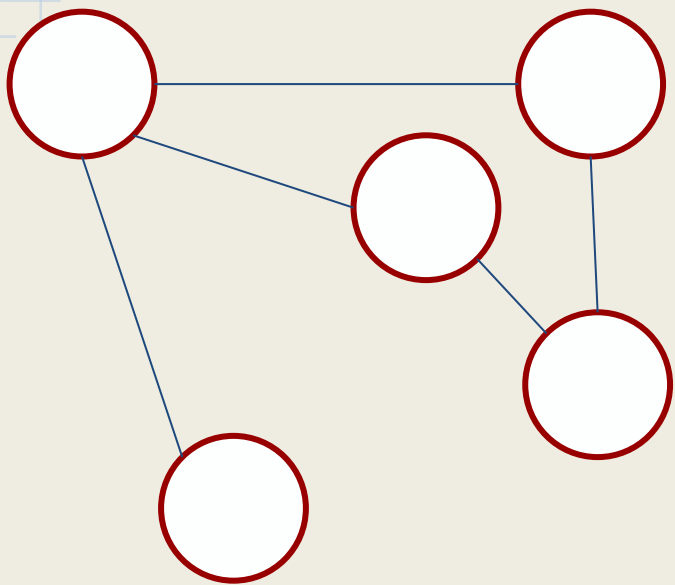


Undirected



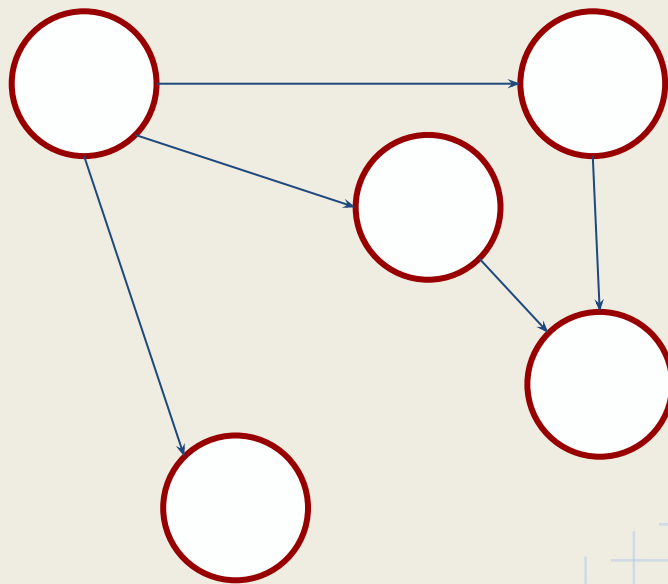
Directed

Graphs



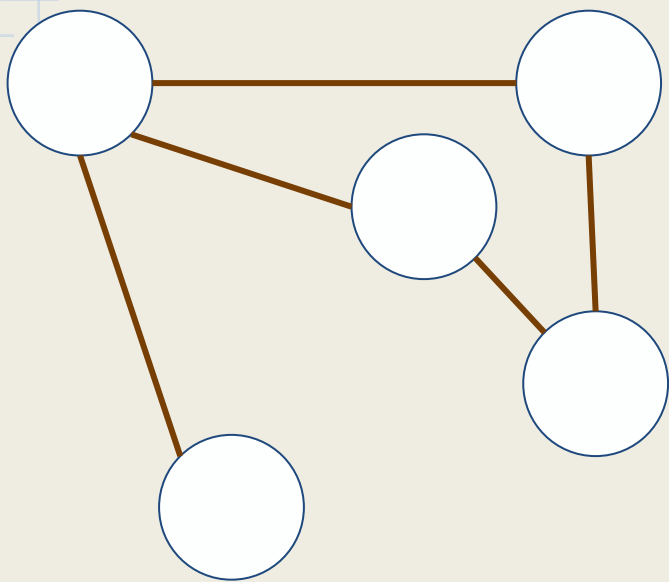
Undirected

Node



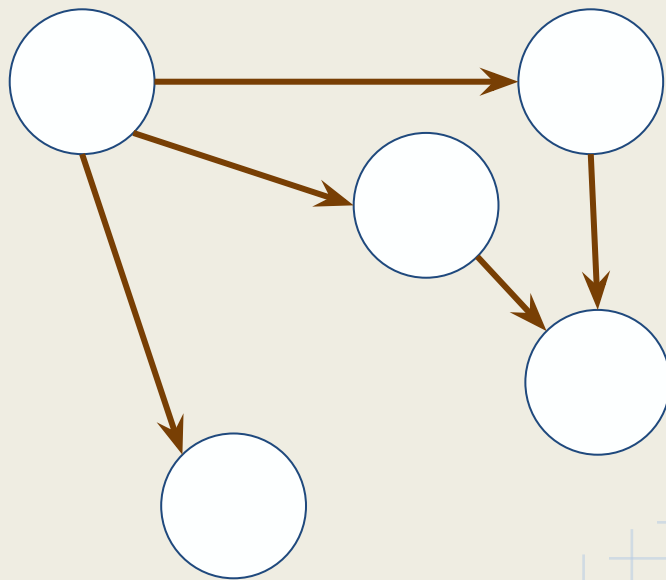
Directed

Graphs



Undirected

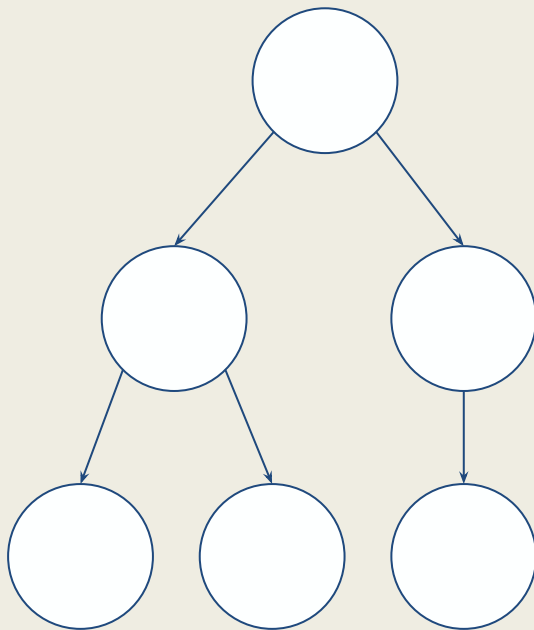
Edge
(arc)



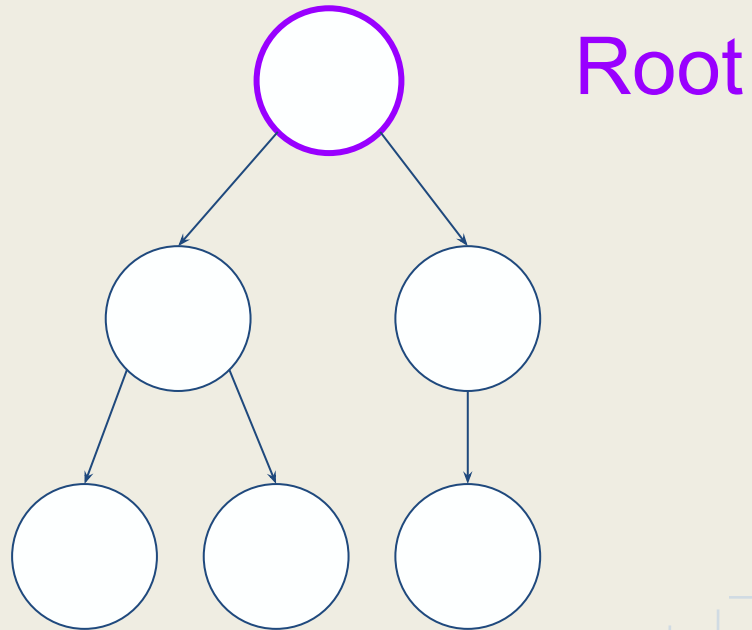
Directed

Trees

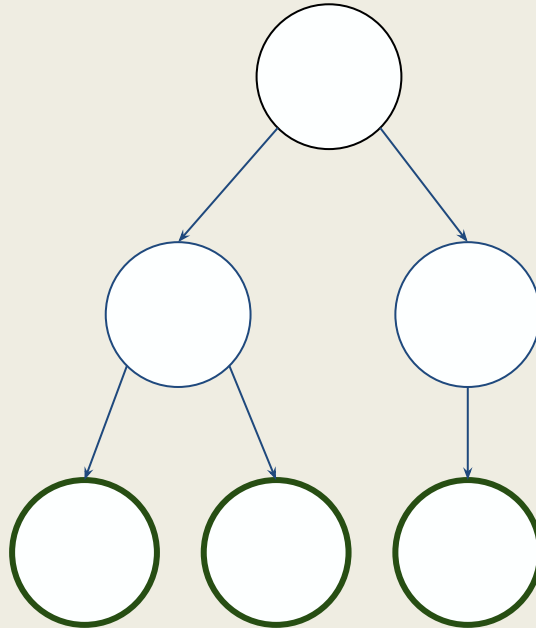
At most one incoming edge per node



Trees

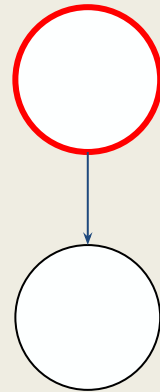


Trees



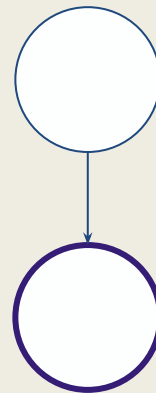
Leaf

Trees



Parent (head)

Trees



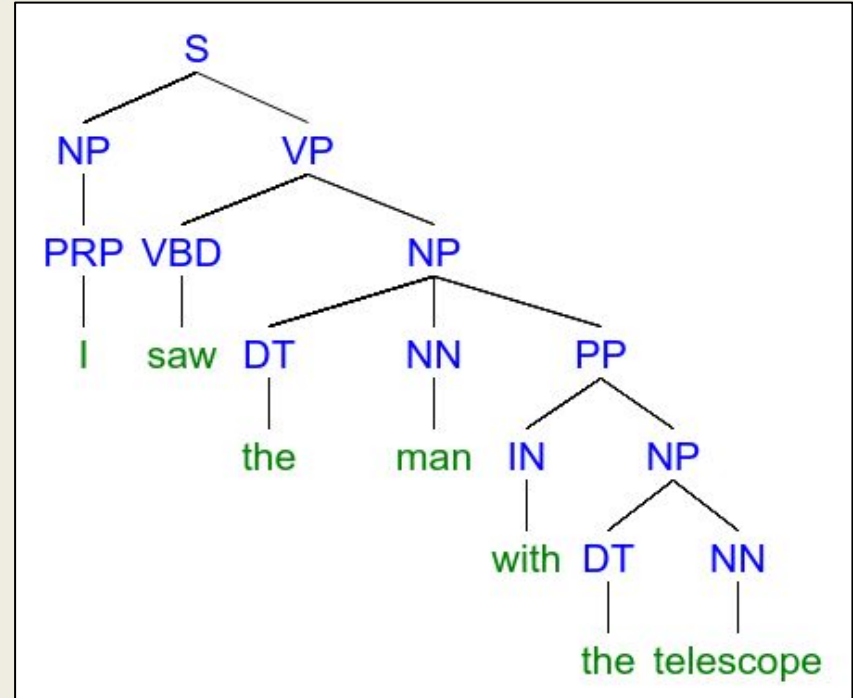
Child (dependent)

Phrase structure trees

Syntactic theory
based on phrases.

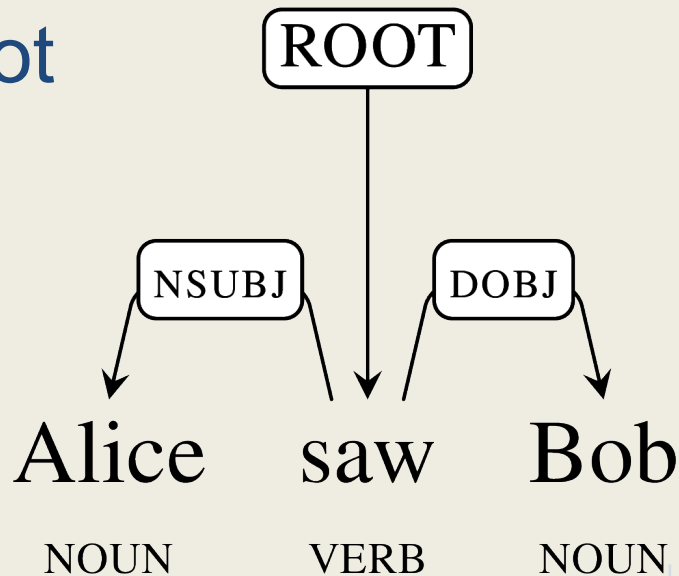
Nodes have labels.

Tokens are leaves.



Dependency parsing

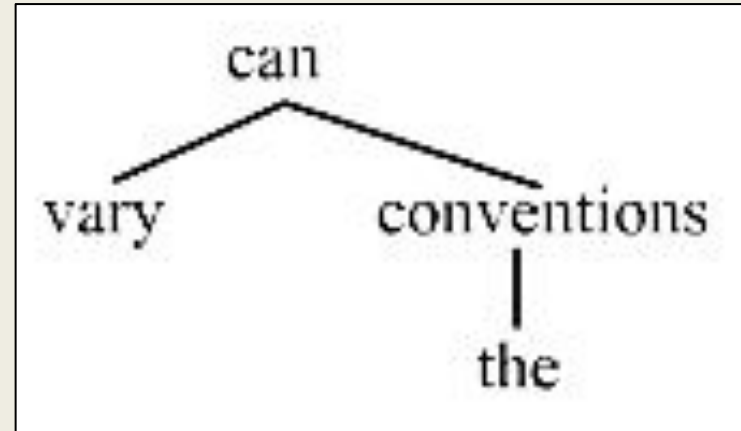
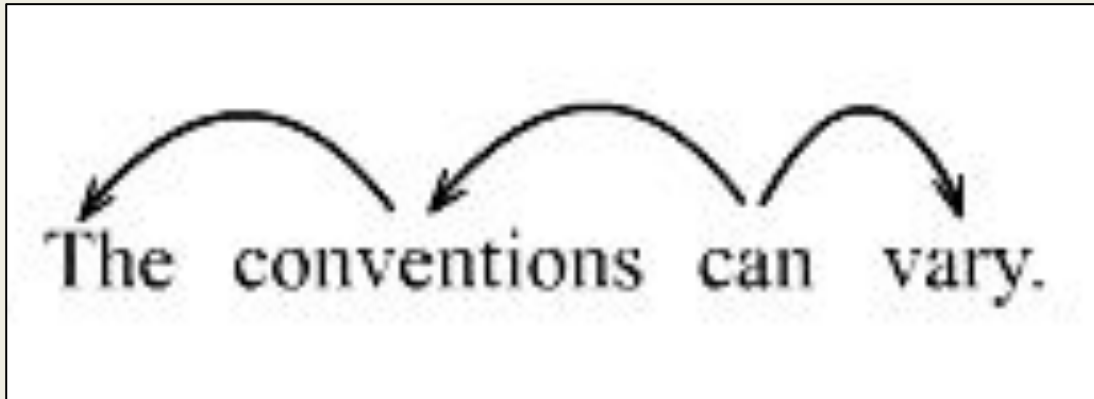
Also syntax, but based on dependencies, not phrases.



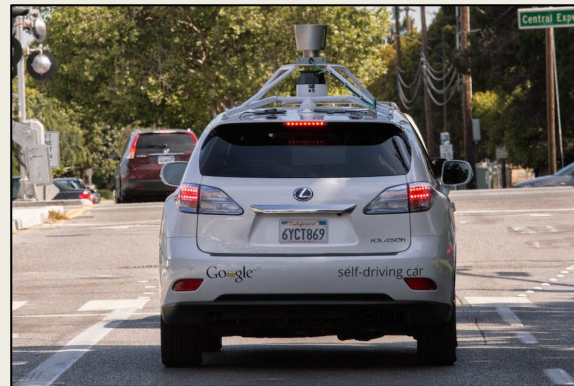
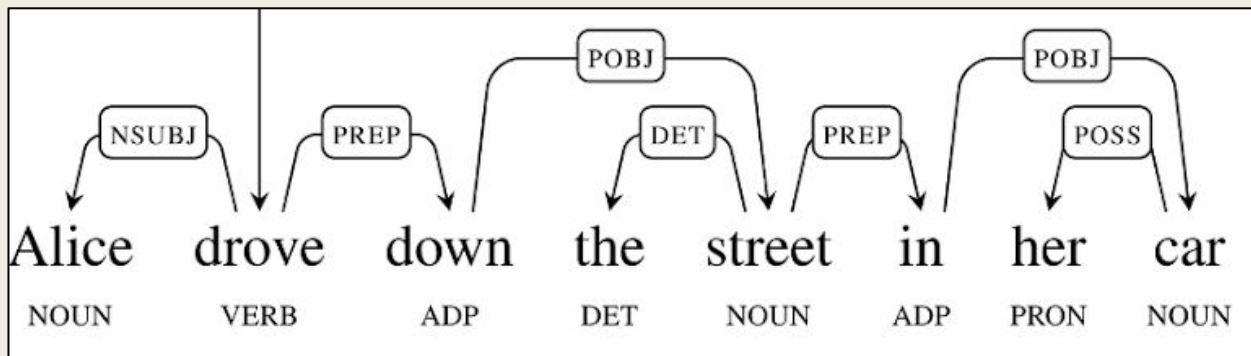
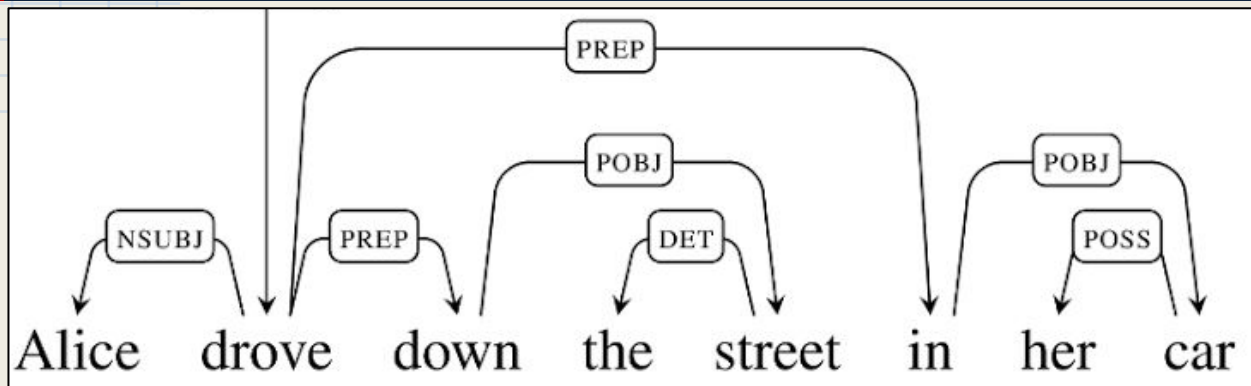
Dependency parsing

Also a tree, but **edges** are labeled

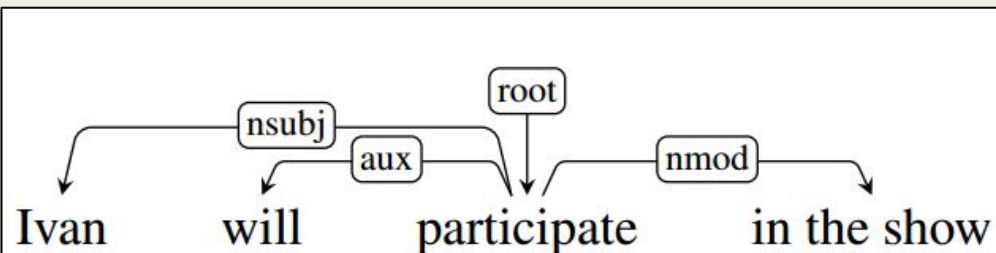
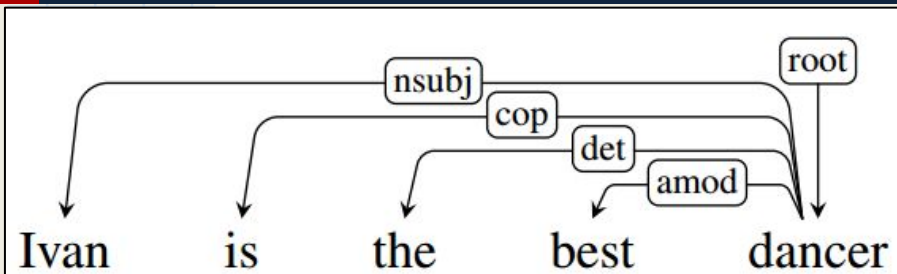
Tokens are all the nodes (not just leaves)



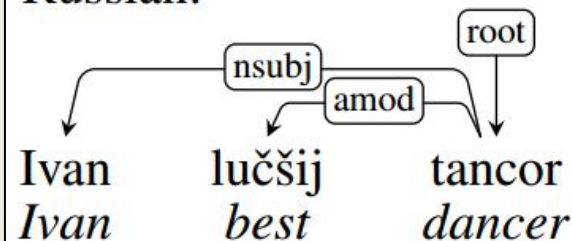
Syntactic ambiguity



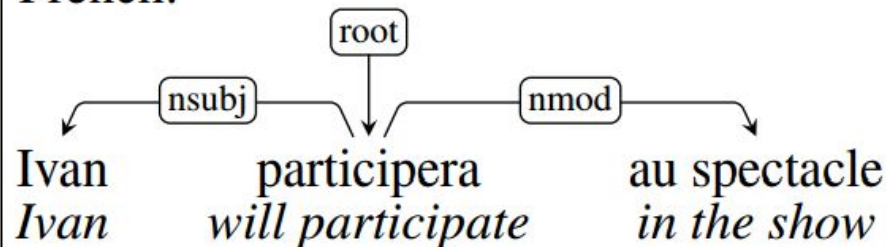
Universal dependencies



































Russian:
























French:



Many
languages
parsed
manually.

	Ancient Greek	182K
	Ancient Greek-PROIEL	198K
	Arabic	217K
	Arabic-NYUAD	629K
	Basque	97K
	Belarusian	6K
	Bulgarian	140K
	Catalan	472K
	Chinese	111K
	Coptic	3K
	Croatian	183K
	Czech	1,330K
	Czech-CAC	482K
	Czech-CLTT	26K
	Danish	94K
	Dutch	197K
	Dutch-LassySmall	93K
	English	229K
	English-ESL	88K
	English-LinES	67K
	English-ParTUT	38K
	Estonian	34K
	Finnish	181K
	Finnish-FTB	143K
	French	381K
	French-ParTUT	17K
	French-Sequoia	58K
	Galician	109K
	Galician-TreeGal	14K
	German	277K
	Gothic	45K
	Greek	51K

	Hebrew	106K
	Hindi	316K
	Hungarian	37K
	Indonesian	110K
	Irish	13K
	Italian	195K
	Italian-ParTUT	39K
	Japanese	173K
	Japanese-KTC	189K
	Kazakh	<1K
	Korean	63K
	Korean-Sejong	89K
	Latin	18K
	Latin-ITTB	280K
	Latin-PROIEL	159K
	Latvian	44K
	Lithuanian	40K
	Norwegian-Bokmaal	280K
	Norwegian-Nynorsk	276K
	Old Church Slavonic	47K
	Persian	135K
	Polish	72K
	Portuguese	201K
	Portuguese-BR	268K
	Romanian	202K
	Russian	87K
	Russian-SynTagRus	988K
	Sanskrit	1K
	Slovak	93K
	Slovenian	126K
	Slovenian-SST	19K

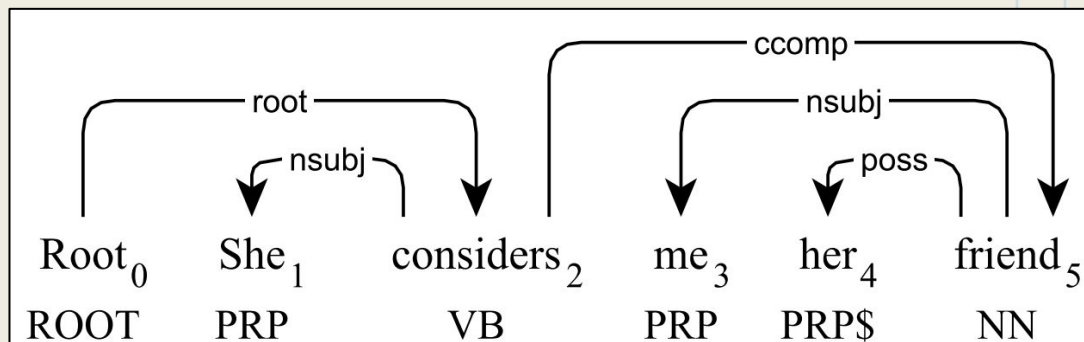
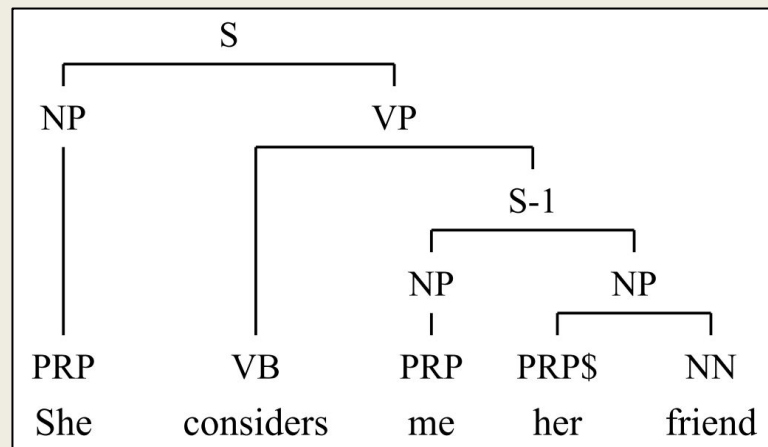
	Spanish	411K
	Spanish-AnCora	495K
	Swedish	76K
	Swedish-LinES	64K
	Swedish Sign Language	<1K
	Tamil	8K
	Turkish	46K
	Ukrainian	12K
	Urdu	123K
	Uyghur	1K
	Vietnamese	31K

Resources: Treebanks

- Many text corpora parsed by humans
- Used for training automatic parsers

Treebank conversion

Trees can be automatically converted to save manual work



Dependency Parsing algorithm

Input: sentence (list of tokens)

Output: dependency tree

or simply, for each word, what is its head
and arc label

Dependency Parsing algorithm

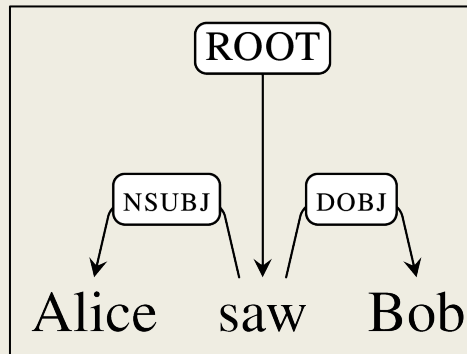
[alice, saw, bob] →

[(2, NSUBJ), (0, ROOT), (2, DOBJ)]

alice

saw

bob



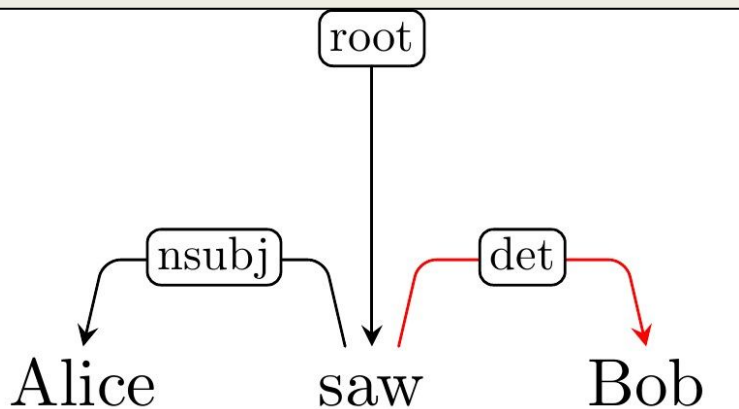
Use the index for each token.

The root node is denoted by 0.

Evaluation

We have a corpus to **train** the algorithm,

And another labeled corpus to **test** it.



What if it returned an incorrect tree?

Evaluation

Labeled Attachment Score (LAS):

% of words with correct head and label

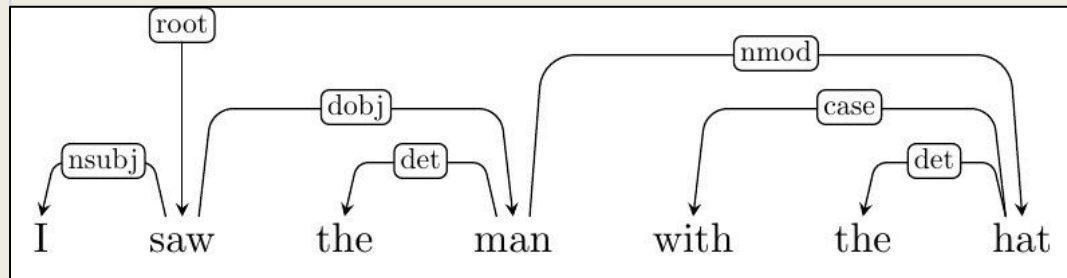
Unlabeled Attachment Score (UAS):

% of words with correct head

Always $0 \leq \text{LAS} \leq \text{UAS} \leq 100\%$

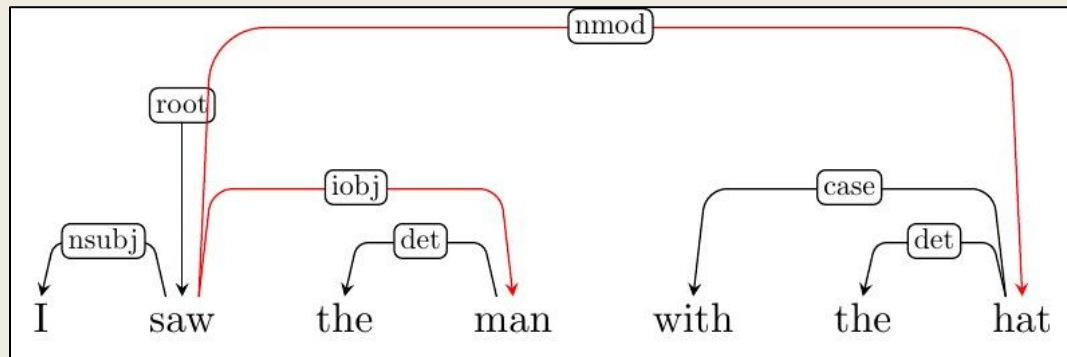
Evaluation example

Correct tree:



$$\text{LAS} = 5/7 \approx 71\%$$

Evaluated tree:



$$\text{UAS} = 6/7 \approx 86\%$$

"hat" has an incorrect head
"man" has a correct head but incorrect label

Parser scores (English)

Parser	UAS (%)	LAS (%)
MaltParser	90.93	88.95
MSTParser	92.17	89.86
ZPar	92.93	91.28
TurboParser	93.80	92.00
Parsey McParseface	94.41	92.55

Transition-based parsing

Incremental parsing algorithms:

Build the tree one arc at a time.

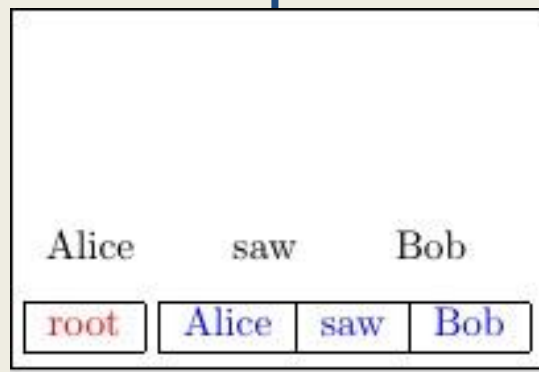
Apply **transitions** until the full tree is built.

Transition-based parsing

Using two lists: **stack** and **buffer**.

The stack keeps nodes being processed.

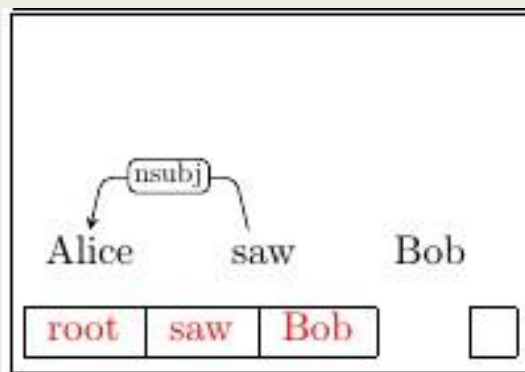
The input tokens are taken from the buffer.



Stack

Buffer

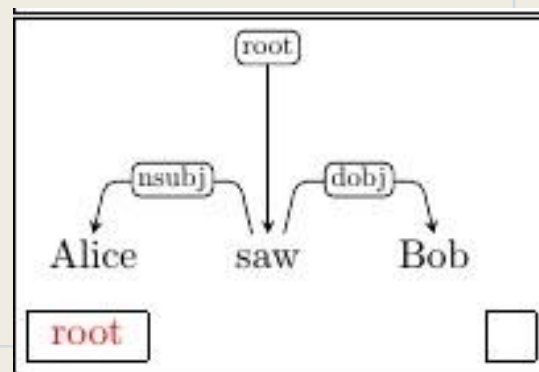
...



Stack

Buffer

...



Stack

Buffer

Transition-based parsing

Possible transitions at each time step:

(Move node from buffer to stack)

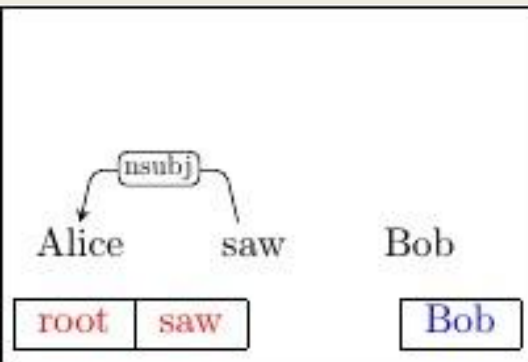
SHIFT

(Create left/right arc between two rightmost stack nodes, and delete child)

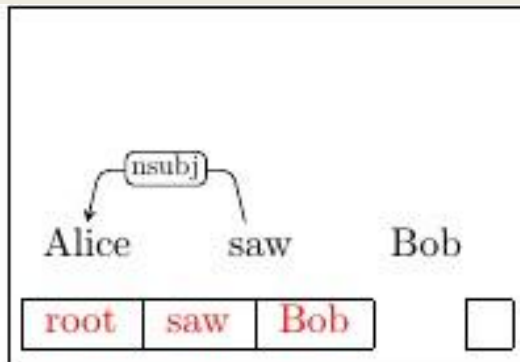
LEFT-ARC

RIGHT-ARC

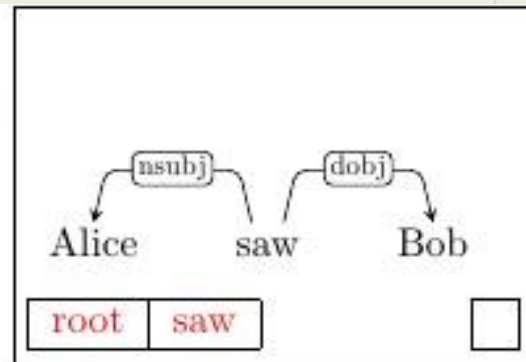
Need to say the label to create (e.g. dobj)



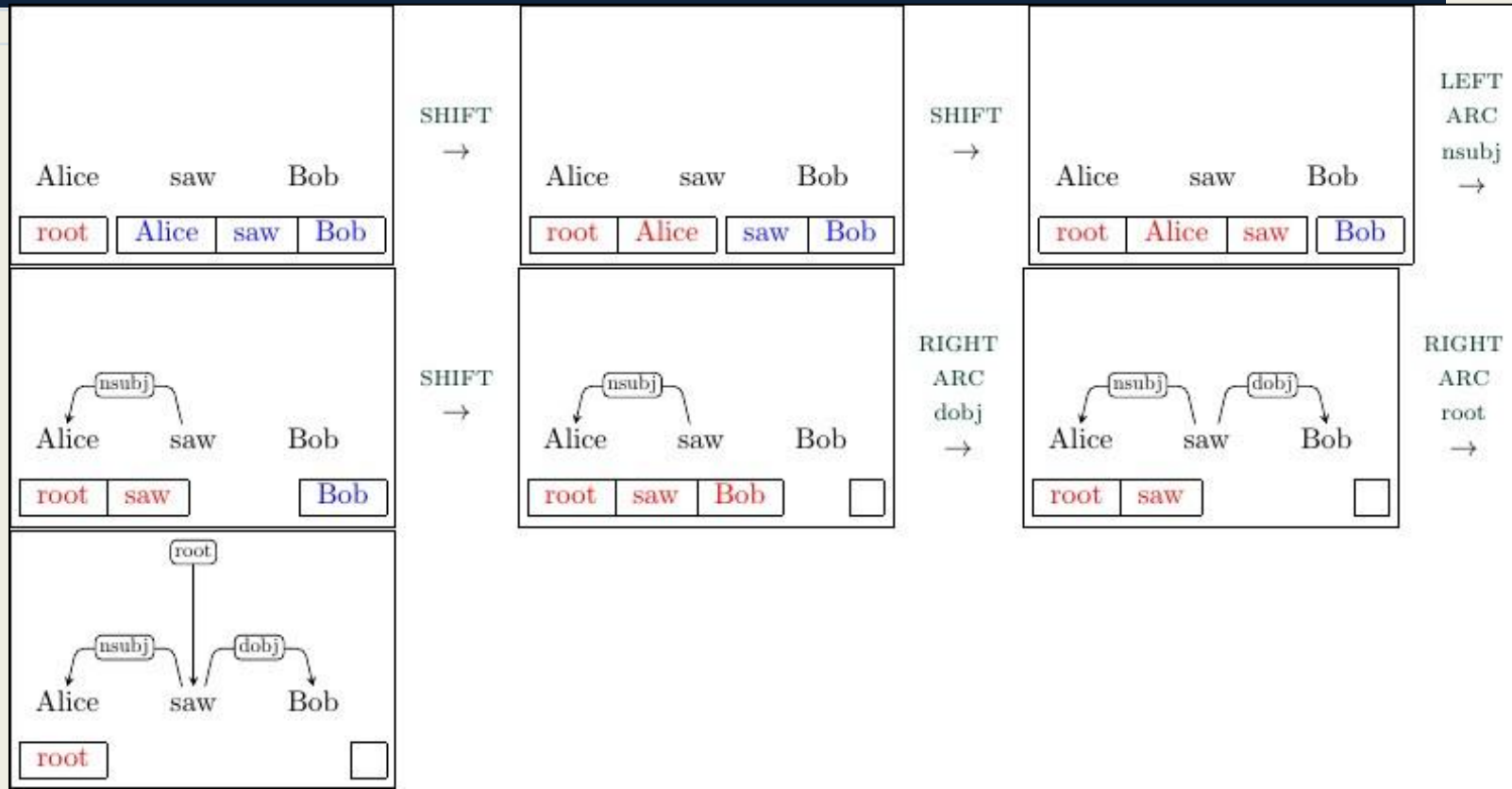
SHIFT
→



RIGHT
ARC
dobj
→

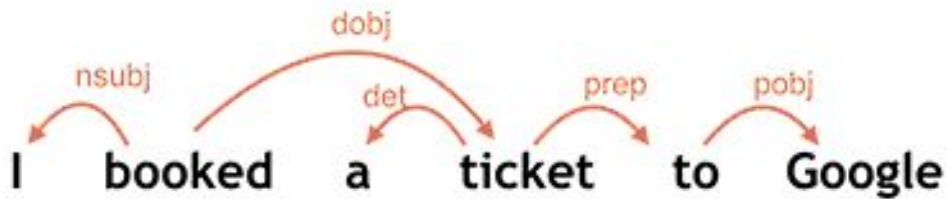


Transition-based parsing



Transition-based parsing

Dependency Parsing



Transition-based parsing

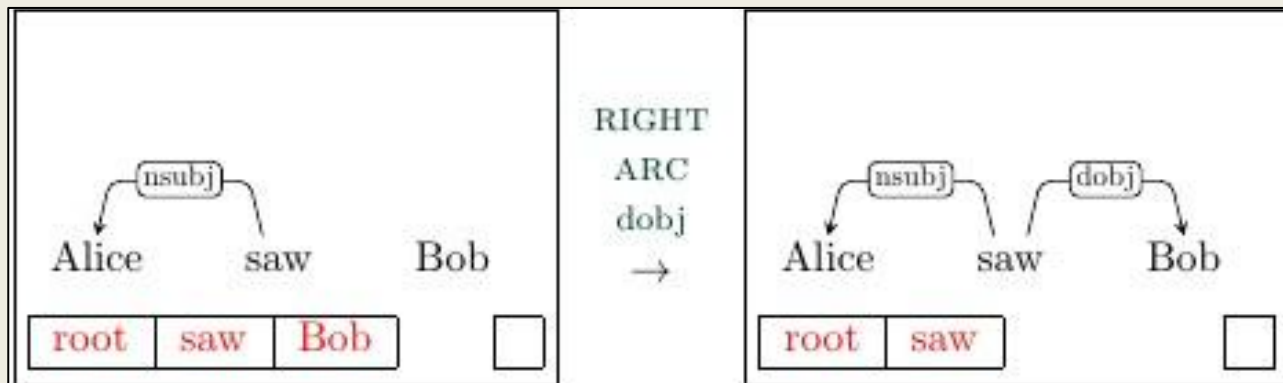
Where is the learning in the algorithm?

When we have a labeled tree, we know which transitions we need to get to it.

The parser learns how to make these decisions so it can parse new sentences correctly.

Transition-based parsing

If we see the state on the left here, we need to know to apply **RIGHT-ARC_{dobj}**



Machine learning

Learning: getting better in a task based on experience.

Examples we have seen in this course:

Language modeling, I WISH I =

Part-of-speech tagging

WISH I COULD	20
WISH I HAD	10

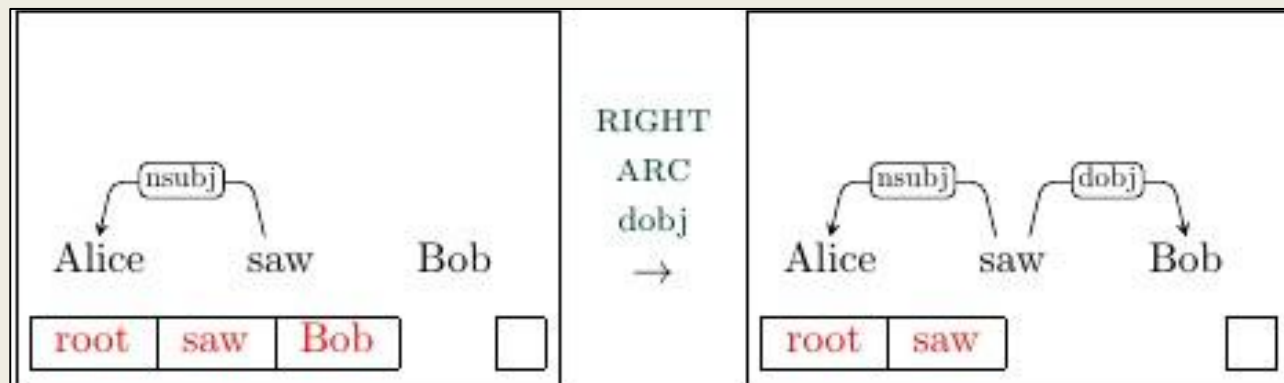
SLEEP WELL
NN RB

THE	DT	1527
WELL	RB	37

NN	NN	312
NN	IN	690

Machine learning

Count-based learning would not work well for transition-based parsing



Machine learning

Learning algorithms used for parsing:

- Perceptron
- Neural networks
- ...

