Grundlegende Parsingalgorithmen

Tomita-Parser

Kurt Eberle

k.eberle@lingenio.de

(Viele Folien, Teile von Folien, Materialien von **Helmut Schmid**'s Parsing-Kurs WS14 Tübingen, u.a.)

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Überblick

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Tomita Parser

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- Graph-structured stack:
  - Directed, acyclic graph with a single source node
  - Nodes correspond to parser configurations.
  - The end nodes are the active configurations.

Eine ambige Grammatik

PP Attachment? S oder NP

```
-------------------------
  (1)   S --> NP VP
  (2)   S --> S PP
  (3)  NP --> *n
  (4)  NP --> *det *n
  (5)  NP --> NP PP
  (6)  PP --> *prep NP
  (7)  VP --> *v NP
-------------------------
```

Figure 2-5: An Example Ambiguous Grammar

Tabelle der Grammatik

PP Attachment? Shift oder Reduce

Figure 2-5: An Example Ambiguous Grammar

State	*det	*n	*v	*prep	$	NP	PP	VP	S
0	sh3	sh4				2			1
1				sh6	acc		5		
2			sh7	sh6			9	8	
3		sh10							
4			re3	re3	re3				
5				re2	re2				
6	sh3	sh4				11			
7	sh3	sh4				12			
8				re1	re1				
9			re5	re5	re5				
10			re4	re4	re4				
11			re6	re6,sh6	re6		9		
12				re7,sh6	re7		9		

Figure 2-6: LR Parsing Table with Multiple Entries

Stack als Liste

I saw a man on the bed in the apartment **with** a telescope

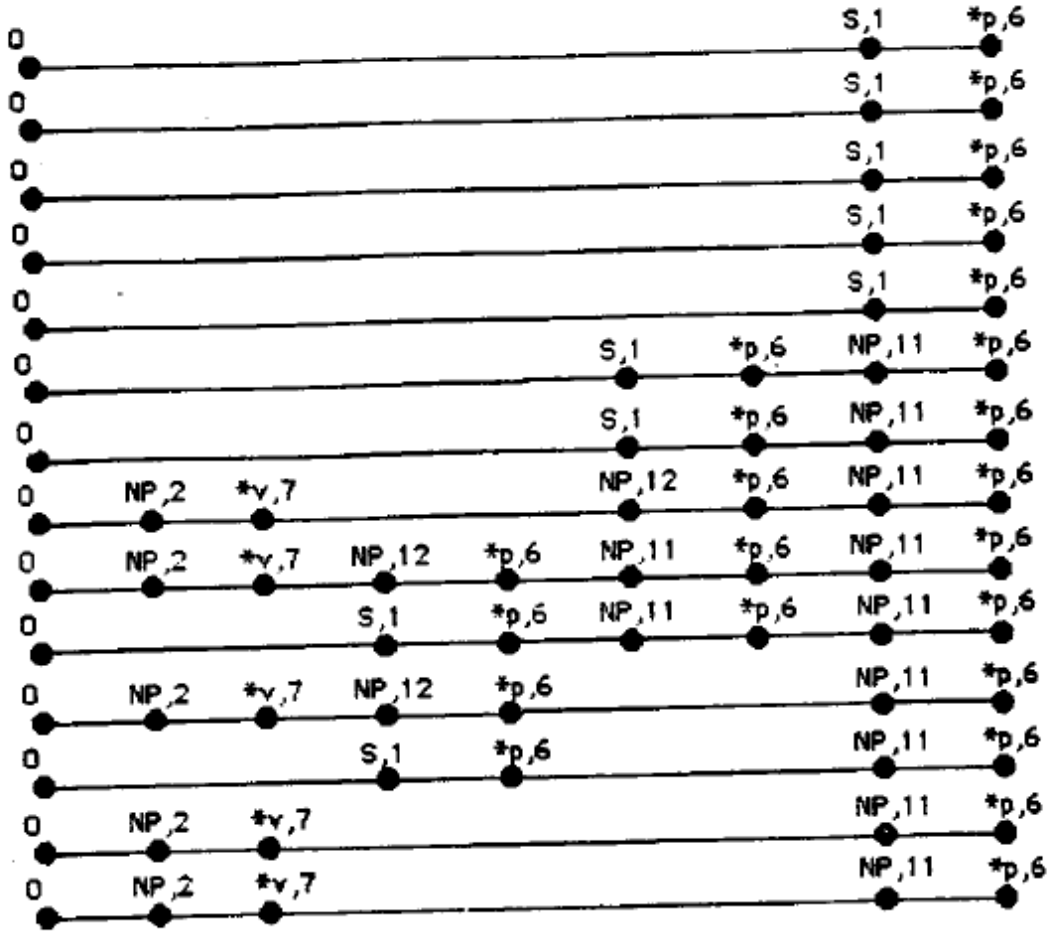

Figure 3-1: Stack List

Stack strukturiert als Baum

I saw a man on the bed in the apartment **with** a telescope

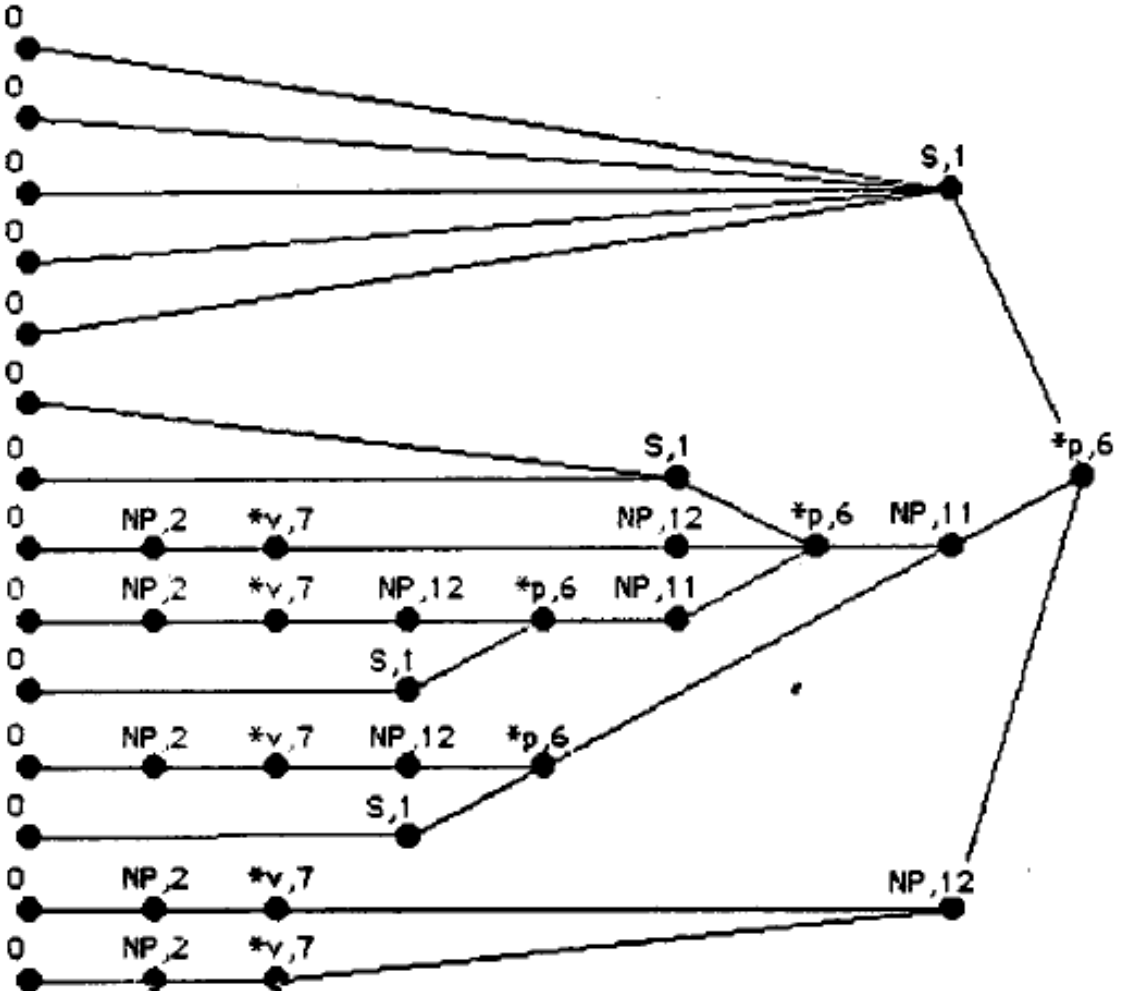

Figure 3-2: A Tree-structured Stack

Stack strukturiert als Graph

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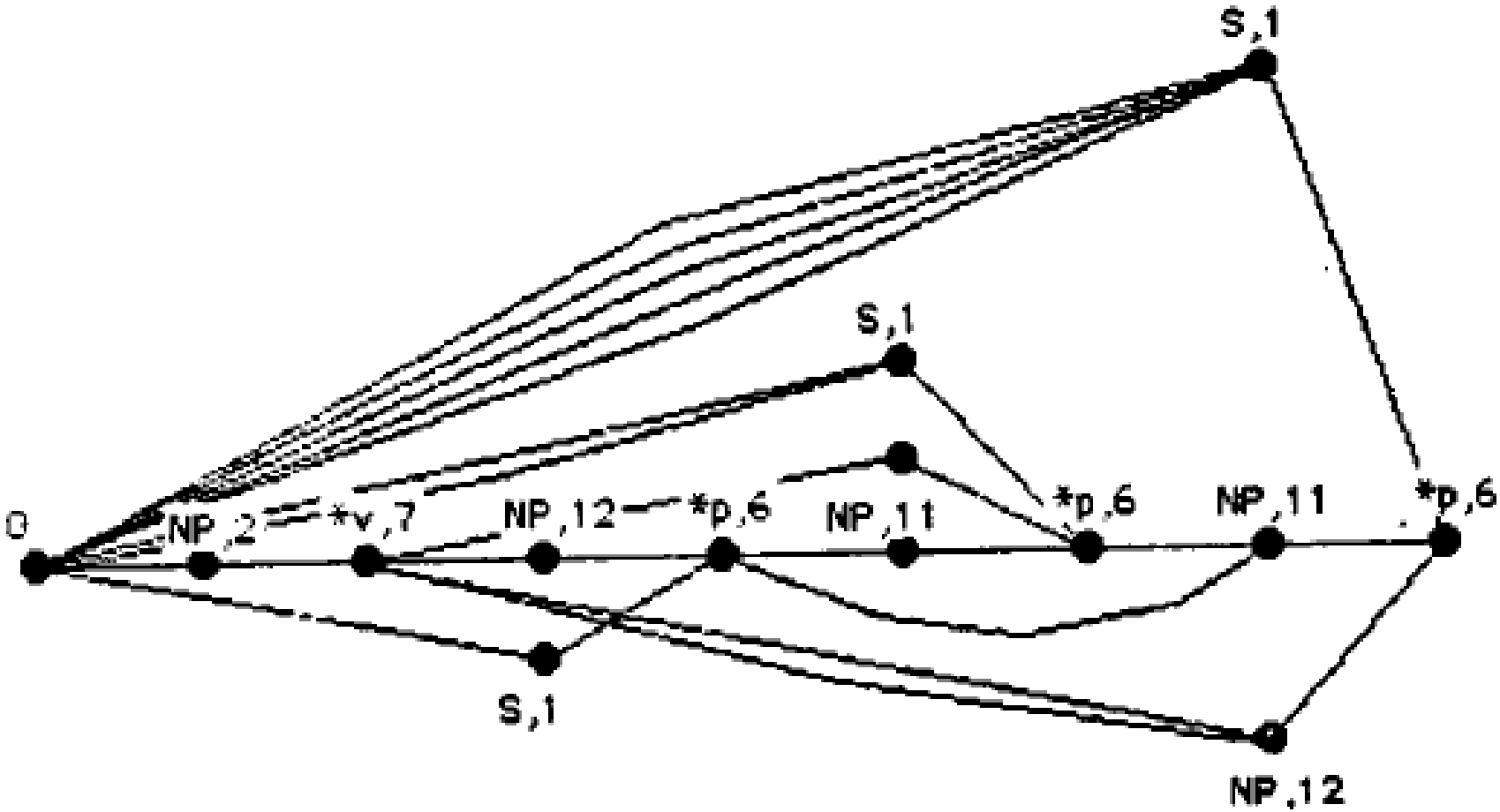


Figure 3-3: A Graph-Structured Stack

Überblick

Tomita Erkenner: Daten-Strukturen

- $\{a, b, c\}$: Set containing the elements a,b and c.
- $[a, b, c]$: List containing the elements a,b and c.
- $\circ$: Concatenation operator for lists
- U_i: Set of top-most stack nodes after i input symbols have been processed
- $\langle i, s, l \rangle$: a node of the graph-structured stack
- $\langle 0, s_0, \{\} \rangle$: Root of the stack
- $\mathit{Actions}(s, x)$: Set of actions in state s with look-ahead symbol x
- $\mathit{Goto}(s, D)$: New state after the non-terminal D has been consumed in state s

Überblick

Tomita Erkenner

$\underline{Recognizer}(x_1 \ldots x_n)$

$x_{n+1} := \$$ %%Add end symbol to input string
$U_0 := [\langle 0, S_0, \{\}\rangle]$ %%initial stack element with start configuration
For $i := 1$ to $n+1$
  $U_i := [\,]$ %%position-i stack elements
  $P := [\,]$ %%nodes already considered
  For all $v = \langle i-1, s, l\rangle$ such that $v \in U_{i-1}$ from left to right
    $P := P \circ [v]$
    For all $a \in Actions(s, x_i)$
      If $a =$ *shift* s' then
        $\underline{Shift}(v, s', i)$
      else if $a =$ *reduce* p then
        $\underline{Reduce}(v, p, i)$
      else if $a =$ *accept* then
        accept
  If $U_i = [\,]$ then
    Report error
Accept

Überblick

Tomita-Erkenner: Shift

$\underline{Shift}(v, s, i)$

If $\exists v' = \langle i, s, l \rangle$ such that $v' \in U_i$ then

$l := l \cup \{v\}$

else

$U_i := U_i \circ [\langle i, s, \{v\} \rangle]$

Tomita-Erkenner: Predecessor

$\underline{Predecessor}(v = \langle j, s, l \rangle, k)$

If $k = 0$ then
  return {v}
else
  return $\cup_{v' \in l} predecessor(v', k - 1)$

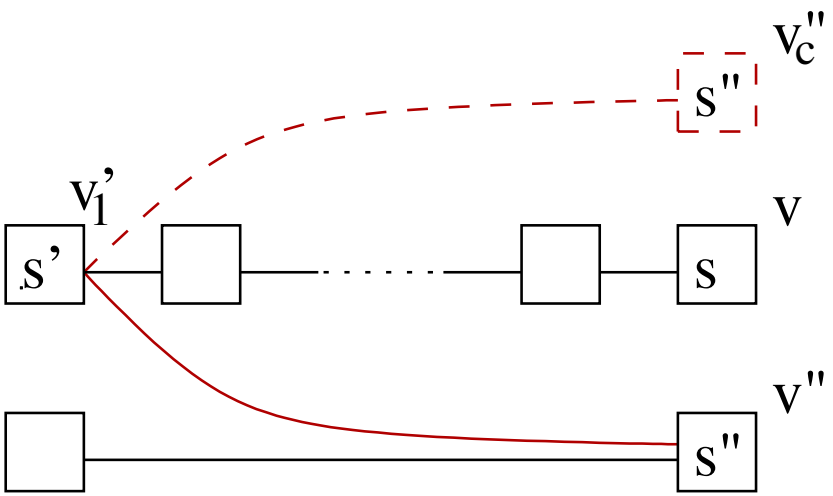
Tomita-Erkenner: Reduce

$\underline{Reduce}(v, p, i)$

For all $v_1' = \langle j', s', l_1' \rangle$ such that $v_1' \in \underline{Predecessor}(v, |p|)$
$s'' := Goto(s', D_p)$
If $\exists v'' = \langle i-1, s'', l'' \rangle$ such that $v'' \in U_{i-1}$
then If $v_1' \in l''$
then do nothing
else if $\exists v_2' = \langle j', s', l_2' \rangle$ such that $v_2' \in l''$
then $v_c'' := \langle i-1, s'', \{v_1'\} \rangle$
For all '*reduce* $p' \in Actions(s'', x_i)$
$Reduce(v_c'', p, i)$
else $l'' := l'' \cup \{v_1'\}$
If $v'' \in P$ then $v_c'' := \langle i-1, s'', \{v_1'\} \rangle$
For all '*reduce* $p' \in Actions(s'', x_i)$
$Reduce(v_c'', p, i)$
else
$U_{i-1} := U_{i-1} \circ [\langle i-1, s'', \{v_1'\} \rangle]$

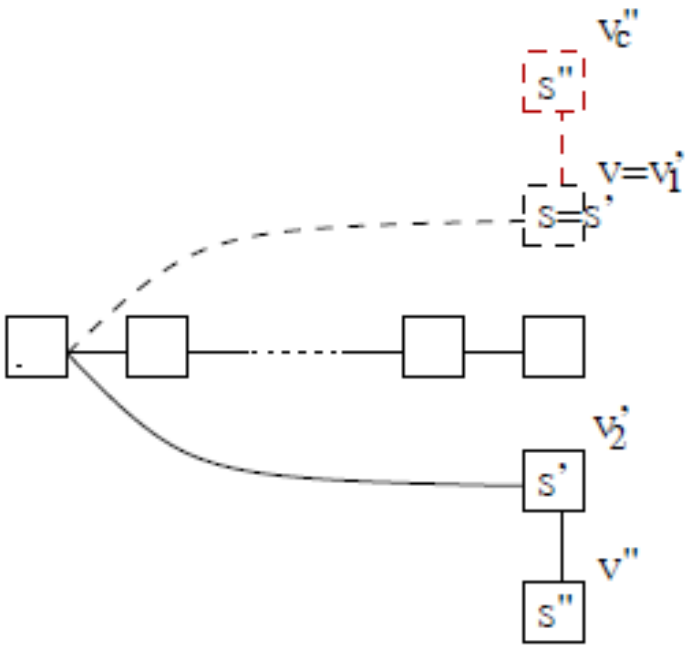
Tomita-Erkenner: Kopien

no s' predecessor yet included, v'' already in P ...



Tomita-Erkenner: Kopien

s' predecessor already included (v'' already in P) ...

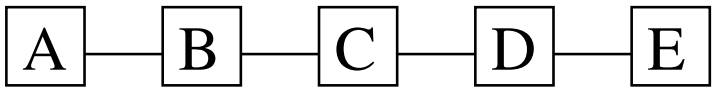


Beispiel: Stacks teilen und zusammenführen

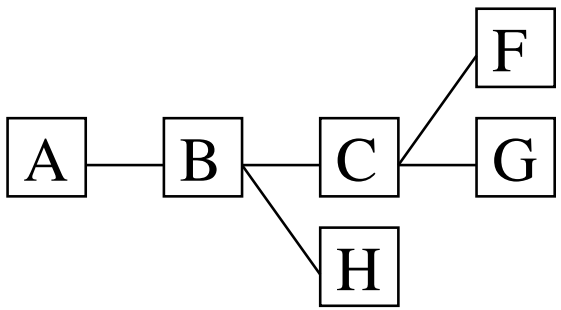
Auszug aus einer Gammatik . . .

$$F \rightarrow D\ E$$
$$G \rightarrow D\ E$$
$$H \rightarrow C\ D\ E$$

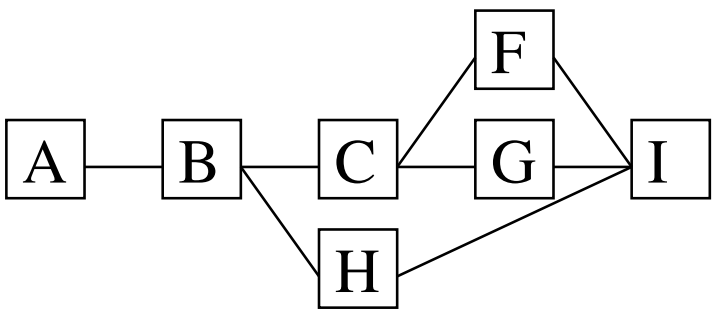
Parsing-Situation. . .



Drei Reduktionen. . .



Shift wird auf alle (offenen) Top-Elemente des Stacks angewendet



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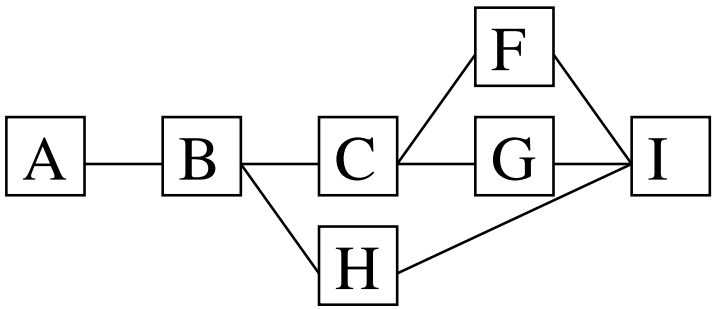
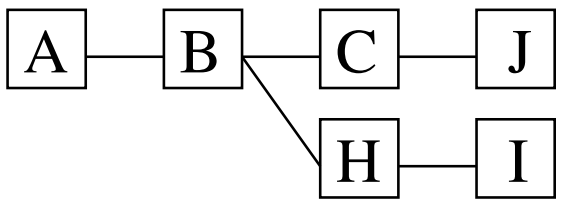


Lokale Ambiguität...

$J \rightarrow F\ I$
$J \rightarrow G\ I$



Beispiel

(Grammatik und Zustände von "ABgram.pdf")

2	a	U2	[⟨2,s3, {v12} ⟩$_{Aa}$, ⟨2,s5, {v13} ⟩$_{Ba}$, ⟨2,s6, {v12} ⟩$_{AB}$, ⟨2,s7, {v13} ⟩$_{BA}$, ⟨2,s8, {v0} ⟩$_{S}$]
1	a	U1	[v11⟨1,s1, {v0} ⟩$_{a}$, v12⟨1,s2, {v0} ⟩$_{A}$, v13⟨1,s4, {v0} ⟩$_{B}$]
0	0	U0	[v0⟨0,so, {} ⟩]

Kontroll-Tabelle Beispiel

Grammar

1: S $\rightarrow$ NP VP
2: VP $\rightarrow$ VP PP
3: VP $\rightarrow$ v NP

4: PP $\rightarrow$ p NP
5: NP $\rightarrow$ NP PP
6: NP $\rightarrow$ d N1

7: NP $\rightarrow$ N1
8: N1 $\rightarrow$ a N1
9: N1 $\rightarrow$ n

Kontroll-Tabelle Beispiel

Table

	d	a	n	p	v	$	N1	NP	PP	VP	S
0	s9	s5	s4				8	2			1
1						acc					
2				s12	s14				3	10	
3				r5	r5	r5					
4				r9	r9	r9					
5		s5	s4				6				
6				r8	r8	r8					
7				r6	r6	r6					
8				r7	r7	r7					
9		s5	s4				7				
10				s12		r1			11		
11				r2		r2					
12	s9	s5	s4				8	13			
13				r4/s12	r4	r4			3		
14	s9	s5	s4				8	15			
15				r3/s12		r3			3		

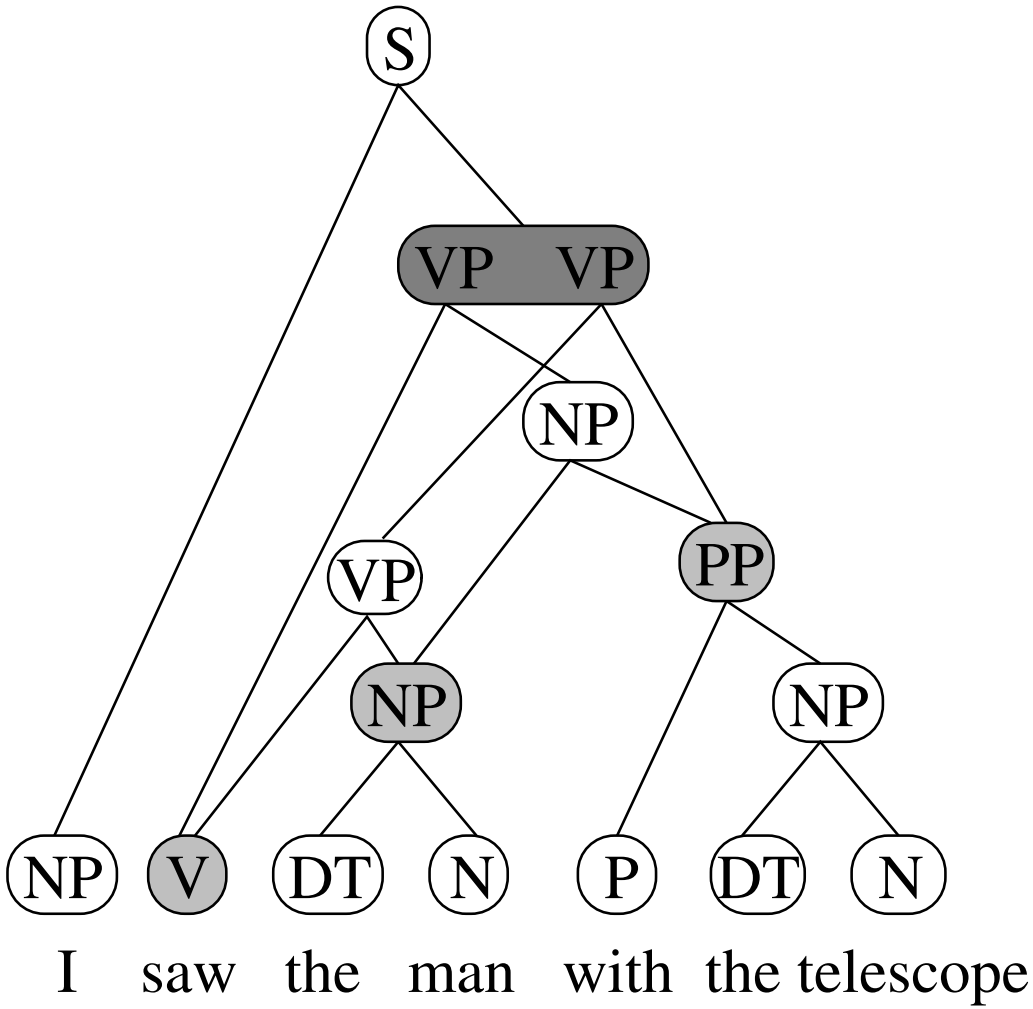
Überblick

Parse-Wald

- Problem: Sätze können exponentiell viele Analysen haben
  $\Rightarrow$ Output der Analysen hat exponentielle Laufzeit
- Lösung: Kompakte Repräsentation in der Form eines *Parse-Waldes*
- Parse-Wald:
  - Gerichteter Graph mit eindeutigem Wurzelknoten
  - Teilbäume werden in verschiedenen Analysen benützt ($\Rightarrow$ Graph)
  - Parse-Bäume die sich nur in einem einzigen Teilbaum (über demselben Teilstring) unterscheiden werden zusammengefasst und die Top-Knoten der Teilbäume werden in einem *gepackten Knoten (packed node)* zusammengeführt.
- Extraktion der individuellen Analysem mit Backtracking

Parse-Wald

with packed nodes and shared nodes



Parse-Wald

with and-nodes and or-nodes (dotted lines)