Computational Linguistics II: Parsing

Introduction to Parsing

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Warm-Up

Ambiguity in Grammar

Def. **ambiguity**:
A sentence can be assigned more than one syntactic tree.

Two types of ambiguity:

- Spurious ambiguity
  - All trees describe the same semantics
  - e.g. 2+5+4 $\Rightarrow$ (2+5)+4 or 2+(5+4)
- Essential ambiguity
  - At least two trees differ in semantics
  - e.g. 2-5-4 $\Rightarrow$ (2-5)-4 or 2-(5-4)

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Ambiguity in Grammar

Does the following sentence have 1 or 2 semantic interpretations?

```
da bin ich auf einer Konferenz in Berlin
```

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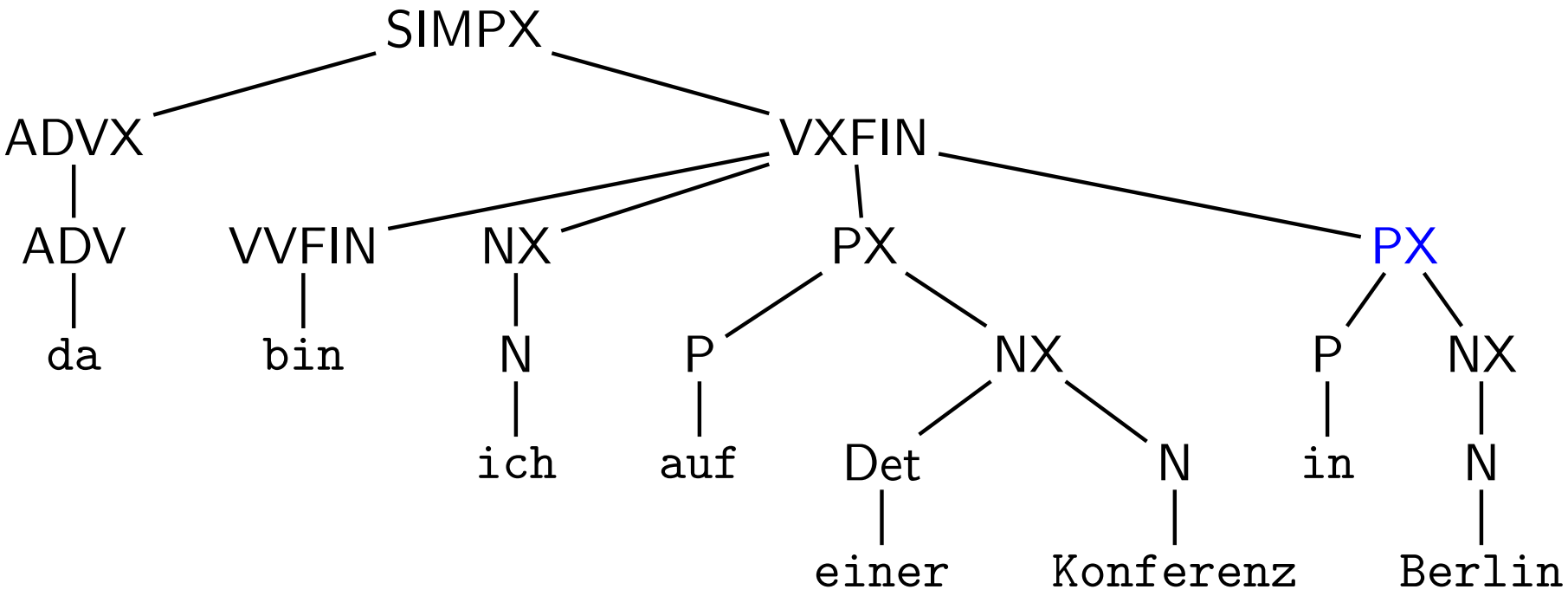

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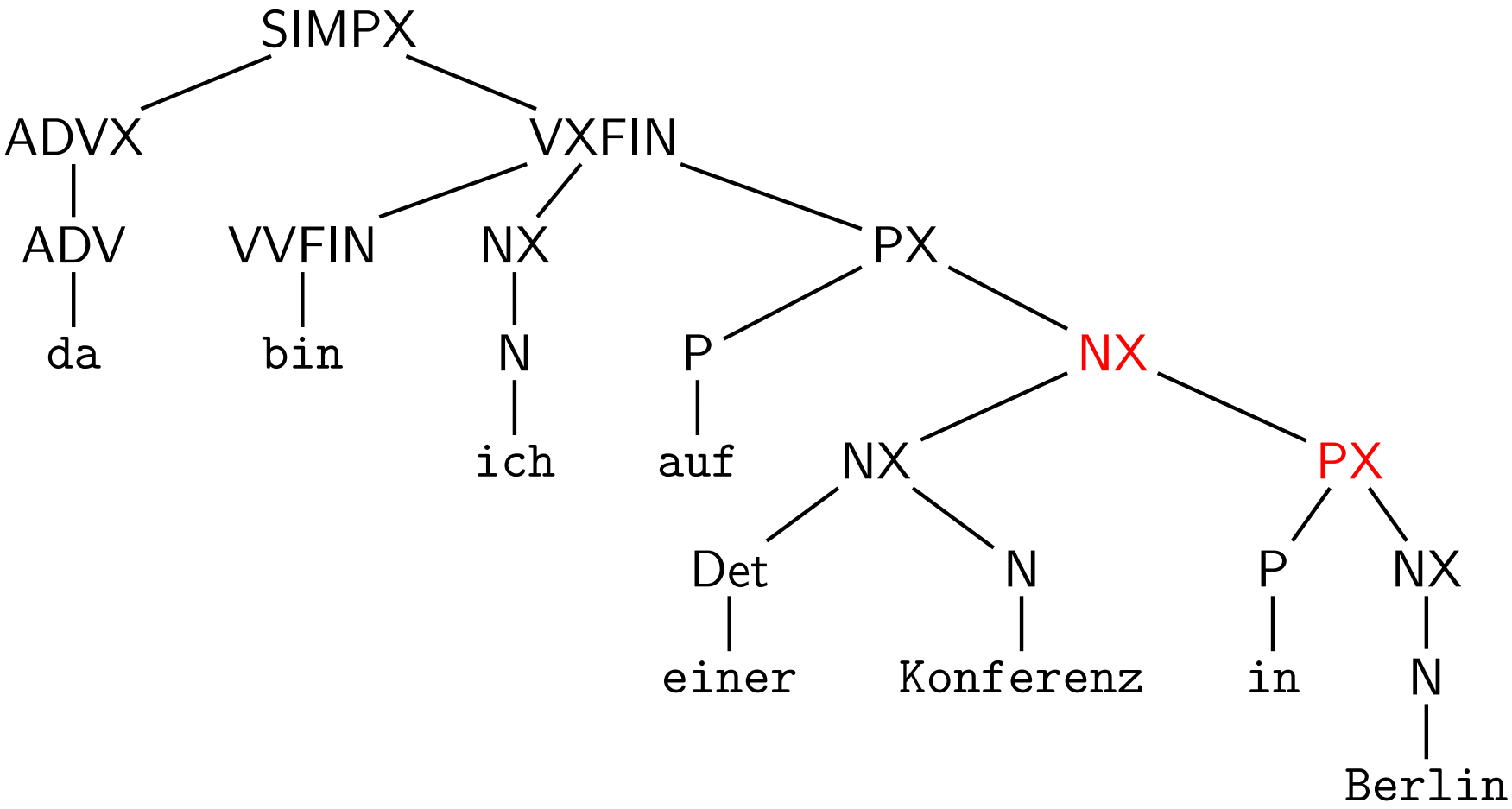

Linearization of parse trees

The only information necessary for reconstructing a tree is the sequence of rules and the notation:

- Prefix notation (i.e. leftmost derivation): each node is listed by listing its number followed by prefix listings of its daughters.
- Postfix notation (i.e. rightmost derivation): each node is listed by listing all daughters in postfix notation followed by node's number.
- infix notation (i.e. left-corner derivation): each node is surrounded by lists of its left and right daughters. The number of daughters which belong to the left list is determined in advance.

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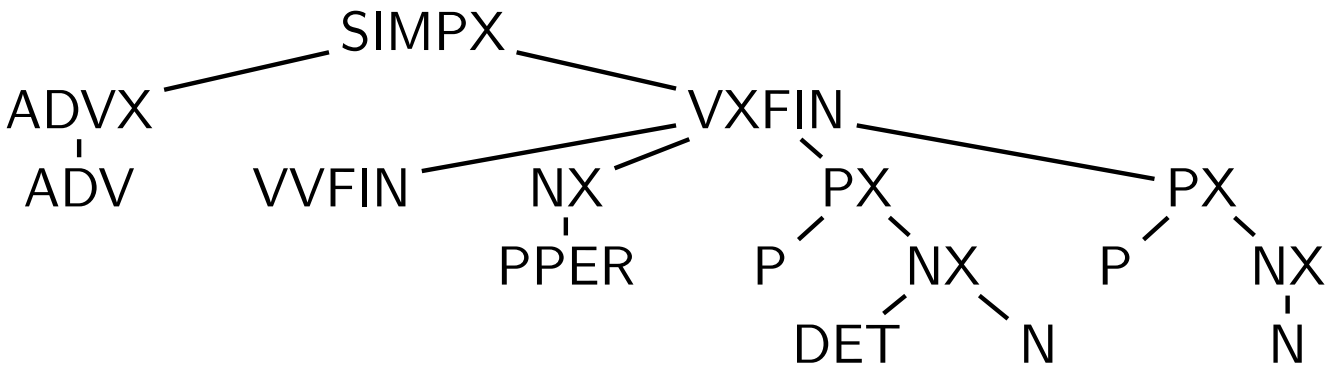
An Example

1: SIMPX → ADVX VXFIN
2: ADVX → ADV
3: VXFIN → VVFIN NX PX PX
4: NX → DET N
5: NX → N | PPER
6: PX → P NX



Classification of Parsing Algorithms

Direction of Processing the Input

- Unidirectional
  - left – right
  - right – left
- Bidirectional

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Rule Invocation Strategy

- Unidirectional
  - Top-down
    - starts from start symbol, expands non-terminals
    - describes "production" side
  - Bottom-up
    - starts from the terminals, replaces righthand side of rules by mothernodes
    - describes "recognition / perception" side
- Bidirectional

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Top-Down Parsing

- start state: start symbol
- internal administration: stores sentential form
  e.g. `the man with the green hat bought` NP PP
- two actions: *predict* and *match*
- predict: select a non-terminal symbol in sentential form and replace it by a righthand side of a rule
  e.g. `the man with the green hat bought` NP PP $\Rightarrow$ `the man with the green hat bought` DET N PP
- match: compare a terminal symbol with the next word in the input string
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Bottom-Up Parsing

- start state: input string
- internal administration: stores sentential form already processed
  e.g. admin: NP P DET N input: `bought a book`
- two actions: *shift* and *reduce*
- shift: move the next word from the input string to the internal administration
  e.g. NP P DET N $\Rightarrow$ NP P DET N `bought`
- reduce: replace the (rightmost) sequence of symbols in the internal administration by a lefthand side symbol of a rule
  e.g. NP P NP $\Rightarrow$ NP PP

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Bottom-Up Parsing II

Bottom-up process can be regarded as production with a "reversed" grammar:

ADVX VXFIN	$\rightarrow$	SIMPX
ADV	$\rightarrow$	ADVX
VVFIN NX PX PX	$\rightarrow$	VXFIN
DET N	$\rightarrow$	NX
N | PPER	$\rightarrow$	NX
P NX	$\rightarrow$	PX

- we need a new terminal symbol: SIMPX $\rightarrow$!
- and a new start symbol:
  Start $\rightarrow$ `da habe ich eine Konferenz in Berlin`

Non-Deterministic Automata

- both parsing methods have two components: one makes the substitutions and stores the parse tree, the other decides which rule to use next
- the substituting component can be defined as a **non-deterministic automaton** (NDA)
- it is non-deterministic because in some states, it has more than one possible rule to choose from, e.g. `NX` $\longrightarrow$ `DET N` or `NX` $\longrightarrow$ `PPER`
- the decision which rule is chosen is made by the control component
- control strategies vary and can be very complex
- one more component: book keeping component for the parse tree

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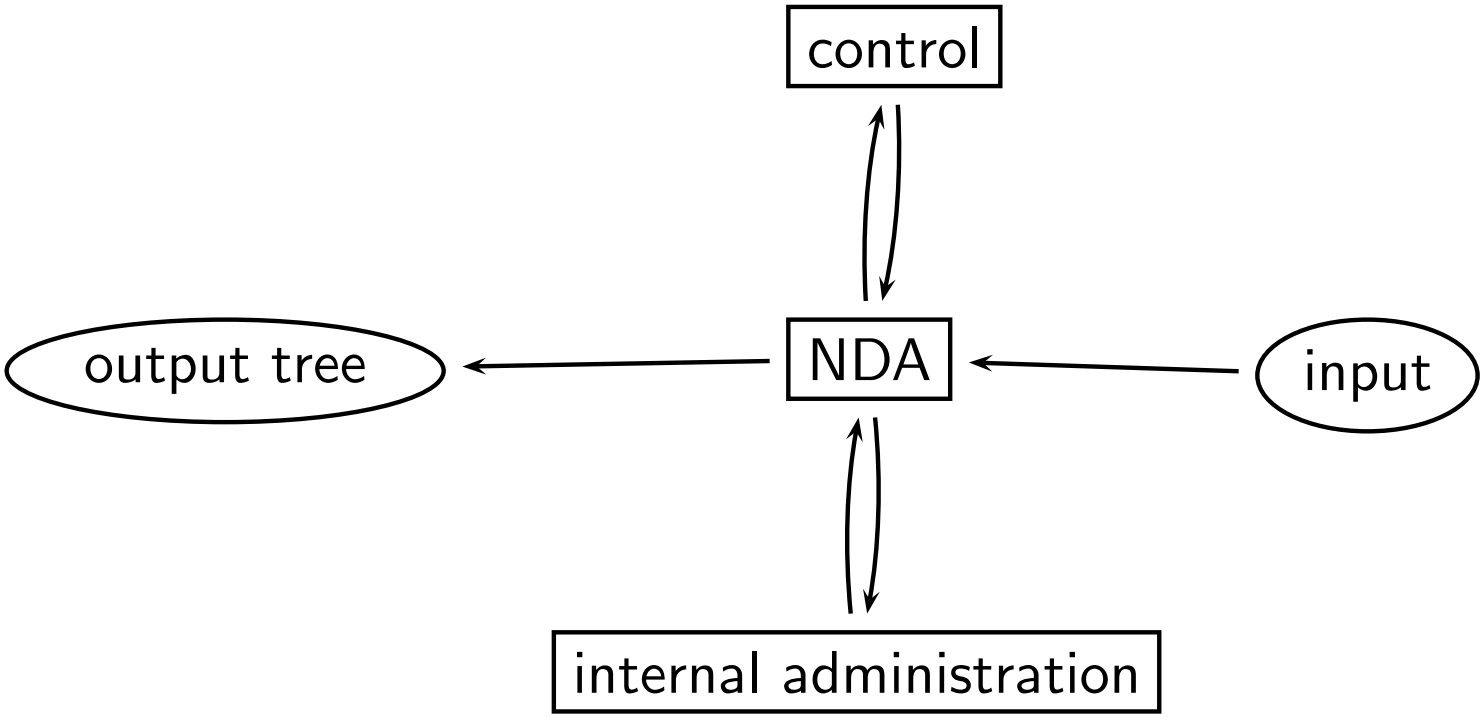

Non-Deterministic Automata III

- the NDA is derived from the grammar
- for top-down parsing, the moves are given by the rules, the administration at the beginning contains the start symbol
- there are many control mechanisms, some are independent of the grammar (e.g. undo the last step), some use tables extracted in advance from the grammar (if I choose `NX` $\longrightarrow$ `NX1 KON NX1` and my next word is *the*, is there a way that `NX1` produces a string that begins with *the*?)
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Searching Strategy

Parsing can be regarded as search: parsing as a graph from start state to end state ⇒ look for the shortest / best path

How does the control mechanism decide on the next move?

- depth-first (backtracking) or breadth-first?
- Deterministic or non-deterministic
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Parsers and Parser Generators

	Parser abstract machine 1st order	**Parser Generator** abstract machine 2nd order
Data	syntax lexicon	parsing algorithm
Processing	parsing algorithm	generating algorithm
Input	sentence	syntax lexicon
Output	structure or FALSE	parser

Putting all together

	Top-down	Bottom-up
Non-directional methods	Unger parser	CYK parser
Directional methods	predict/match Depth-first (backtrack) Breadth-first, DCGs	shift/reduce Depth-first (backtrack) Breadth-first (Earley)
	Left-corner	
Linear directional methods		LR(k) SLR(1)
Efficient general directional methods		Tomita