

Parsers, prioritet och associativitet

TDP019 Projekt: Datorspråk
Föreläsning 3

Översikt

- Grundtanken med top-down-parsning
- Naiva grammatiken för aritmetik
- Omskrivning av regler
- Bottom-up-parsning?
- Unära operatorer och associativitet

Utvecklarblogg | Språkdagbok

- <https://www.ida.liu.se/~TDP019/current/sprakdagbok/index.sv.shtml>

top-down-parsning

- Strategi för att "parsa"
- Har en "hypotes" kontrollerar om strukturen passar
- Kan se på det som att varje regel är ett funktionsanrop

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$$\begin{array}{l} E \rightarrow E + T \\ | \quad E - T \\ | \quad T \end{array}$$

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$$\begin{array}{lll} E \rightarrow E + T & "1+2" & E(1,+ ,2) \\ | & E - T & E(+ (1,2)) \\ | & T & E(+ (E(T(1)), E(T(2))) \end{array}$$

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- Strategi för att "parsa"
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$$\begin{array}{lll} E \rightarrow E + T & "1+2" & E(1,+,2) \\ | & E - T & E(+\!(1,2)) \\ | & T & E(+\!(E(T(1)),E(T(2))) \end{array}$$

- I sin enklaste form utforskar denna typ av parser vänsterledet i sin helhet först

Utforska vänsterledet i sin helhet

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$
 $\langle V \rangle ::= x \mid y \mid z$

y + z



Utforska vänsterledet i sin helhet

```
<E> ::= <E> + <E> | <E> * <E> | <V>  
<V> ::= x | y | z
```

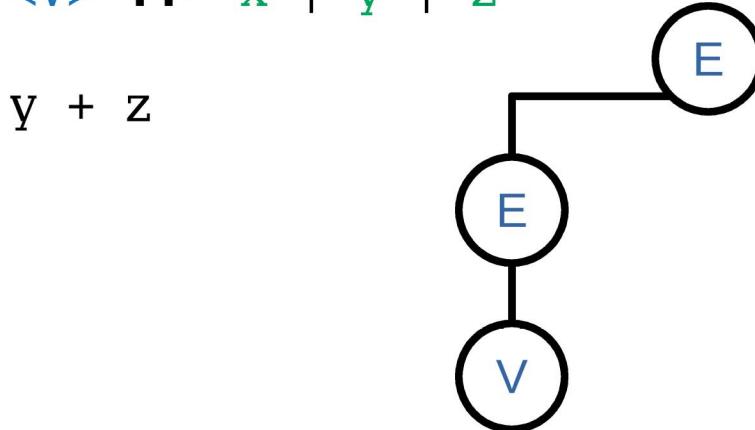


Utforska vänsterledet i sin helhet

13

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$

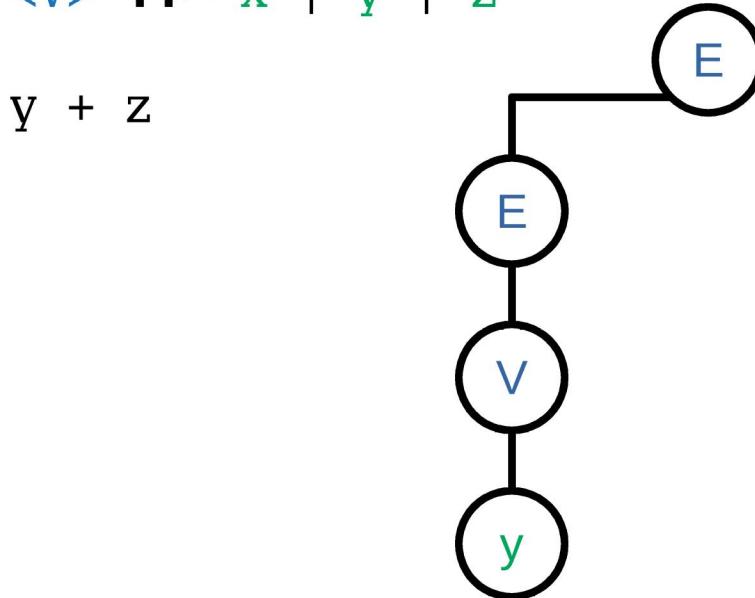
$\langle V \rangle ::= x \mid y \mid z$



Utforska vänsterledet i sin helhet

14

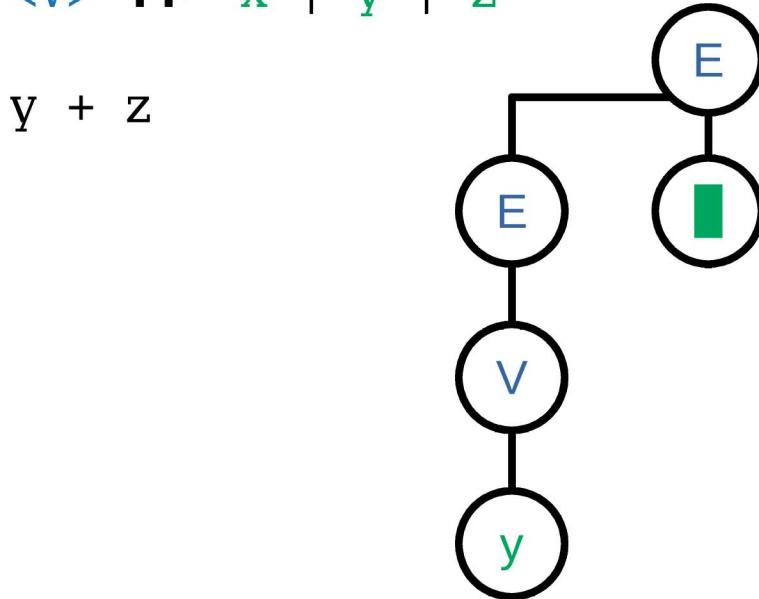
```
<E> ::= <E> + <E> | <E> * <E> | <V>  
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Utforska vänsterledet i sin helhet

15

```
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```

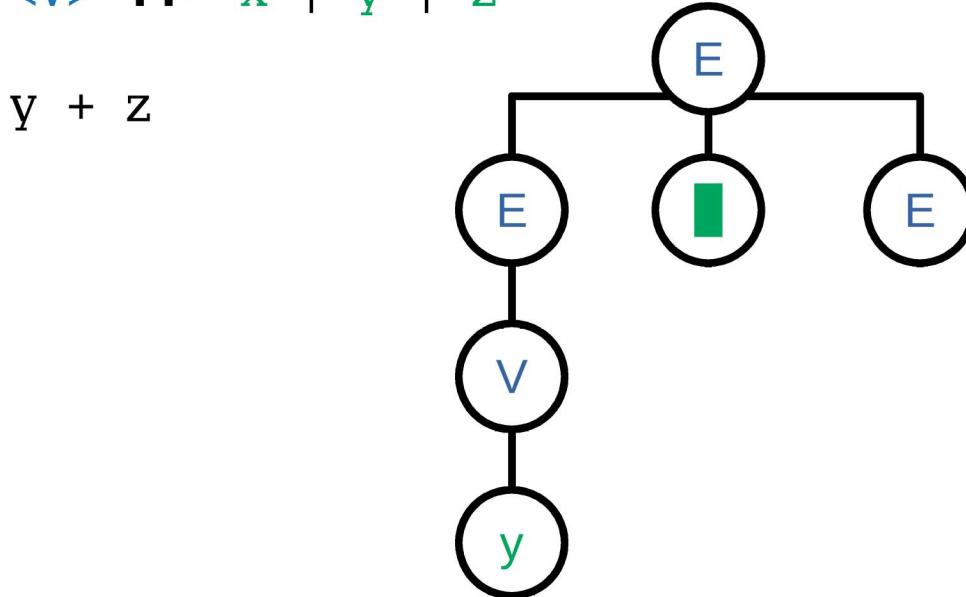


Utforska vänsterledet i sin helhet

16

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$

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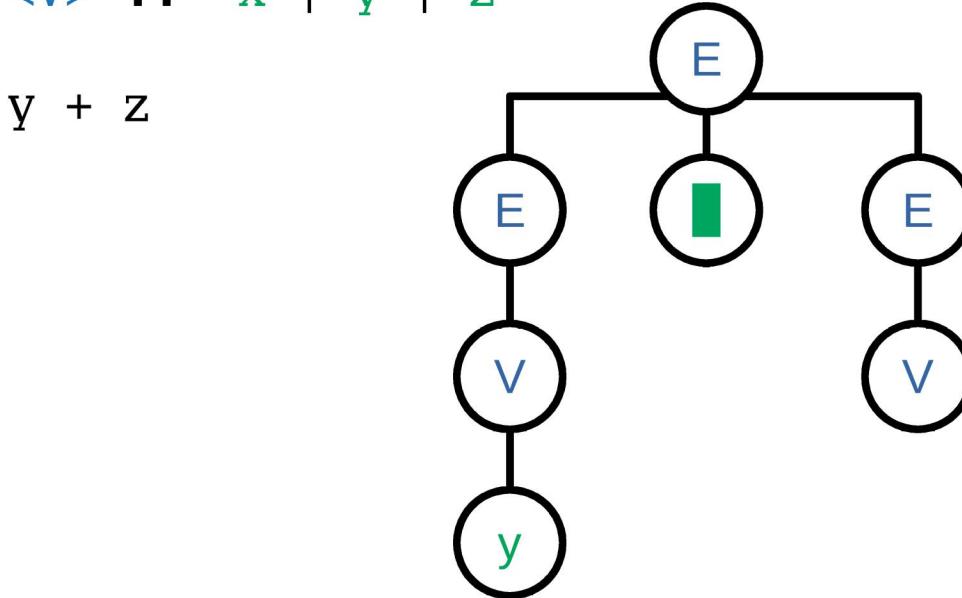


Utforska vänsterledet i sin helhet

17

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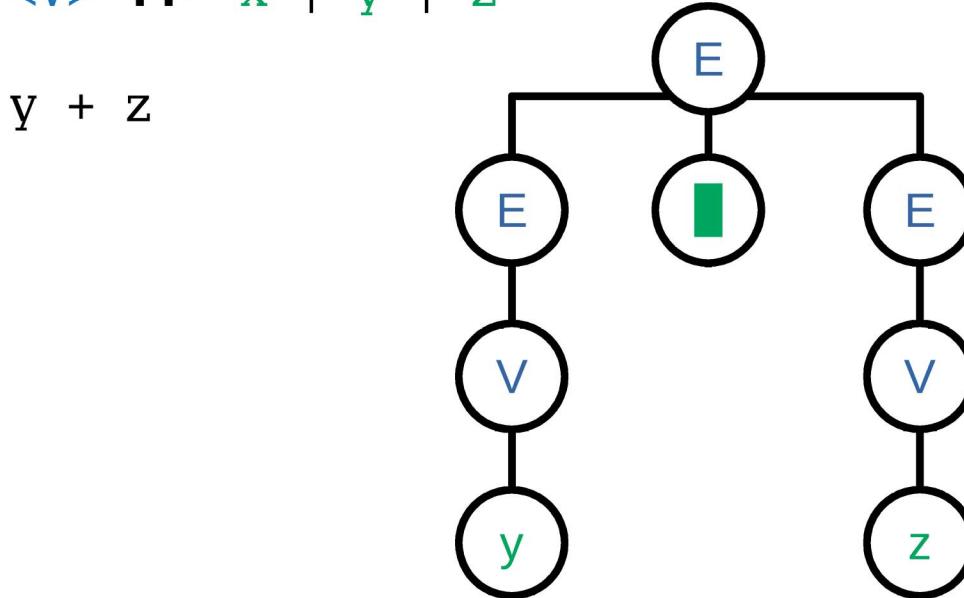


Utforska vänsterledet i sin helhet

18

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$

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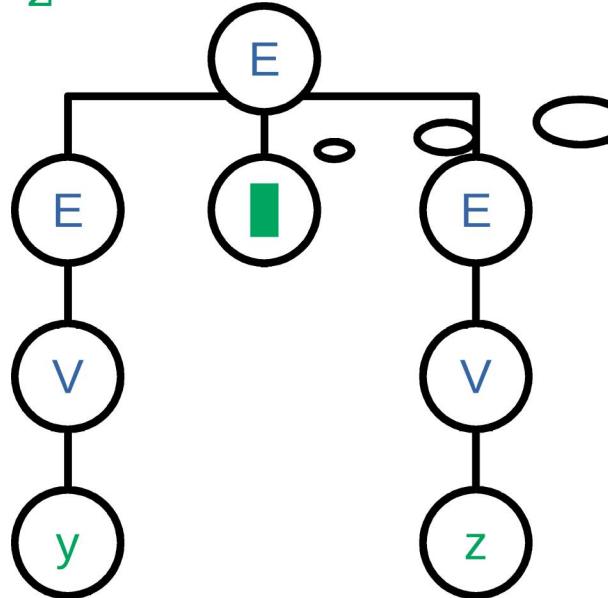
Utforska vänsterledet i sin helhet

19

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$

$\langle V \rangle ::= x \mid y \mid z$

y + z



Men vänta, hur
vet vi om '+'?

Problem som kan uppstå

Oändlig rekursion

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$
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y + z

Oändlig rekursion

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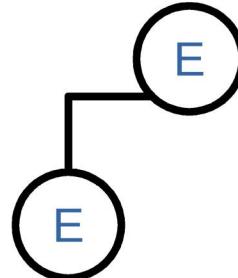
y + z



Oändlig rekursion

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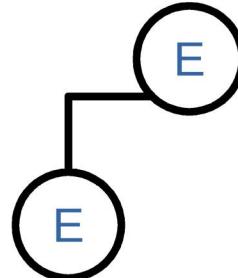
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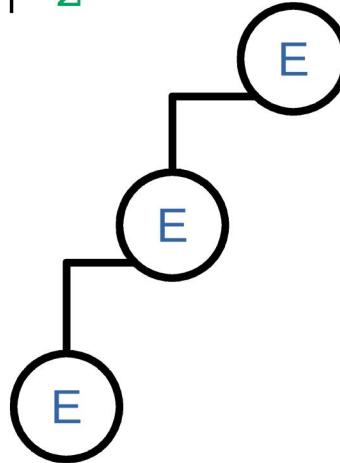
y + z



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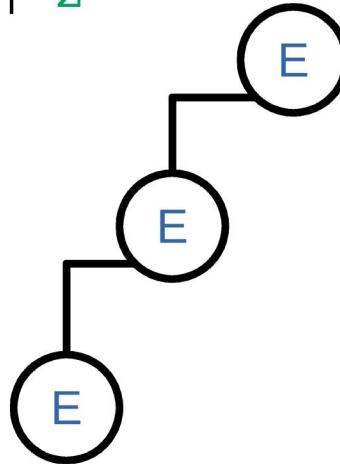
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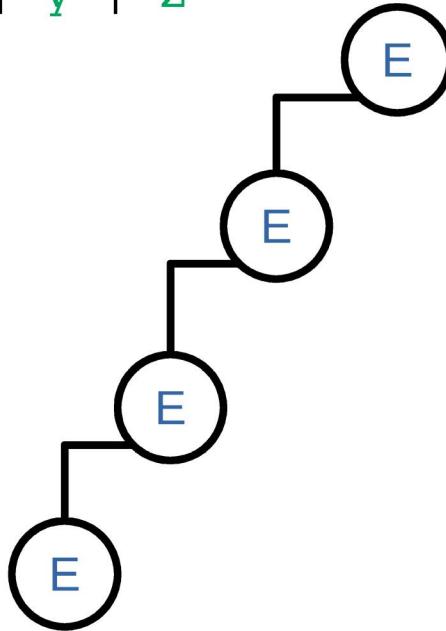
y + z



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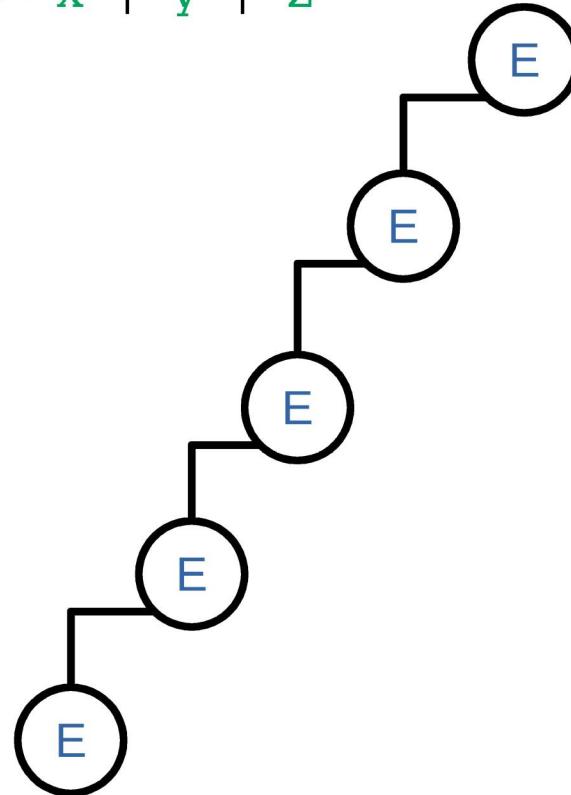
$y + z$



Oändlig rekursion

<E> ::= <E> + <E> | <E> * <E> | <V>
<V> ::= x | y | z

Y + Z

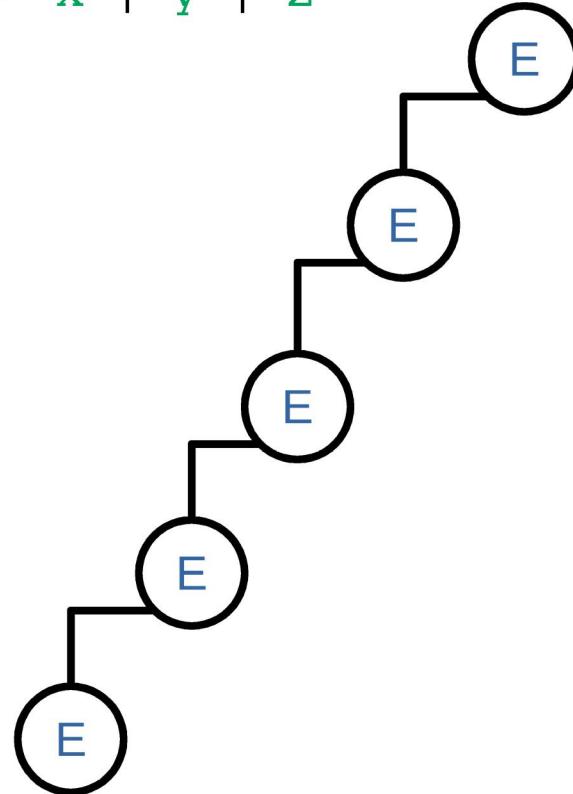


Oändlig rekursion

30

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 $\langle V \rangle ::= x \mid y \mid z$

y + z

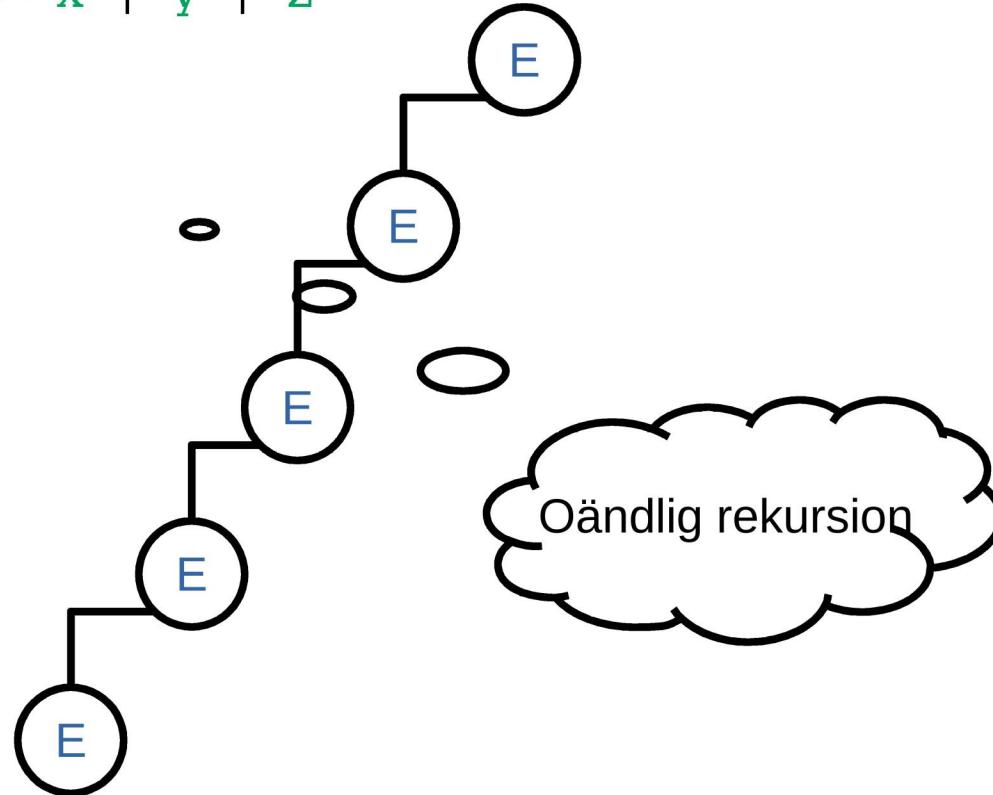


Oändlig rekursion

31

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$
 $\langle V \rangle ::= x \mid y \mid z$

y + z



Är detta ett problem?

- Ja och nej
- Rdpars är lite smartare
- Men om vi hade en dummare parser?

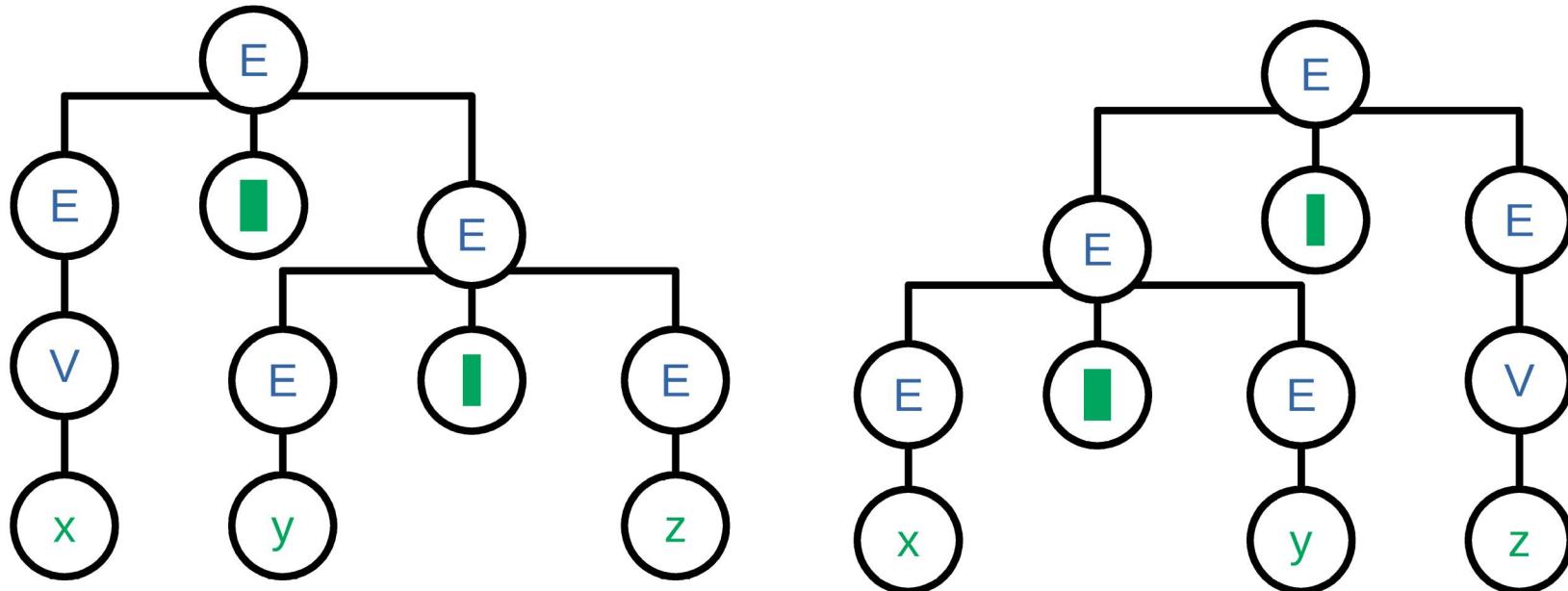
Tvetydighet

33

$\langle E \rangle ::= \langle E \rangle + \langle E \rangle \mid \langle E \rangle * \langle E \rangle \mid \langle V \rangle$

$\langle V \rangle ::= x \mid y \mid z$

$x + y * z$



Är detta ett problem?

- Ja och nej
- Rdparsen kommer vara konsekvent, men...
- Rätt sätt att lösa detta på är att skriva entydig grammatik

$$\begin{array}{l} E \rightarrow E + T \\ | \quad E - T \\ | \quad T \end{array}$$

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$$\begin{array}{l} E \rightarrow E + T \\ | \quad E - T \\ | \quad T \end{array} \quad \xrightarrow{\hspace{1cm}} \quad \begin{array}{l} E \rightarrow T E' \\ E' \rightarrow + T E' \\ | \quad - T E' \\ | \quad \langle\text{empty}\rangle \end{array}$$

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Insikt: Problemet är att det vi vill skilja på måste vara längst till vänster

Se till att skillnaden är längst till vänster

37

```
<E> ::= <V> <E'>
<E'> ::= + <V> <E'>
          | <empty>
<V> ::= x | y | z
```

y + z

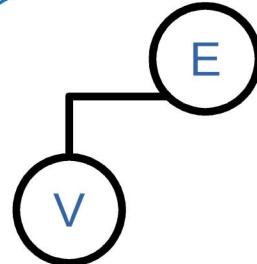
$\langle E \rangle ::= \langle V \rangle \langle E' \rangle$
 $\langle E' \rangle ::= + \langle V \rangle \langle E' \rangle$
 | $\langle \text{empty} \rangle$
 $\langle V \rangle ::= x \mid y \mid z$



y + z

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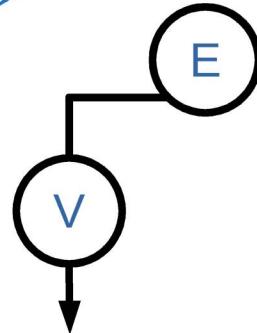
$y + z$



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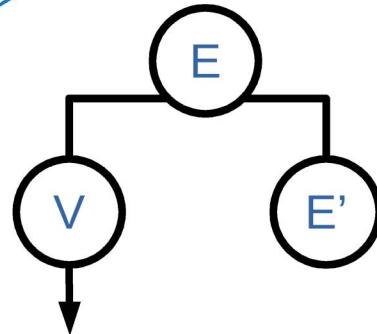
$\langle V \rangle ::= x \mid y \mid z$

y + z



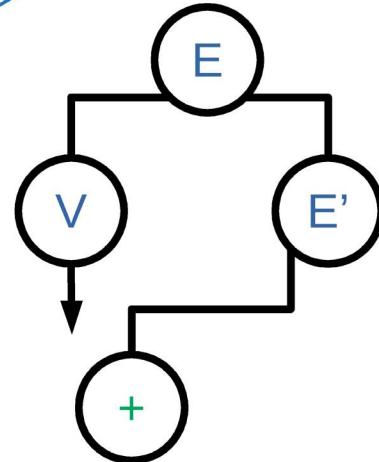
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y + z



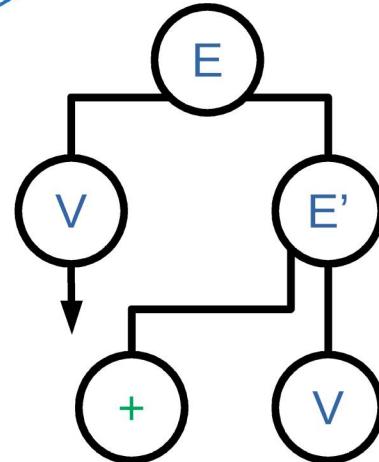
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 $\langle V \rangle ::= x \mid y \mid z$

y **+** z



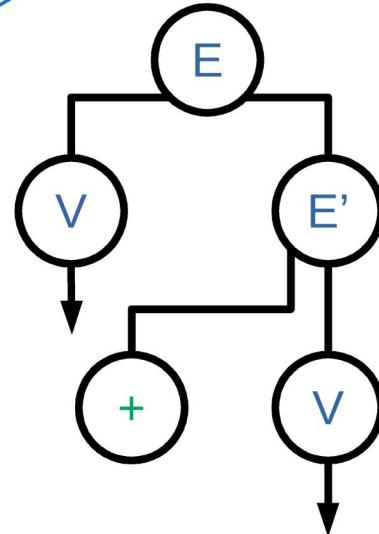
$\langle E \rangle ::= \langle V \rangle \langle E' \rangle$
 $\langle E' \rangle ::= + \langle V \rangle \langle E' \rangle$
|
 $\langle empty \rangle$
 $\langle V \rangle ::= x \mid y \mid z$

y + z



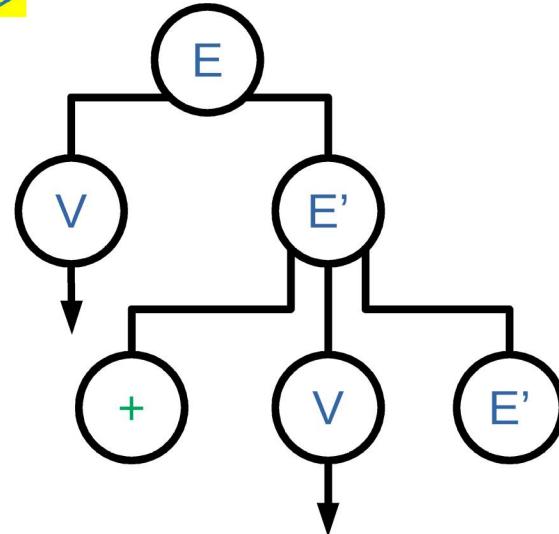
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 $\langle V \rangle ::= x \mid y \mid z$

y + z



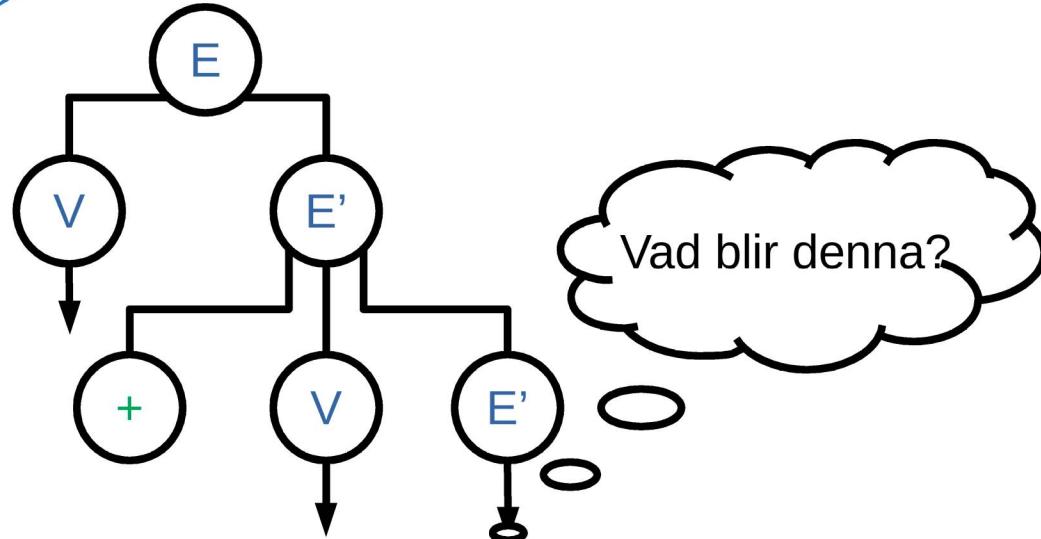
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y + z



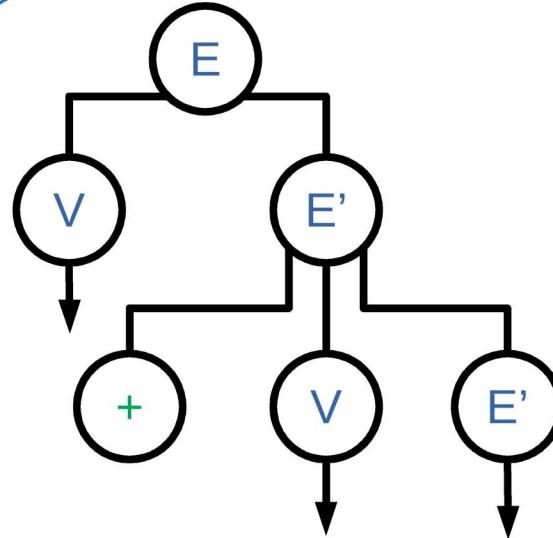
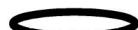
$\langle E \rangle ::= \langle V \rangle \langle E' \rangle$
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|
 $\langle V \rangle ::= x \mid y \mid z$

y + z



```
<E> ::= <V> <E'>
<E'> ::= + <V> <E'>
          | <empty>
<V> ::= x | y | z
```

y + z



Om det är komplexare uttryck?

Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

$\langle E' \rangle ::= + \langle T \rangle \langle E' \rangle$
| $\langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \langle T' \rangle$

$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
| $\langle \text{empty} \rangle$

$\langle V \rangle ::= x \mid y \mid z$

x * y + z

Utbyggbart

$\langle E \rangle ::= \langle T \rangle \ \langle E' \rangle$



$\langle E' \rangle ::= + \ \langle T \rangle \ \langle E' \rangle$
| $\langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \ \langle T' \rangle$

$\langle T' \rangle ::= * \ \langle V \rangle \ \langle T' \rangle$
| $\langle \text{empty} \rangle$

$\langle V \rangle ::= x \ | \ y \ | \ z$

x * y + z

Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

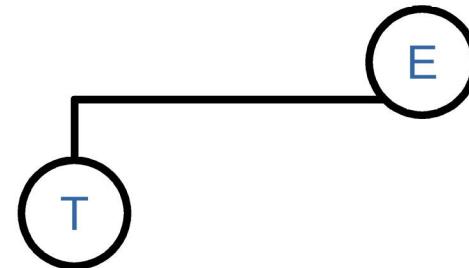
$\langle E' \rangle ::= + \langle T \rangle \langle E' \rangle$
 | $\langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \langle T' \rangle$

$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
 | $\langle \text{empty} \rangle$

$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

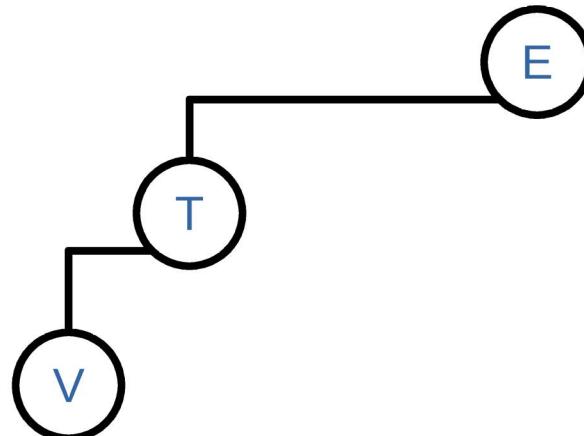
$\langle E' \rangle ::= + \langle T \rangle \langle E' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \langle T' \rangle$

$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

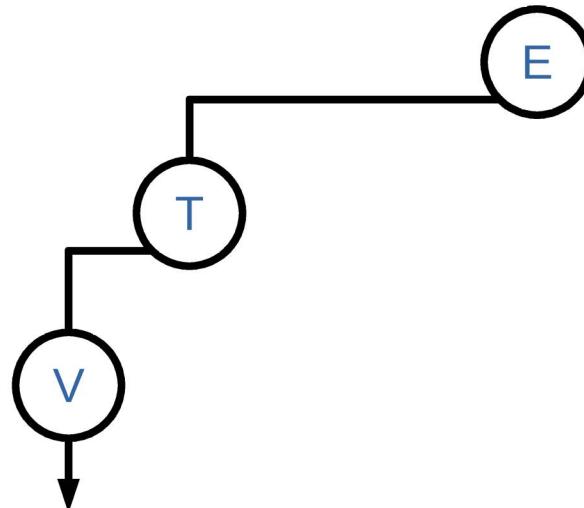
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 $\quad | \quad \langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \langle T' \rangle$

$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle V \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

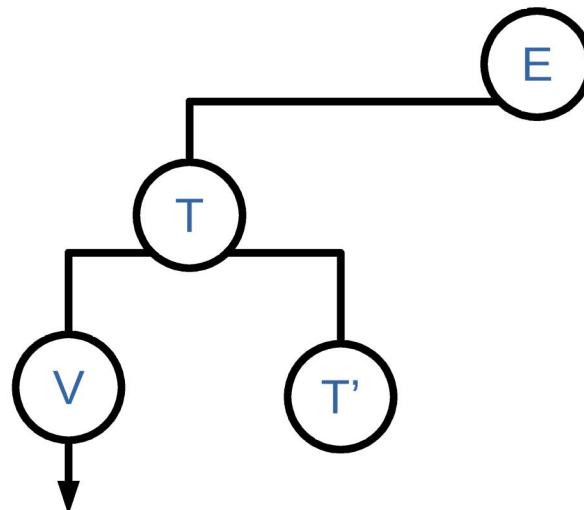
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$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

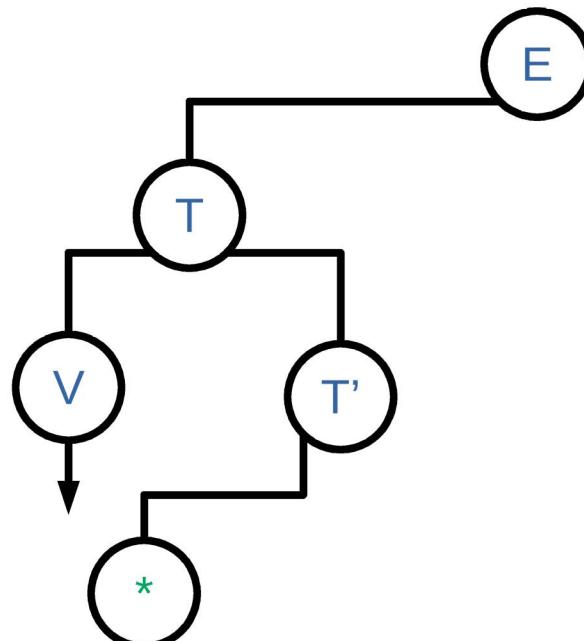
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$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

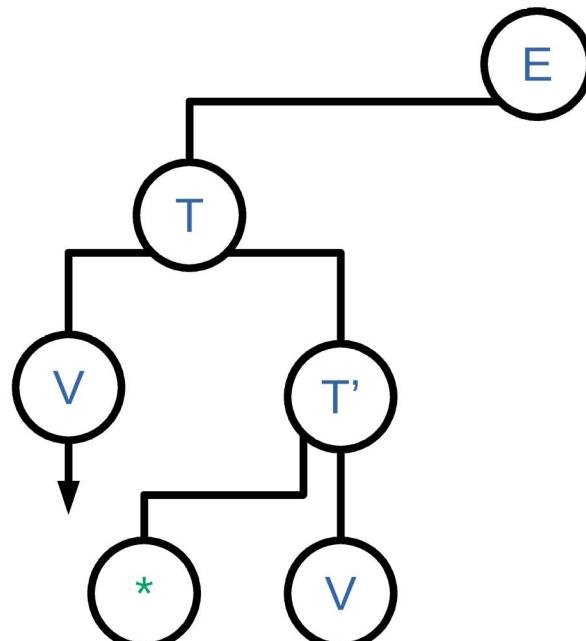
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$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

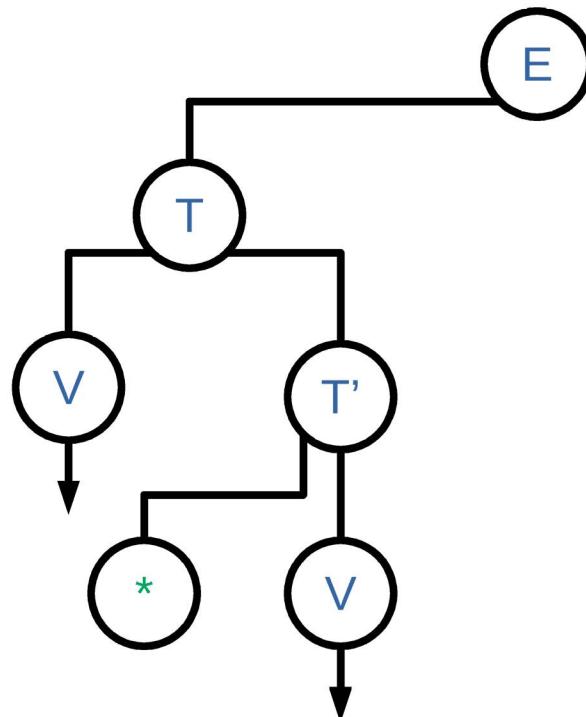
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x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

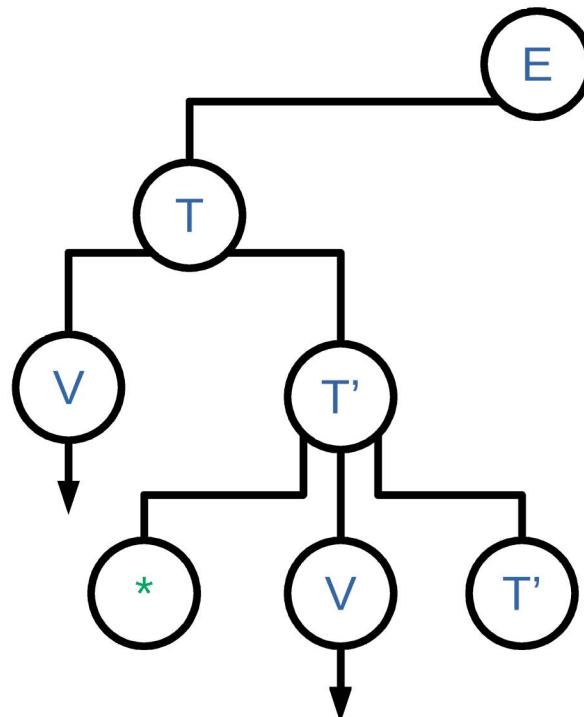
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Utbyggbart

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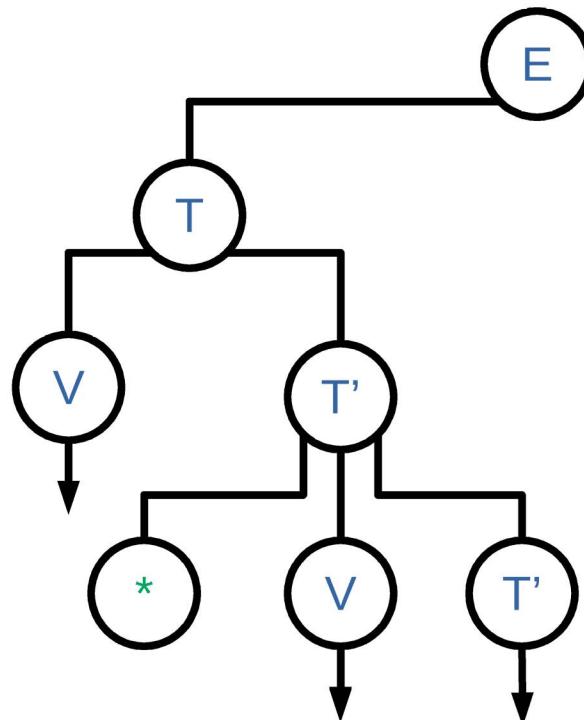
$\langle E' \rangle ::= + \langle T \rangle \langle E' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \langle T' \rangle$

$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \ \langle E' \rangle$

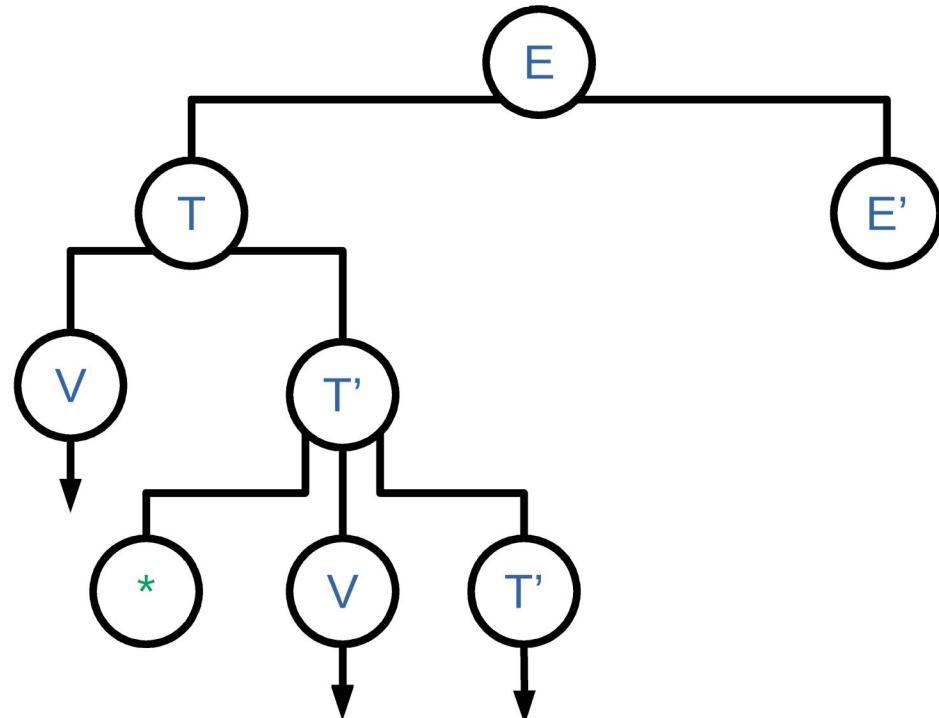
$\langle E' \rangle ::= + \ \langle T \rangle \ \langle E' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle T \rangle ::= \langle V \rangle \ \langle T' \rangle$

$\langle T' \rangle ::= * \ \langle V \rangle \ \langle T' \rangle$
 $\quad | \quad \langle \text{empty} \rangle$

$\langle V \rangle ::= x \ | \ y \ | \ z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

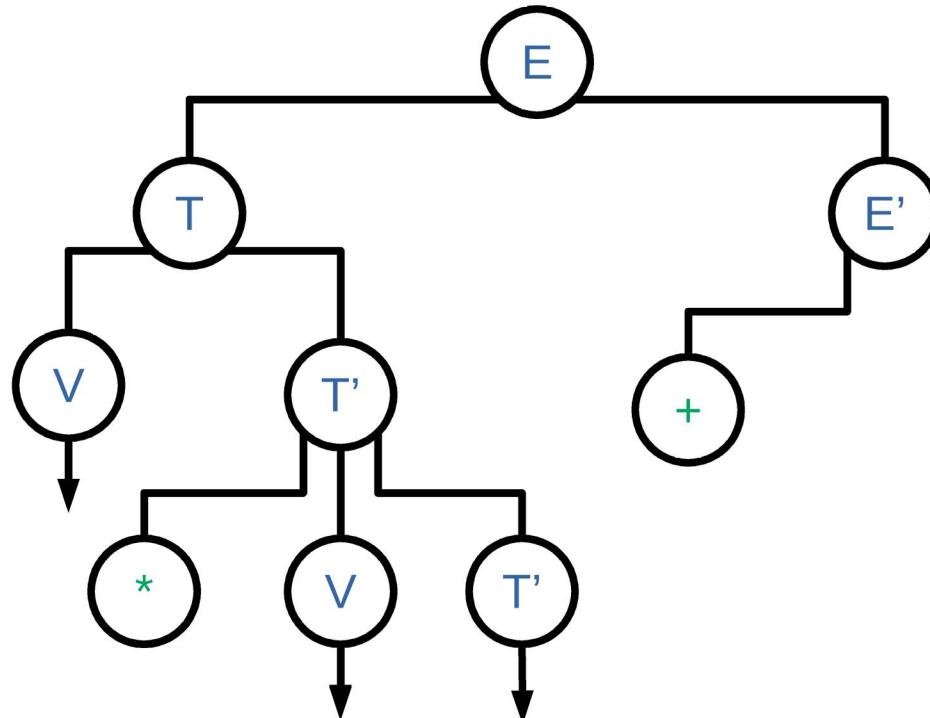
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Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

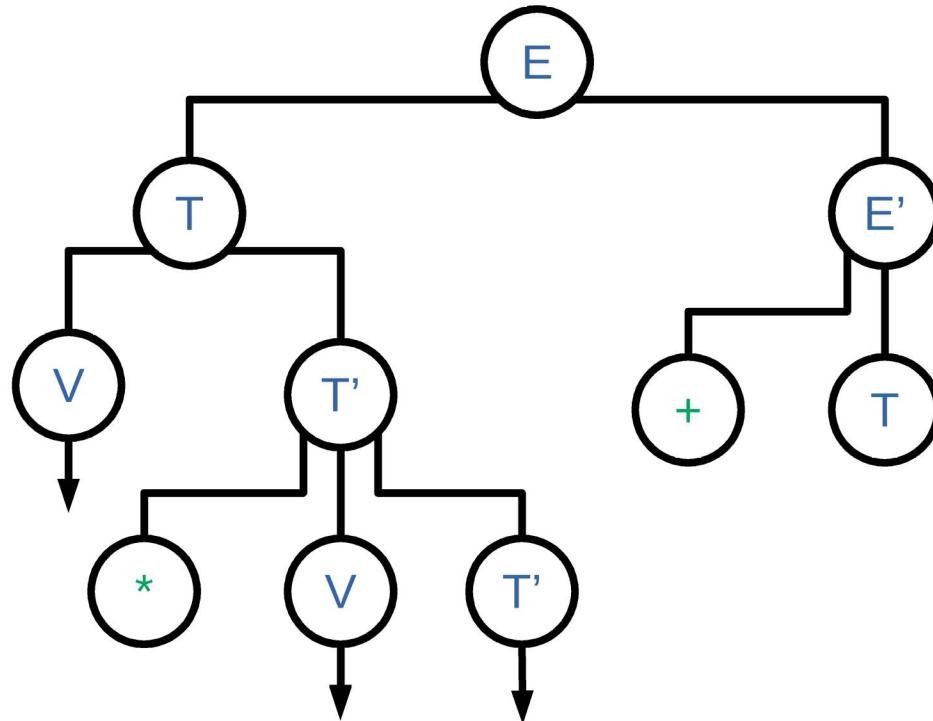
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x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

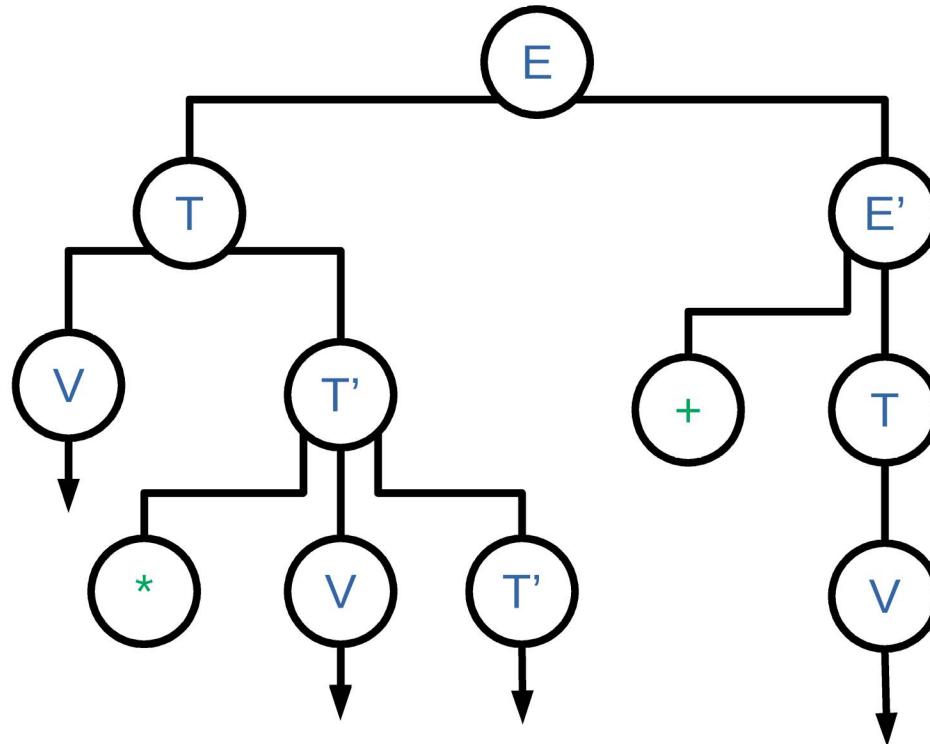
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x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

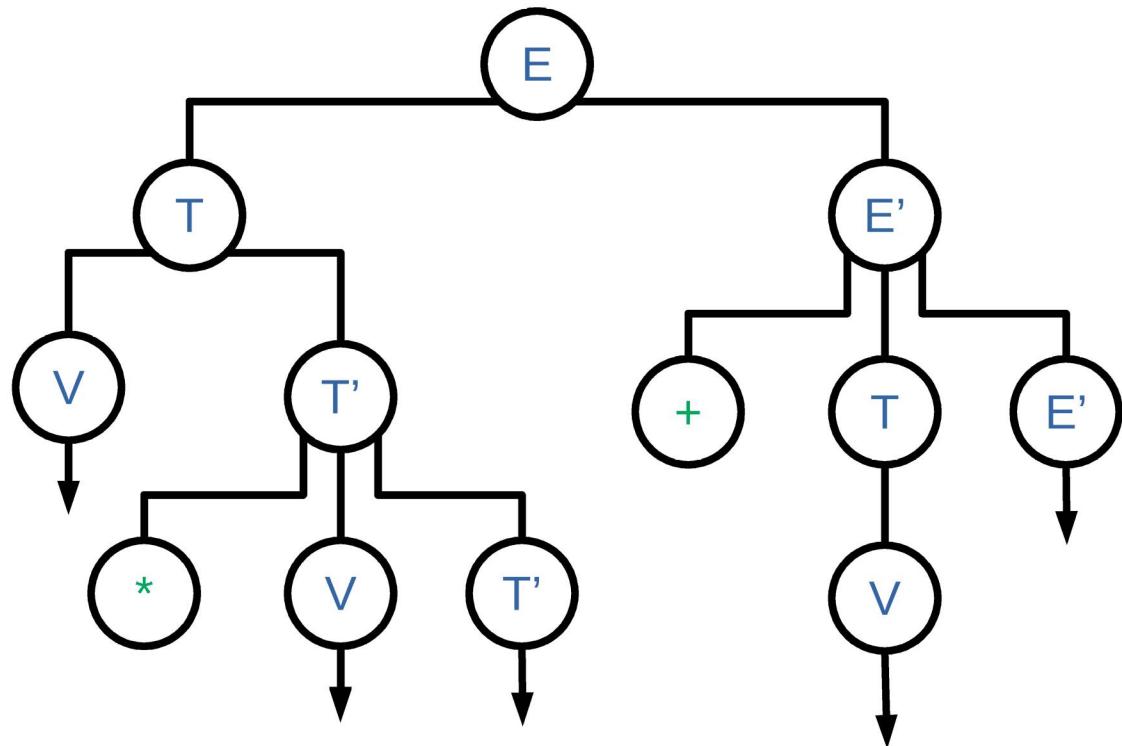
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$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
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$\langle V \rangle ::= x | y | z$

x * y + z



Utbyggbart

$\langle E \rangle ::= \langle T \rangle \langle E' \rangle$

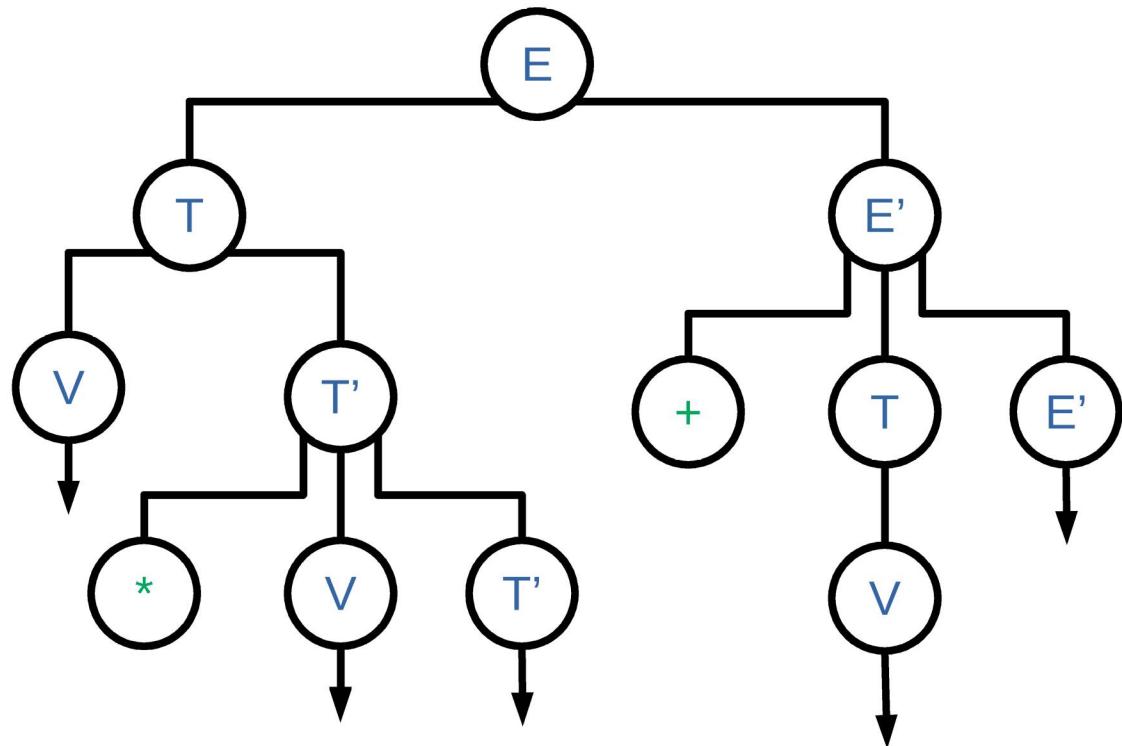
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$\langle T' \rangle ::= * \langle V \rangle \langle T' \rangle$
 $| \quad \langle \text{empty} \rangle$

$\langle V \rangle ::= x \mid y \mid z$

x * y + z



Insikt: Detta löser massor av problem med tvetydighet

Prioritet

Prioritet

- I vilken ordning ska saker utföras?

1+2*3
1*2+3

Prioritet

- I vilken ordning ska saker utföras?

$$\begin{array}{l} 1+2*3 \\ \longrightarrow \\ 1*(2*3) \\ 1*2+3 \end{array}$$

Prioritet

- I vilken ordning ska saker utföras?

$$\begin{array}{ccc} 1+2*3 & \xrightarrow{\hspace{1cm}} & 1+(2*3) \\ 1*2+3 & \xrightarrow{\hspace{1cm}} & (1*2)+3 \end{array}$$

Prioritet

- I vilken ordning ska saker utföras?

$$1+2*3 \longrightarrow 1+(2*3)$$

$$1*2+3 \longrightarrow (1*2)+3$$

$$-1+3$$

$$--1+3$$

$$x < y \text{ and } y > z$$

Prioritet

- I vilken ordning ska saker utföras?

$$\begin{array}{ll} 1+2*3 & \xrightarrow{\hspace{1cm}} 1+(2*3) \\ 1*2+3 & \xrightarrow{\hspace{1cm}} (1*2)+3 \\ -1+3 & \xrightarrow{\hspace{1cm}} (-1)+3 \end{array}$$

$$--1+3$$

$$x < y \text{ and } y > z$$

Prioritet

- I vilken ordning ska saker utföras?

$1+2*3$	\longrightarrow	$1+(2*3)$
$1*2+3$	\longrightarrow	$(1*2)+3$
$-1+3$	\longrightarrow	$(-1)+3$
$--1+3$	\longrightarrow	$(-(-1))+3$
$x < y$ and $y > z$		

Prioritet

- I vilken ordning ska saker utföras?

$1+2*3$	\longrightarrow	$1+(2*3)$
$1*2+3$	\longrightarrow	$(1*2)+3$
$-1+3$	\longrightarrow	$(-1)+3$
$--1+3$	\longrightarrow	$(-(-1))+3$
$x < y \text{ and } y > z$	\longrightarrow	$(x < y) \text{ and } (y > z)$

Prioritet

- I vilken ordning ska saker utföras?

$1+2*3$	\longrightarrow	$1+(2*3)$
$1*2+3$	\longrightarrow	$(1*2)+3$
$-1+3$	\longrightarrow	$(-1)+3$
$--1+3$	\longrightarrow	$(-(-1))+3$
$x < y \text{ and } y > z$	\longrightarrow	$(x < y) \text{ and } (y > z)$

- Att välja en bra ordning
- Att styra hur det fungerar

Prioritet

- I vilken ordning ska saker utföras?

$1+2*3$	\longrightarrow	$1+(2*3)$
$1*2+3$	\longrightarrow	$(1*2)+3$
$-1+3$	\longrightarrow	$(-1)+3$
$--1+3$	\longrightarrow	$(-(-1))+3$
$x < y \text{ and } y > z$	\longrightarrow	$(x < y) \text{ and } (y > z)$

- Att välja en bra ordning
- Att styra hur det fungerar

Insikt: Att styra ordningen har vi redan lärt oss, detta är samma sak
Längre ned betyder högre prioritet

Korrekt associativitet

associativitet

- Hur styr jag detta?
- Hur kontrollerar jag detta?
- Vänster eller höger?

associativitet

- Hur styr jag detta?
 - Hur kontrollerar jag detta?
 - Vänster eller höger?
 - Vänster: Höger:

associativitet

- Hur styr jag detta?
 - Hur kontrollerar jag detta?
 - Vänster eller höger?
 - Vänster: H

1 + 2 + 3

Höger:

1 + 2 + 3

associativitet

- Hur styr jag detta?
 - Hur kontrollerar jag detta?
 - Vänster eller höger?
 - Vänster: H

$$\begin{array}{r} 1 + 2 + 3 \\ (1 + 2) + 3 \end{array}$$

Höger:

$$\begin{array}{r} 1 + 2 + 3 \\ 1 + (2 + 3) \end{array}$$

associativitet

- Hur styr jag detta?
 - Hur kontrollerar jag detta?
 - Vänster eller höger?
 - Vänster: H

$$\begin{array}{r} 1 + 2 + 3 \\ (1 + 2) + 3 \end{array}$$

Höger:

$$\begin{array}{r} 1 + 2 + 3 \\ 1 + (2 + 3) \end{array}$$



associativitet

Exempel som bör vara höger associativa

$$-1+3$$

$$--1+3$$

$$1+1^2$$

$$1+1^2^3$$

$$(-1)+3$$

$$(-(-1))+3$$

$$1+(1^2)$$

$$1+1^{(2^3)}$$

associativitet != Prioritet

- Skillnad mellan associativitet och prioritet
- $1+2*3$
 $1*2+3$
 $1-2-3$

Höger associativitet

$\langle \text{UE} \rangle ::= + \langle \text{UE} \rangle$
| - $\langle \text{UE} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

--x

Höger associativitet

$\langle \text{UE} \rangle ::= + \langle \text{UE} \rangle$
| - $\langle \text{UE} \rangle$
| $\langle \text{V} \rangle$



$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

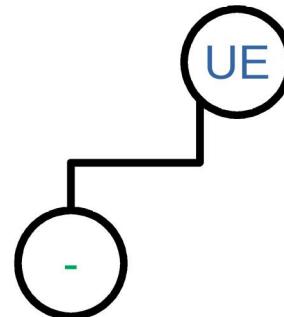
--x

Höger associativitet

$\langle \text{UE} \rangle ::= + \langle \text{UE} \rangle$
| - $\langle \text{UE} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

--x

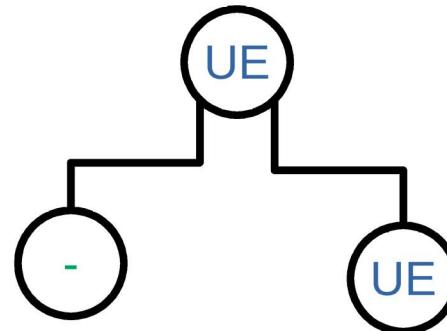


Höger associativitet

$\langle \text{UE} \rangle ::= + \langle \text{UE} \rangle$
| $- \langle \text{UE} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

---x

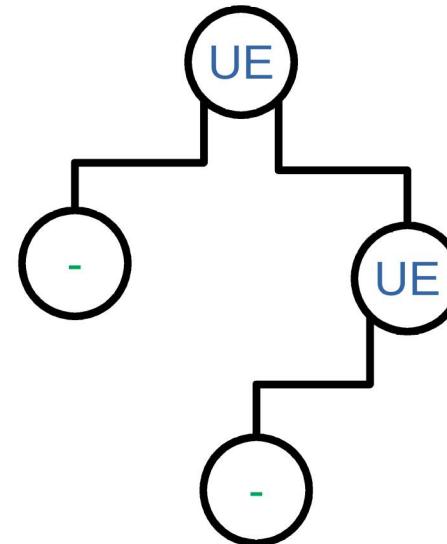


Höger associativitet

```
<UE> ::= + <UE>
      | - <UE>
      | <V>
```

```
<V> ::= x | y | z
```

--x

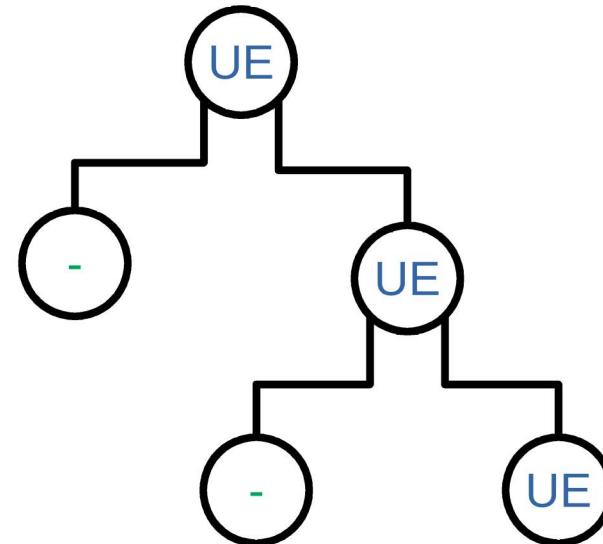


Höger associativitet

$\langle \text{UE} \rangle ::= + \langle \text{UE} \rangle$
| - $\langle \text{UE} \rangle$
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$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

--x

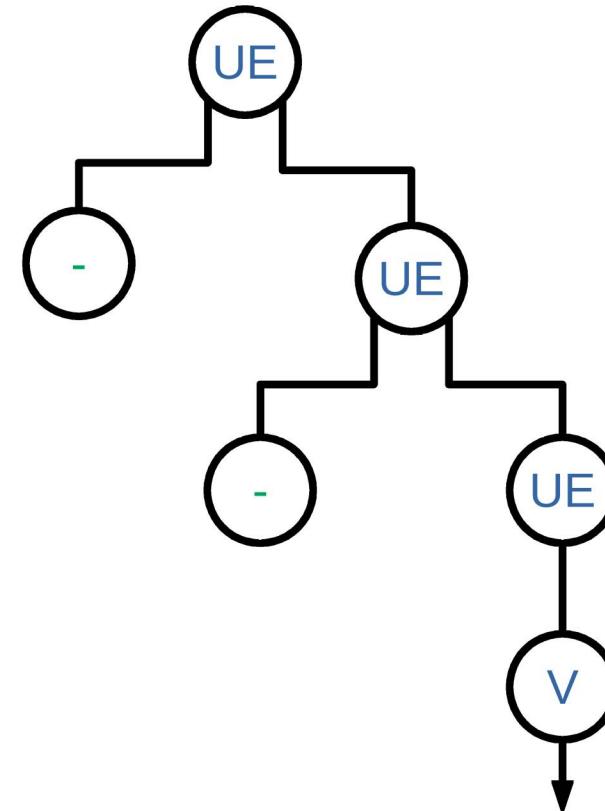


Höger associativitet

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| - $\langle \text{UE} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

--x

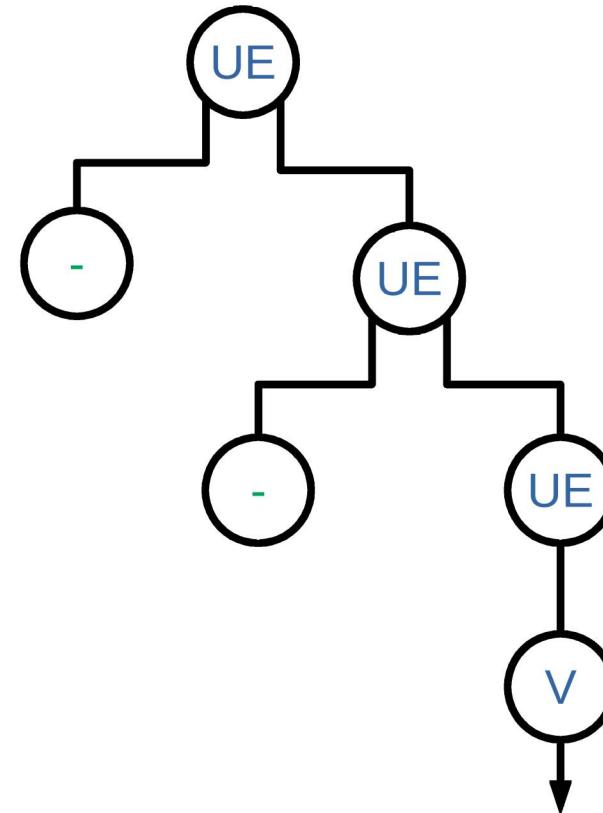


Höger associativitet

$\langle \text{UE} \rangle ::= + \langle \text{UE} \rangle$
 | $- \langle \text{UE} \rangle$
 | $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

---x



Insikt: Detta verkar fungera... Och är det enda rimliga sättet att skriva det på

Höger associativitet – annat exempel

91

```
<EX> ::= <EX> ^ <V>
        | <V>
```

```
<V> ::= x | y | z
```

x^y^z

Höger associativitet – annat exempel

<EX> ::= <EX> ^ <V>
| <V>

EX

<V> ::= x | y | z

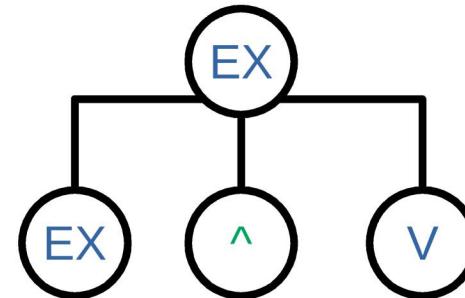
x^y^z

Höger associativitet – annat exempel

```
<EX> ::= <EX> ^ <V>
        | <V>
```

```
<V> ::= x | y | z
```

x^y^z

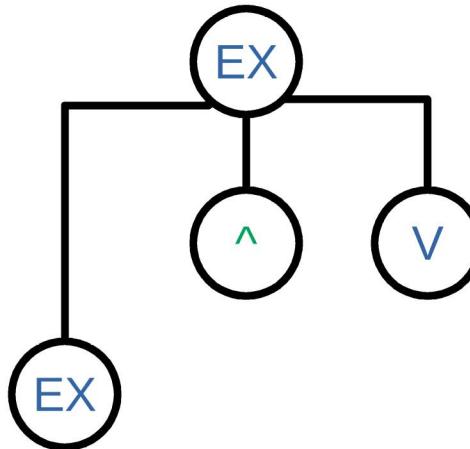


Höger associativitet – annat exempel

```
<EX> ::= <EX> ^ <V>  
      | <V>
```

```
<V> ::= x | y | z
```

x^y^z

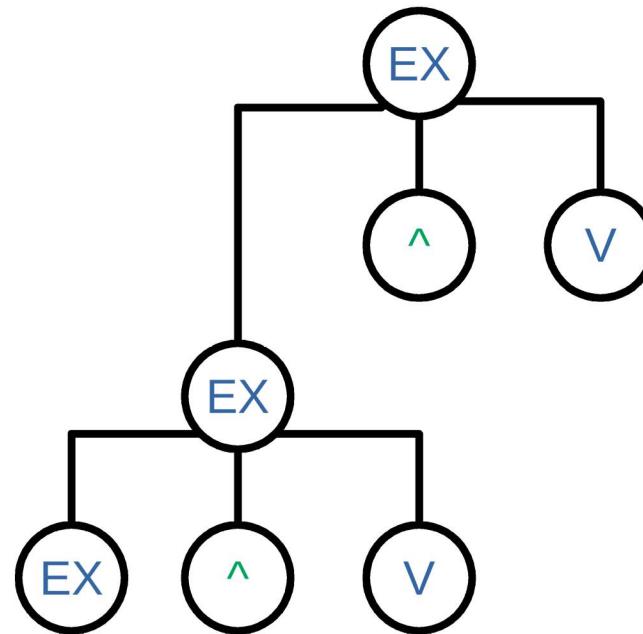


Höger associativitet – annat exempel

`<EX> ::= <EX> ^ <V>`
| `<V>`

`<V> ::= x | y | z`

`x^y^z`

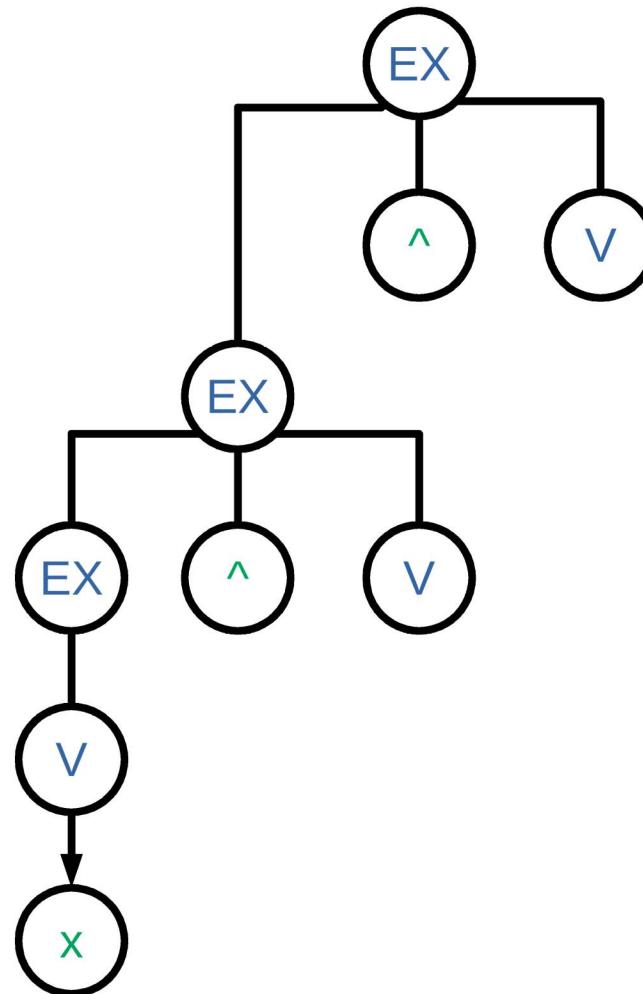


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{EX} \rangle \wedge \langle \text{V} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$\text{x} \wedge \text{y} \wedge \text{z}$

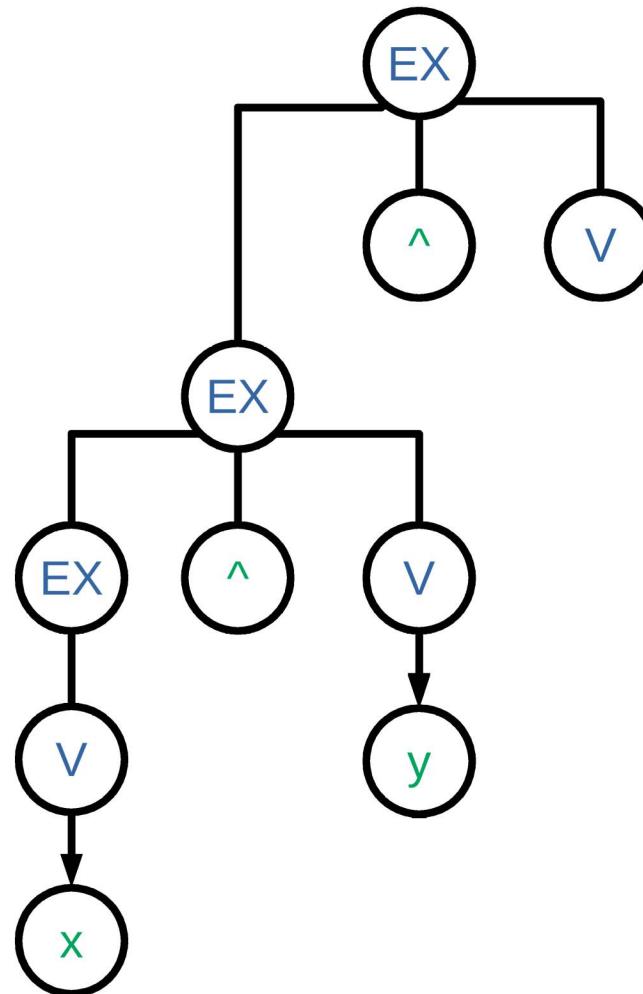


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{EX} \rangle \wedge \langle \text{V} \rangle$
 | $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$\text{x} \wedge \text{y} \wedge \text{z}$

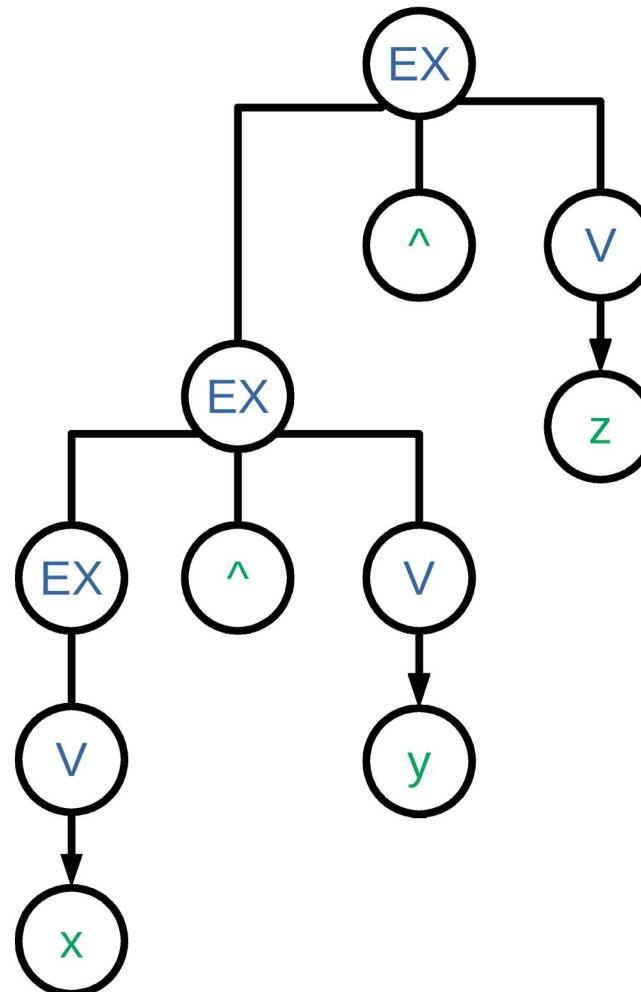


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{EX} \rangle \wedge \langle \text{V} \rangle$
|
 $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

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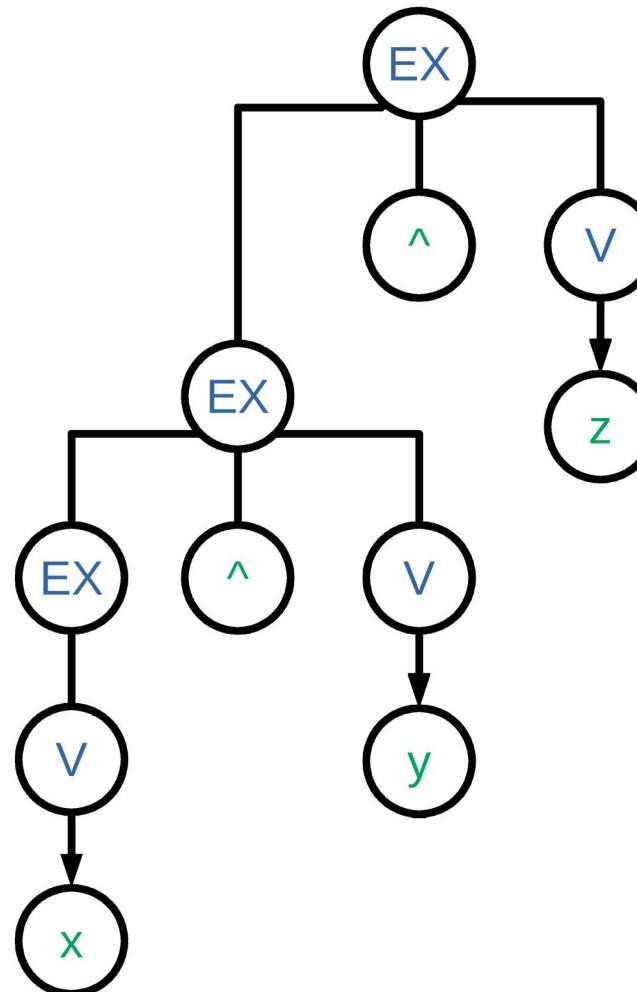


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{EX} \rangle \wedge \langle \text{V} \rangle$
 | $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$(x \wedge y) \wedge z$



Höger associativitet – annat exempel

100

<EX> ::= <EX> ^ <V>
| <V>

<V> ::= x | y | z

x^y^z

Höger associativitet – annat exempel

101

```
<EX> ::= <V> ^ <EX>
        | <V>
```

```
<V> ::= x | y | z
```

x^y^z

Höger associativitet – annat exempel

102



$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$x \wedge y \wedge z$

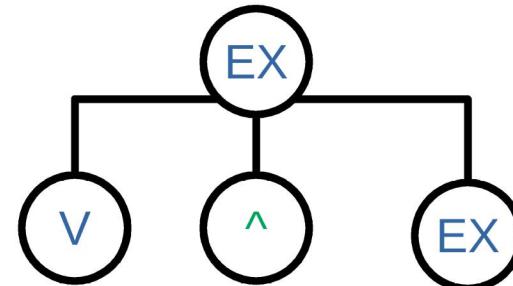
Höger associativitet – annat exempel

103

$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$x \wedge y \wedge z$

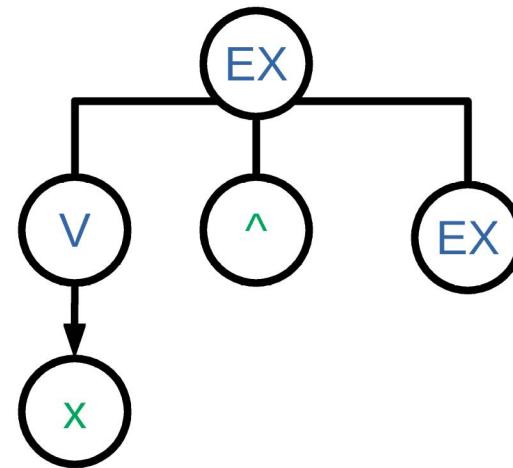


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$\text{x} \wedge \text{y} \wedge \text{z}$

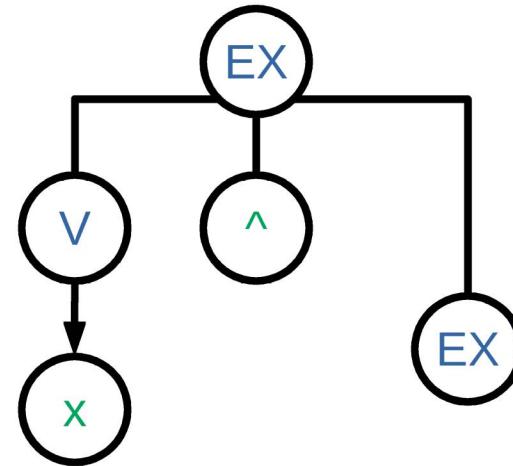


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$\text{x} \wedge \text{y} \wedge \text{z}$



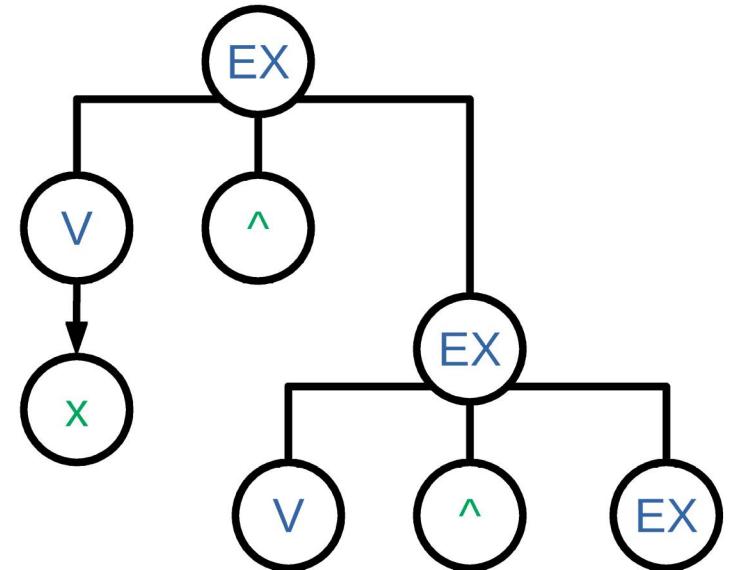
Höger associativitet – annat exempel

106

$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$\text{x} \wedge \text{y} \wedge \text{z}$



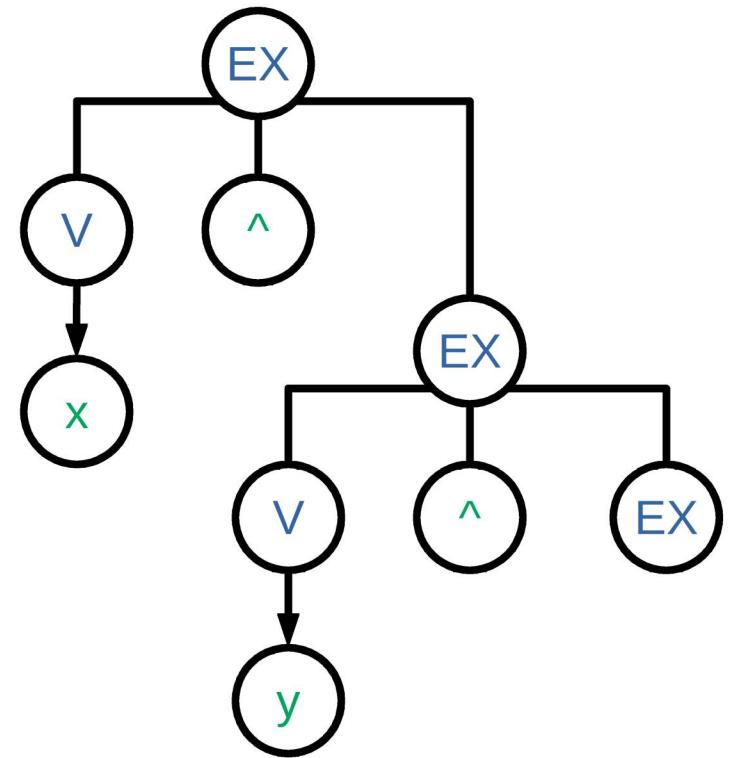
Höger associativitet – annat exempel

107

$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
| $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$\text{x} \wedge \text{y} \wedge \text{z}$

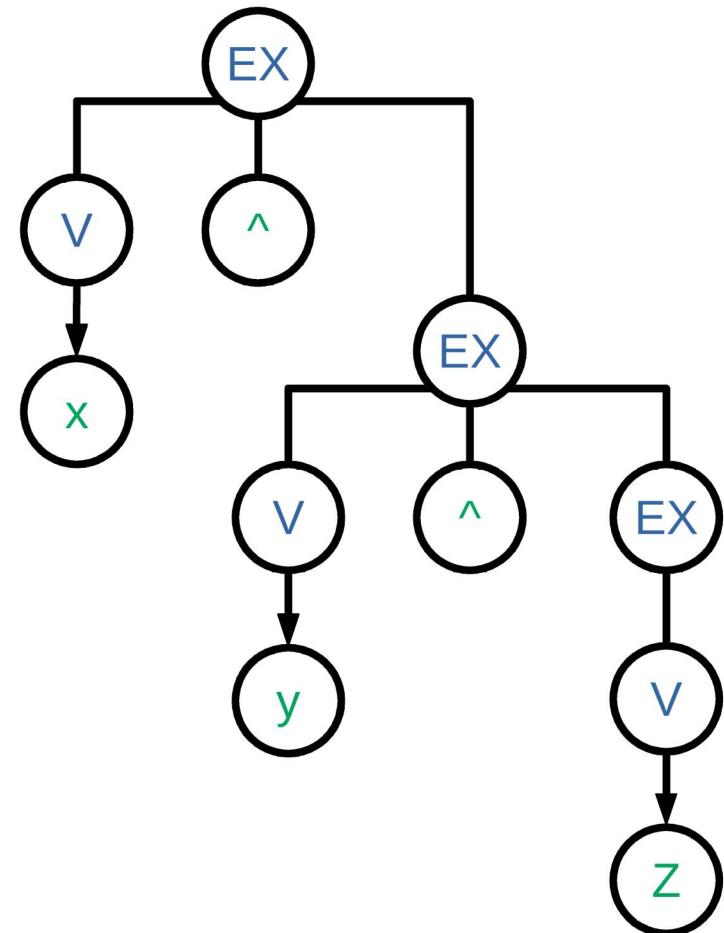


Höger associativitet – annat exempel

$\langle \text{EX} \rangle ::= \langle \text{V} \rangle \wedge \langle \text{EX} \rangle$
 | $\langle \text{V} \rangle$

$\langle \text{V} \rangle ::= \text{x} \mid \text{y} \mid \text{z}$

$x \wedge y \wedge z$

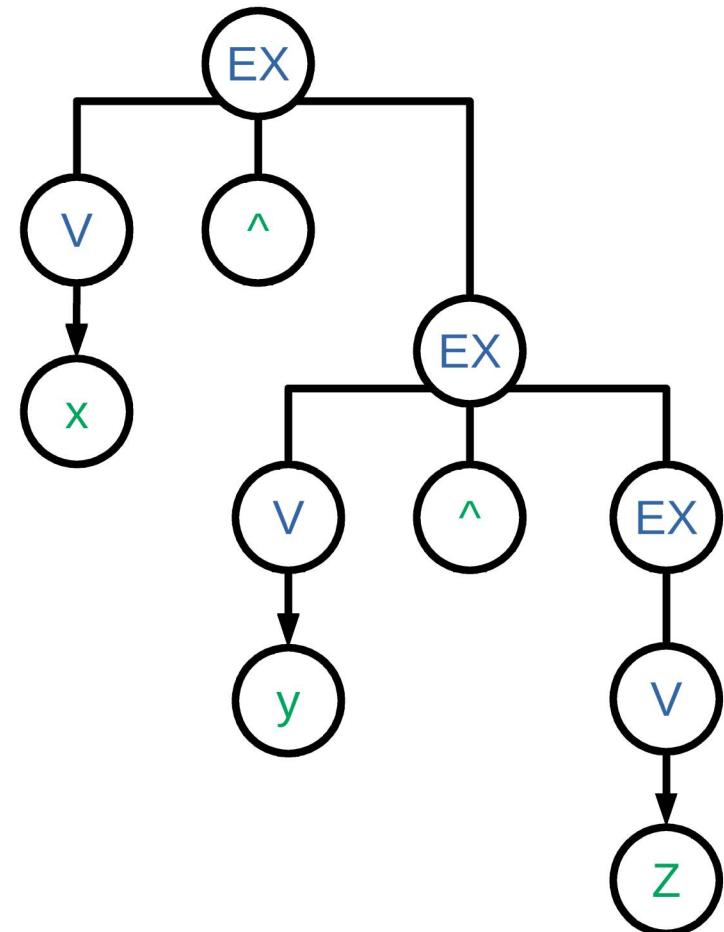


Höger associativitet – annat exempel

$\langle EX \rangle ::= \langle V \rangle \wedge \langle EX \rangle$
 | $\langle V \rangle$

$\langle V \rangle ::= x \mid y \mid z$

$x \wedge (y \wedge z)$

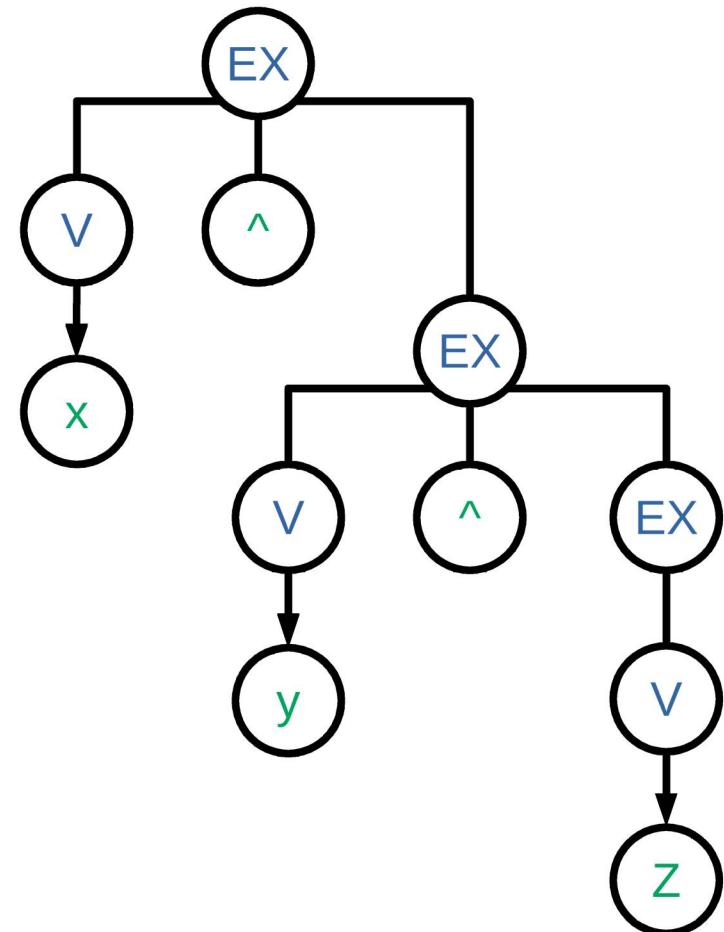
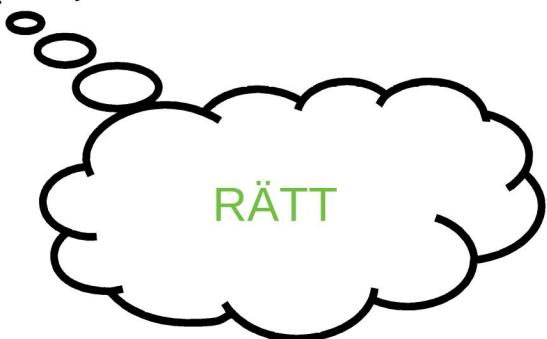


Höger associativitet – annat exempel

$\langle EX \rangle ::= \langle V \rangle \wedge \langle EX \rangle$
 | $\langle V \rangle$

$\langle V \rangle ::= x \mid y \mid z$

$x \wedge (y \wedge z)$



associativitet - avslutning

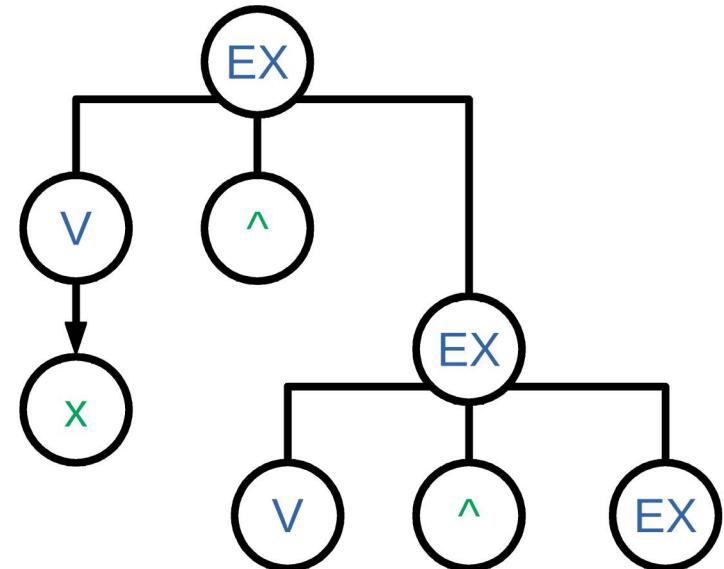
- Bestäm hur det är rimligt att det ska fungera
- Styr associativiteten med grammatiken
- Vänster så är den lägsta (djupaste) regeln till vänster i regeln
- Höger så är den lägsta (djupaste) regeln till höger i regeln

$$\begin{array}{l} \langle EX \rangle ::= \langle EX \rangle \wedge \langle V \rangle \\ | \quad \langle V \rangle \end{array}$$
$$\begin{array}{l} \langle EX \rangle ::= \langle V \rangle \wedge \langle EX \rangle \\ | \quad \langle V \rangle \end{array}$$
$$\langle V \rangle ::= x \mid y \mid z$$
$$\langle V \rangle ::= x \mid y \mid z$$
$$x \wedge (y \wedge z)$$
$$(x \wedge y) \wedge z$$

Några tankar om Bottom-Up

Bottom-Up

- Annat sätt att parsa på.
- Går minsta → största när det kommer till delar i språket.
- Potentiellt kraftfullt.



Bottom-Up | Hur läser Top-Down?

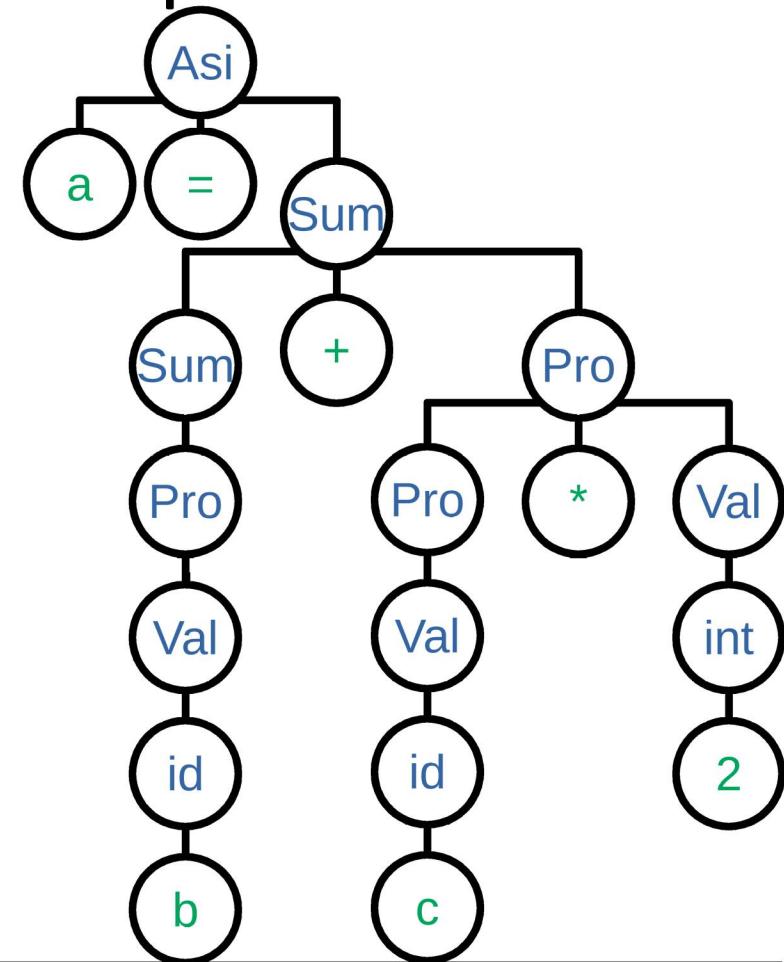
Assign ::= id = Sums

Sums ::= Sums + Products
| Products

Products ::= Products*Value
| Value

Value ::= int
| id

a = b + c * 2



Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

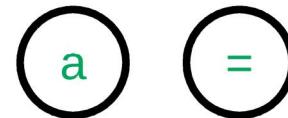


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

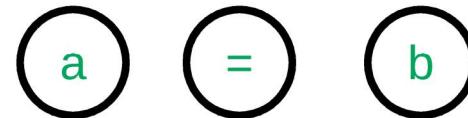


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

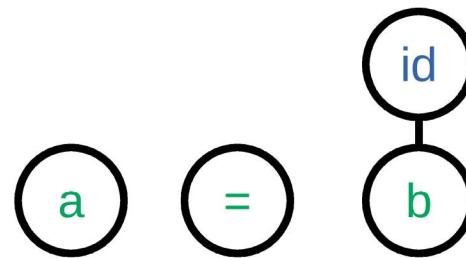


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

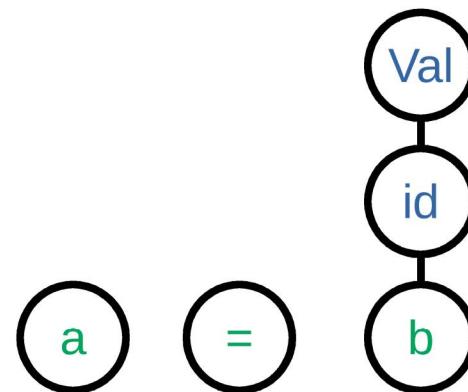


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

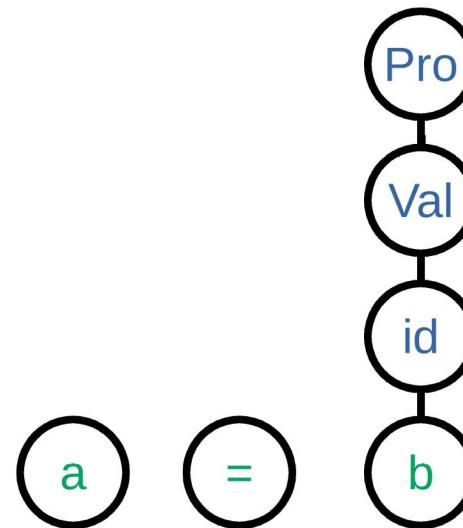


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

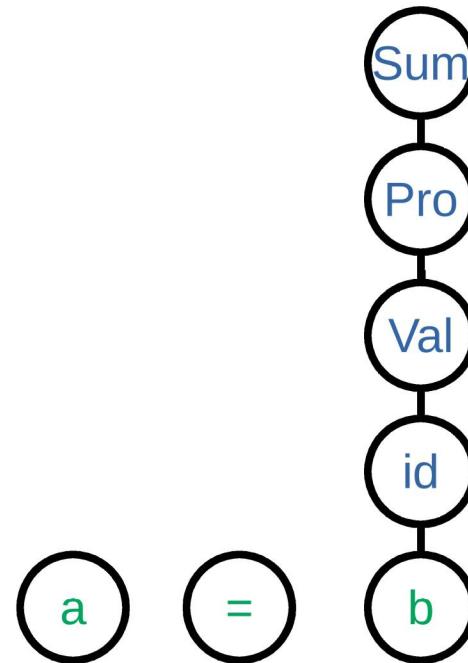


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

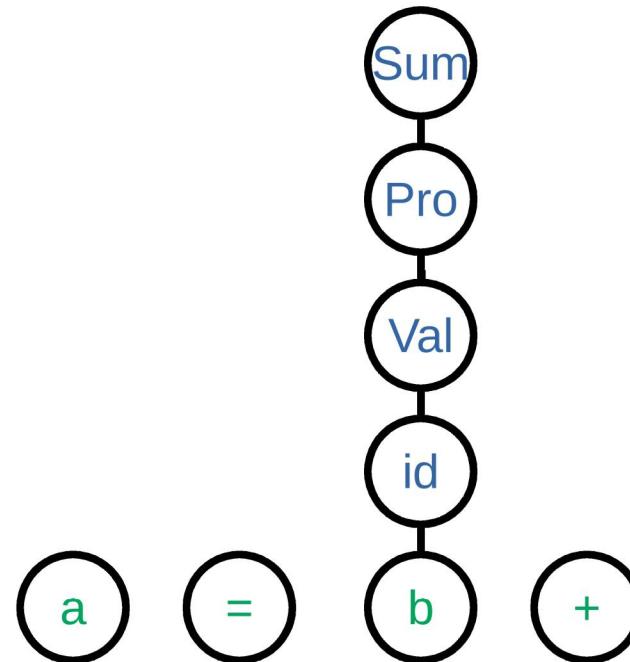


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

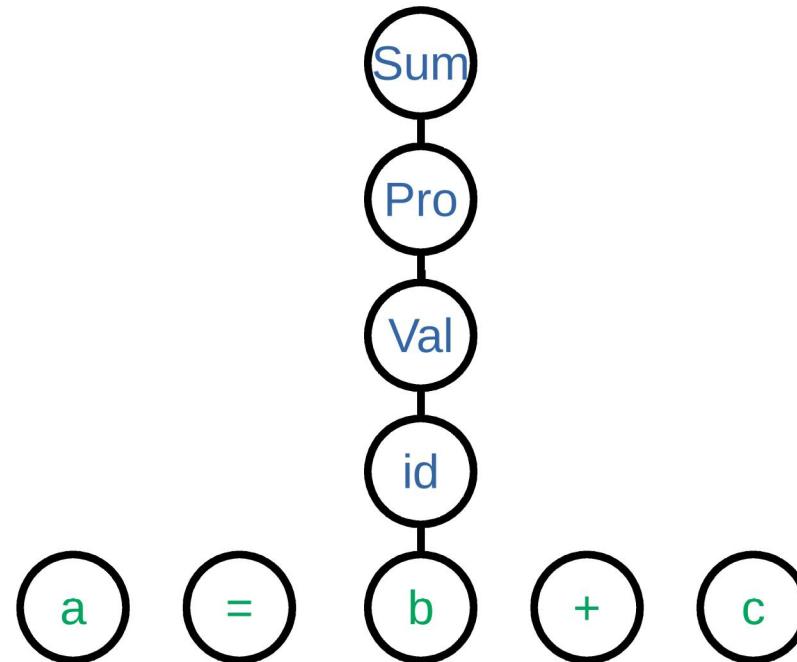


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

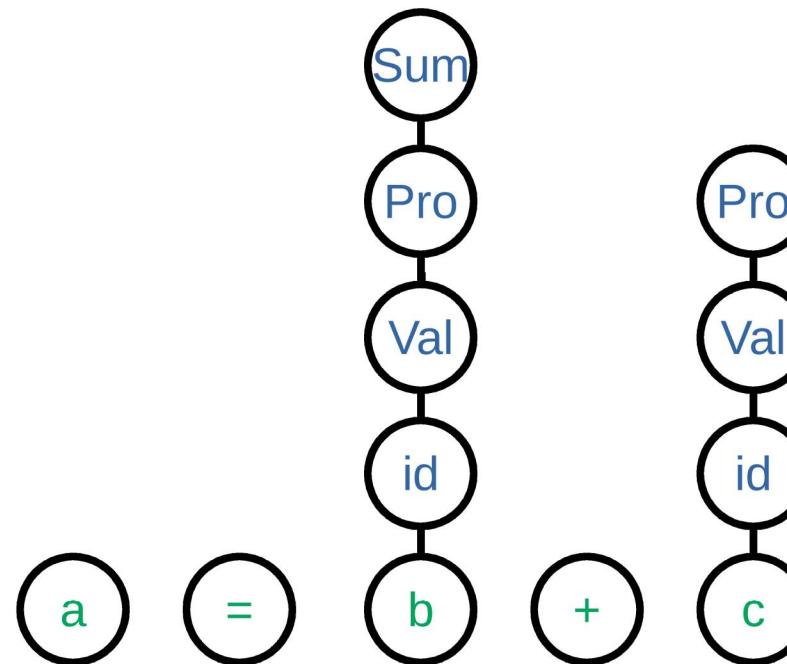


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

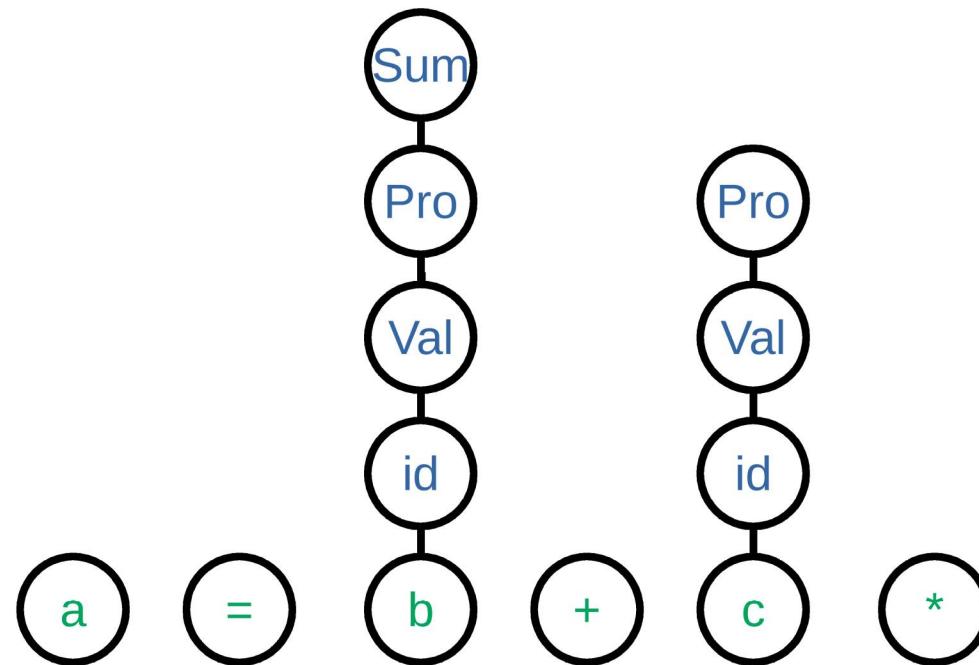


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

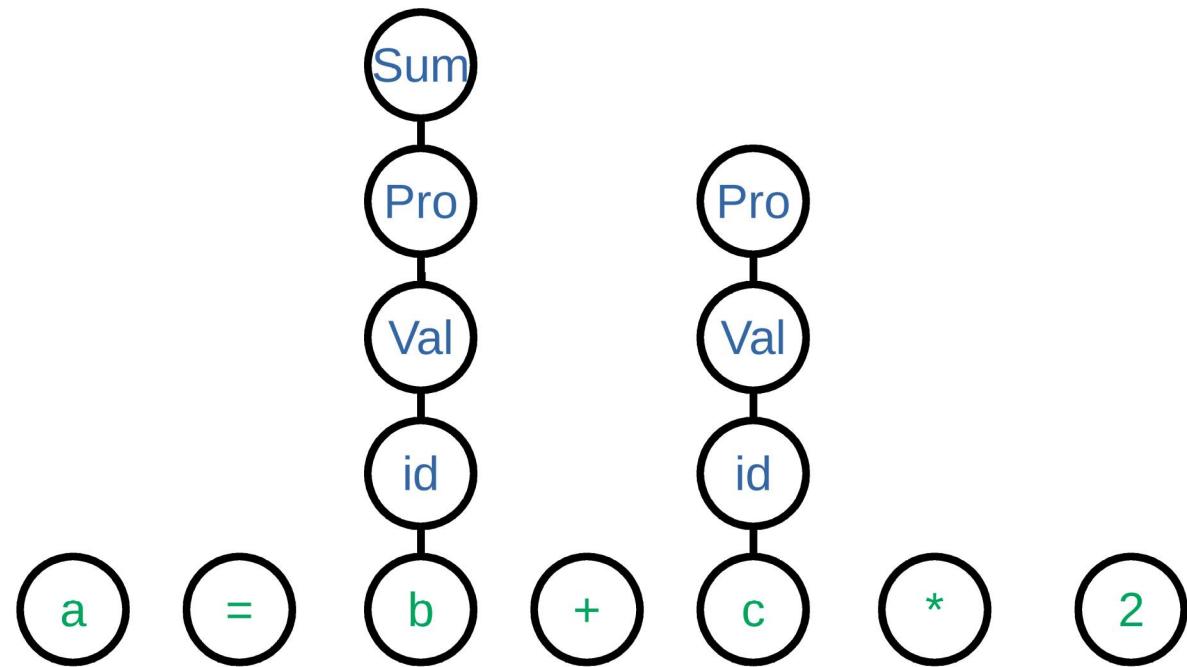


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

SHIFT

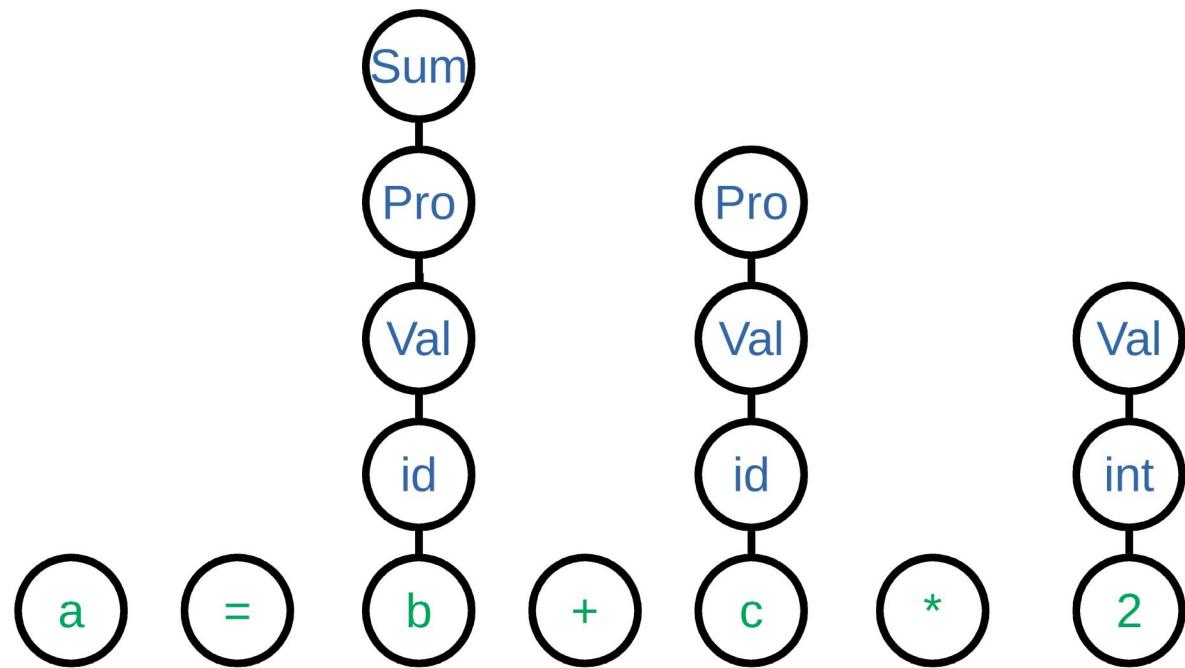


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

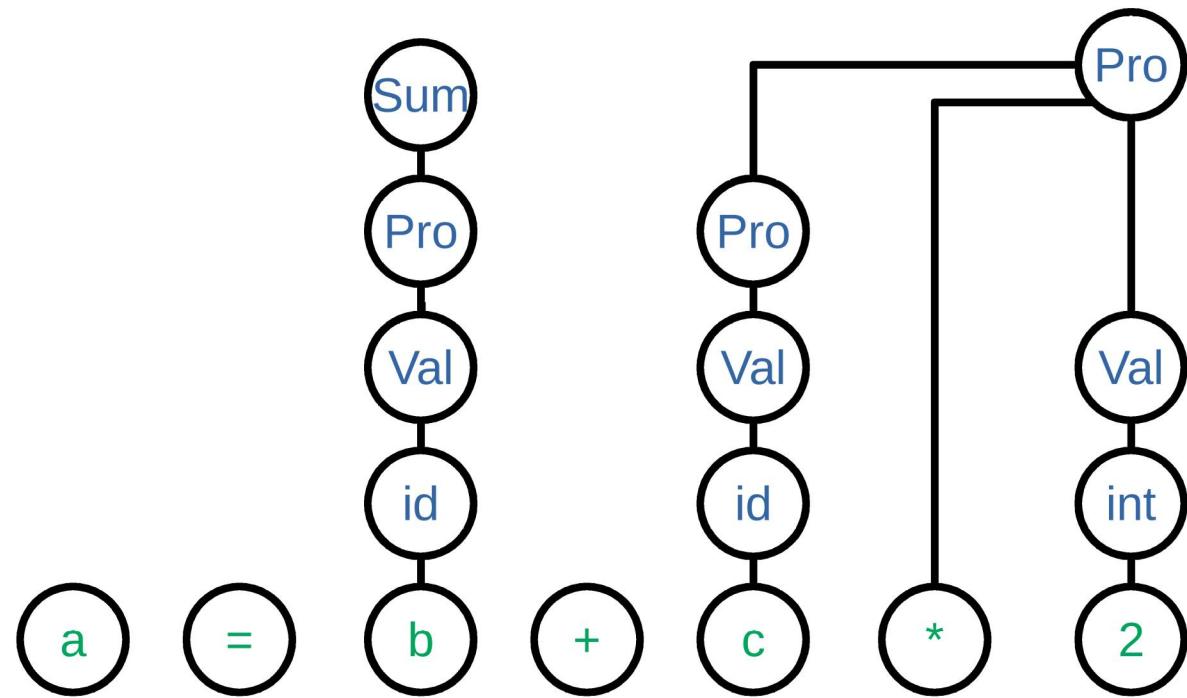


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

a = b + c * 2

REDUCE

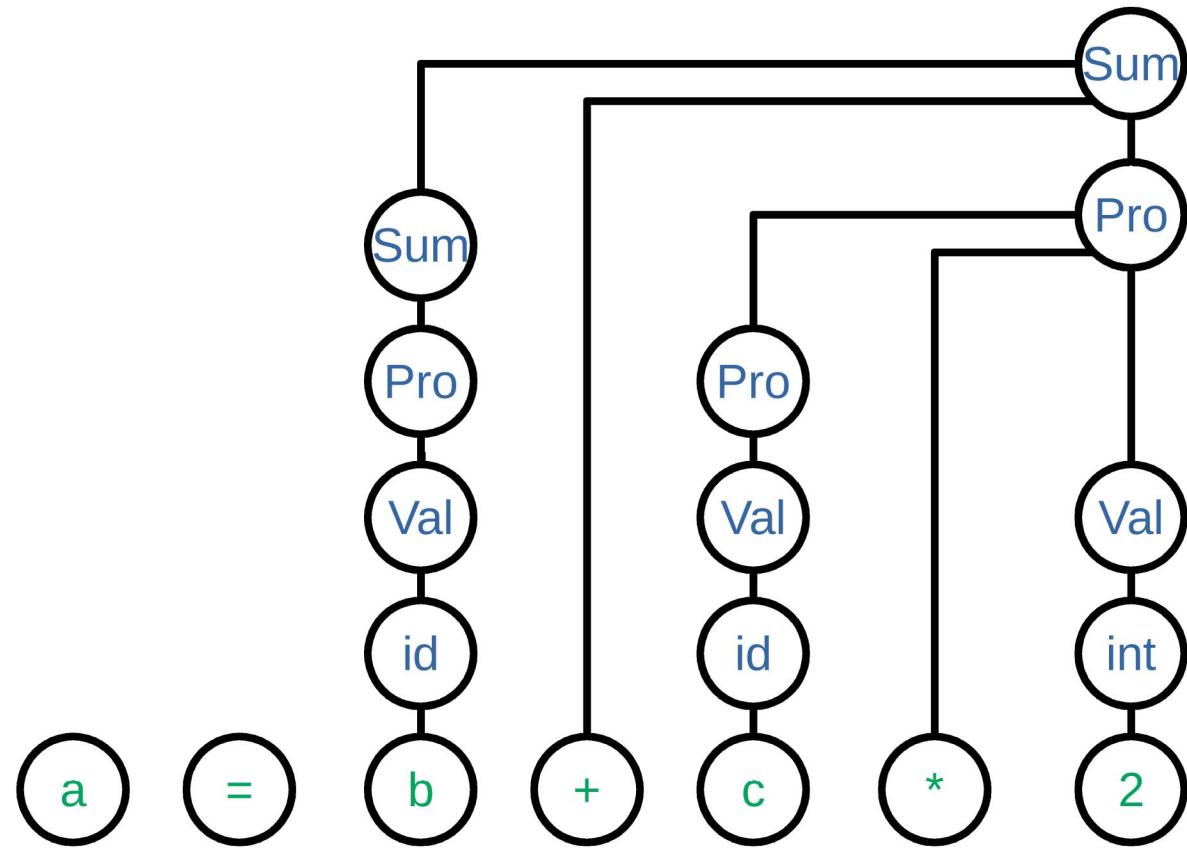


Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser

$a = b + c * 2$

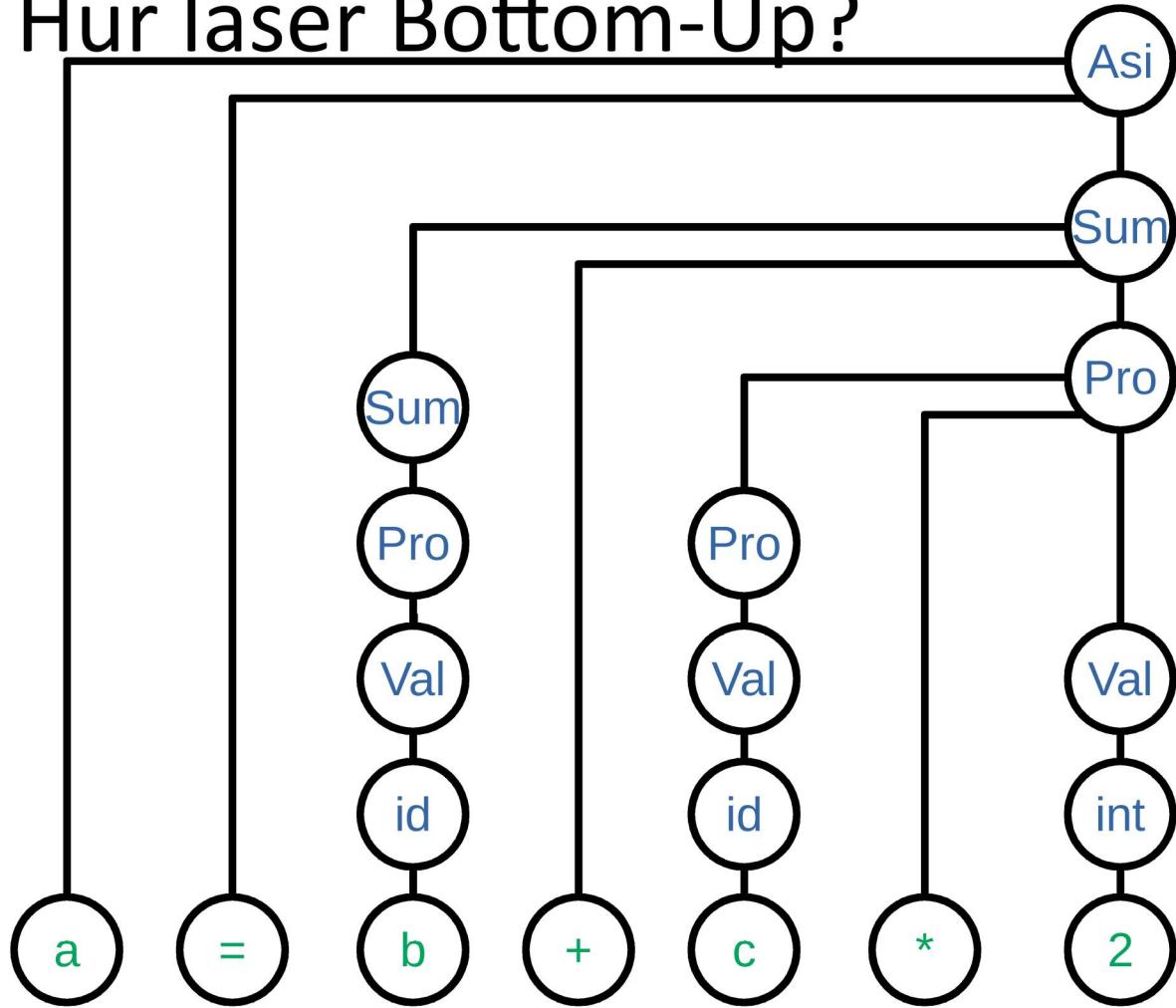
REDUCE



Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser
 $a = b + c * 2$

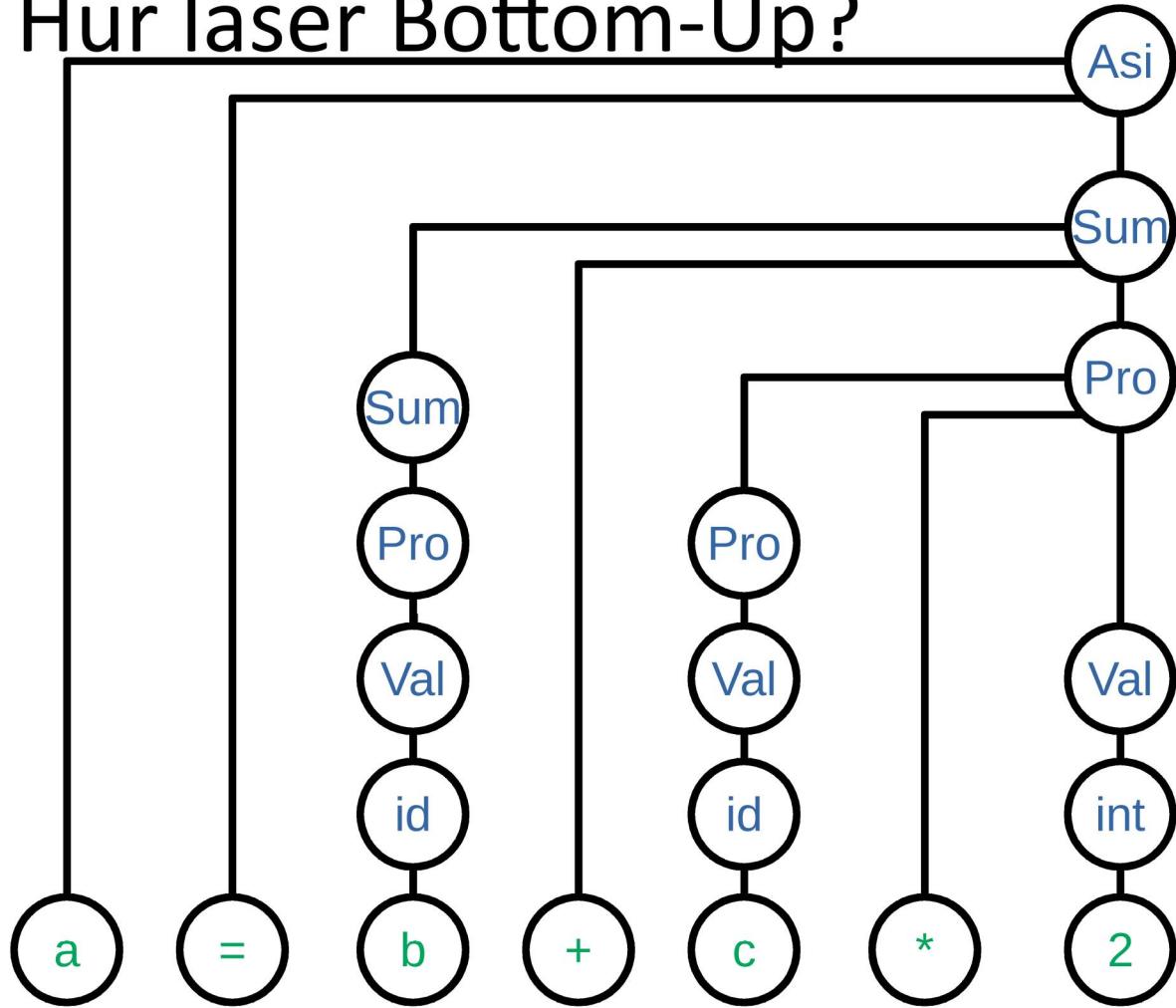
REDUCE



Bottom-Up | Hur läser Bottom-Up?

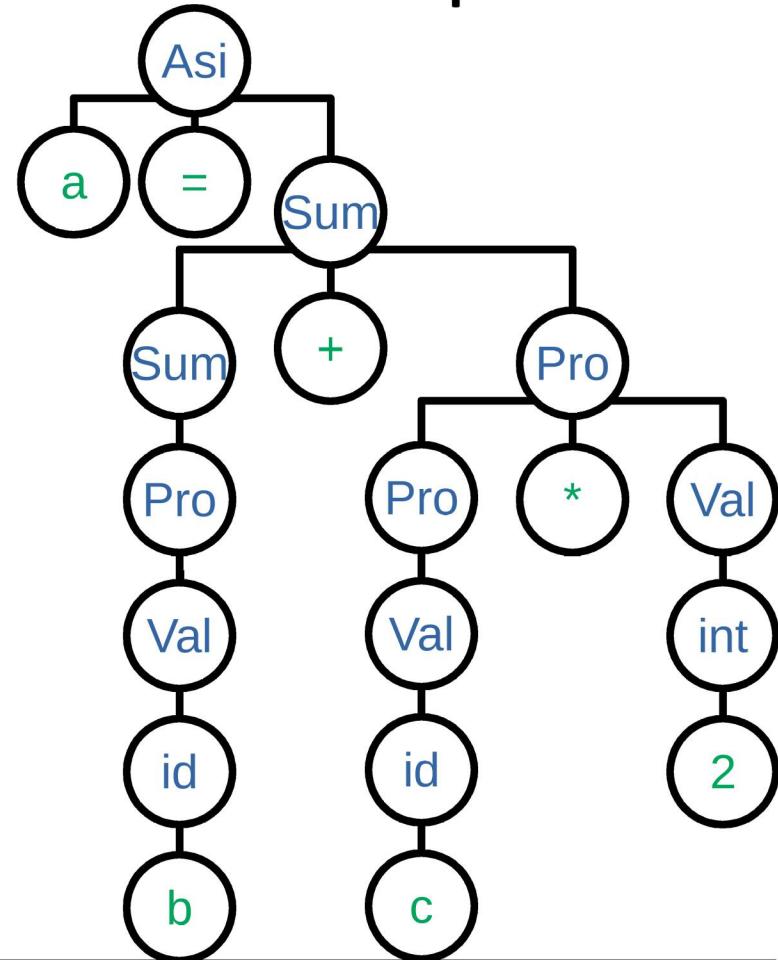
Shift-reduce parser
 $a = b + c * 2$

DONE



Bottom-Up | Hur läser Bottom-Up?

Shift-reduce parser
 $a = b + c * 2$



Övningar

Booleans

- Man vill ofta kunna skriva något liknande if-satser, or, and, etc i alla språk
- Exempelvis kan man då behöva parsa strängen:
a+b > 3 and x > y+z

`<C> ::= <AE> Comp <AE>`

`<Comp> ::= < | <= | >= | > | != | ==`

`<BE> ::= <BE> or <BT> | <BT>`

`<BT> ::= <BT> and <BF> | <BF>`

`<BF> ::= (<BE>) | <V> | true | false`

Övning: Hur kopplar man ihop
`<C>` med `<BE>/<BT>/<BF>` ?

Alltså lägg till eller ändra i de
existerande reglerna så att
strängen ovan går att köra.

Du kan anta att `<AE>` fungerar
helt

Syntaxträd

- 1) Rita syntaxträd för **a + b > 3 and (x > y or x==2)**
- 2) med unärt minus **(-1 - x)**
- 3) med negation (not) **x > y or not(x==2)**
- 4) med negation (not) **x > y or not(not(x==2))**
- 5) med exponent **x^y^z == x^(y^z)**

Palindrom - strängar

- Hur kan man matcha palindrom med grammatik?
- aabaa abcba abba aaaa
- Fungerar följande? Varför eller varför inte?

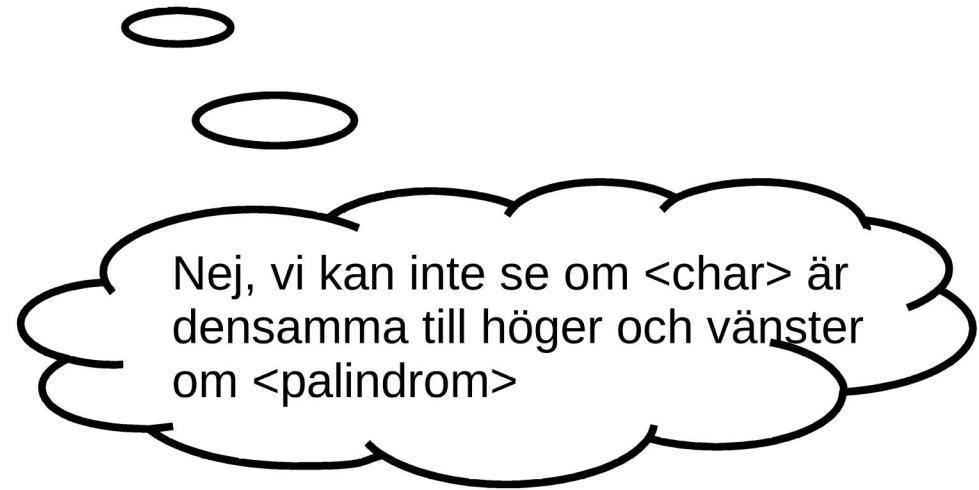
```
<palindrom> ::= <char> <palindrom> <char>
<char>          ::= a | b | c
```

Lösning på nästa sida

Palindrom - strängar

- Hur kan man matcha palindrom med grammatik?
- aabaa abcba abba aaaa
- Fungerar följande? Varför eller varför inte?

```
<palindrom> ::= <char> <palindrom> <char>
<char>       ::= a | b | c
```



Palindrom – strängar Lösning1

- Hur kan man matcha palindrom med grammatik?
- aabaa abcba abba aaaa
- Fungerar följande? Varför eller varför inte?

```
<palindrom> ::= <char> <palindrom> <char>
<char>       ::= a | b | c
```

Lösning1

Utöka parserna för att tillåta en speciell notation som försäkrar likheten

Palindrom – strängar Lösning1

- Hur kan man matcha palindrom med grammatik?
- aabaa abcba abba aaaa
- Fungerar följande? Varför eller varför inte?

```
<palindrom> ::= <char> <palindrom> <char>
<char>       ::= a|b|c
```

Lösning2

Skriv ut fallen

```
<palindrom> ::= 'a' <palindrom> 'a'
               | 'b' <palindrom> 'b'
               | 'b' <palindrom> 'b'
               | 'a' | 'b' | 'c' | <empty>
```

Palindrom – strängar Lösning1

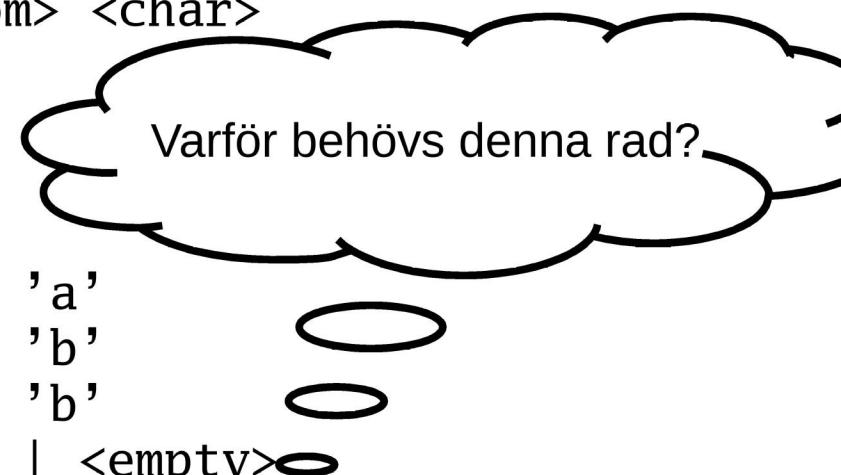
- Hur kan man matcha palindrom med grammatik?
- aabaa abcba abba aaaa
- Fungerar följande? Varför eller varför inte?

```
<palindrom> ::= <char> <palindrom> <char>
<char>       ::= a|b|c
```

Lösning2

Skriv ut fallen

```
<palindrom> ::= 'a' <palindrom> 'a'
              | 'b' <palindrom> 'b'
              | 'b' <palindrom> 'b'
              | 'a' | 'b' | 'c' | <empty>
```



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Lista

Lista (samma problem som parametrar)

- $\langle \text{list} \rangle ::= \text{slut}$
- | $\langle \text{element} \rangle \langle \text{lista} \rangle$
- | $\langle \text{lista} \rangle, \langle \text{lista} \rangle$
-
- $\langle \text{element} \rangle ::= 1 | 2$
-
- Ett underprogram för varje icketerminal, i någon form av pseudokod
- $\text{lista}() = \text{if "slut" then true;}$
- $\text{if element()} \text{ then lista();}$
- $\text{lista(); ','; lista();}$
-
- $\text{element}() = '1' \text{ or } '2';$