



Compilers

Handles

Bottom-up parsing uses two actions:

Shift

$ABC \mid xyz \Rightarrow ABCx \mid yz$

Reduce

$Cbxy \mid ijk \Rightarrow CbA \mid ijk$

- Left string can be implemented by a stack
 - Top of the stack is the |
- Shift pushes a terminal on the stack
- Reduce
 - pops 0 or more symbols off of the stack
 - production rhs
 - pushes a non-terminal on the stack
 - production lhs

- How do we decide when to shift or reduce?

- Example grammar:

$E \rightarrow T + E \mid T$

$T \rightarrow \text{int} * T \mid \text{int} \mid (E)$

- Consider step $\text{int} \mid * \text{int} + \text{int}$
 - We could reduce by $T \rightarrow \text{int}$ giving $T \mid * \text{int} + \text{int}$
 - A fatal mistake!
 - No way to reduce to the start symbol E

- Intuition: Want to reduce only if the result can still be reduced to the start symbol
- Assume a rightmost derivation

$$S \rightarrow^* \alpha X \omega \rightarrow \alpha \beta \omega$$

- Then $\alpha\beta$ is a *handle* of $\alpha\beta\omega$

- Handles formalize the intuition
 - A handle is a reduction that also allows further reductions back to the start symbol
- We only want to reduce at handles
- Note: We have said what a handle is, not how to find handles

Handles

Given the grammar at right, identify the handle for the following shift-reduce parse state: $E' + -id \mid + -(id + id)$

$$E \rightarrow E' \mid E' + E$$

$$E' \rightarrow -E' \mid id \mid (E)$$

- ☐ $E' + -id$
- ☐ id
- ☐ $-id$
- ☐ $E' + -E'$

Important Fact #2 about bottom-up parsing:

In shift-reduce parsing, handles appear only at the top of the stack, never inside

- Informal induction on # of reduce moves:
- True initially, stack is empty
- Immediately after reducing a handle
 - right-most non-terminal on top of the stack
 - next handle must be to right of right-most non-terminal, because this is a right-most derivation
 - Sequence of shift moves reaches next handle

- In shift-reduce parsing, handles always appear at the top of the stack
- Handles are never to the left of the rightmost non-terminal
 - Therefore, shift-reduce moves are sufficient; the need never move left
- Bottom-up parsing algorithms are based on recognizing handles