CS310

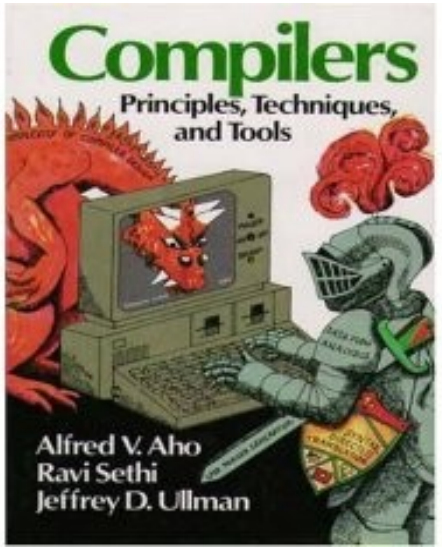
Parsing with Context Free Grammars

Today's reference:

Compilers: Principles, Techniques, and Tools

by: Aho, Sethi, Ullman

aka: The Dragon Book



Section 4.4

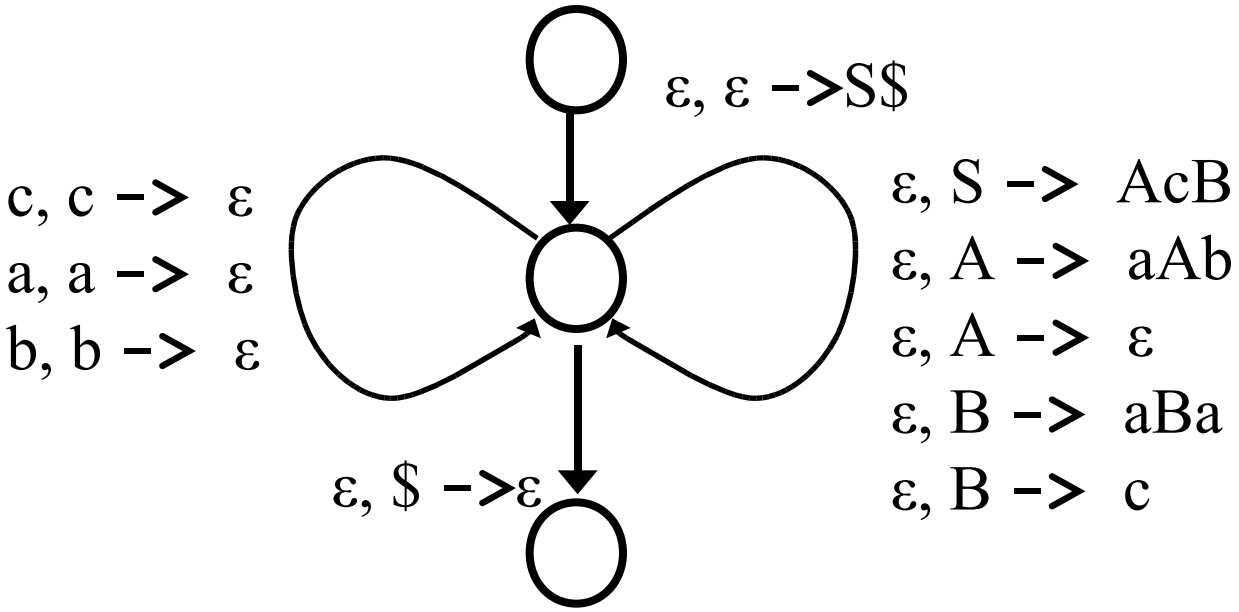
October 24, 2008

Parse Tables

Stack \ Input	a	b	c	$
S	1	-	1	
A	2	3	3	
B	4	-	5	

(1) S -> AcB
(2) A -> aAb
(3) A -> ε
(4) B -> aBb
(5) B -> c

- Let's think in terms of the PDA



FIRST

FIRST(X) = terminals that can begin strings derivable from X

X -*> av X -*> ε

FIRST(X) = {a, ε}

Algorithm

– x is a terminal or ε, FIRST(x) = {x}

– x is nonterminal x -> $x_1 \mid x_2 \mid .. \mid x_n$

$FIRST(x) = U_k FIRST(x_k)$

3) $x = x_1 x_2 .. x_n$ (concatenation)

$FIRST(x) = FIRST(x_1)$ U $FIRST(x_2)$ U $FIRST(x_3)$

if x_1 -*> ε if x_2 -*> ε

Example

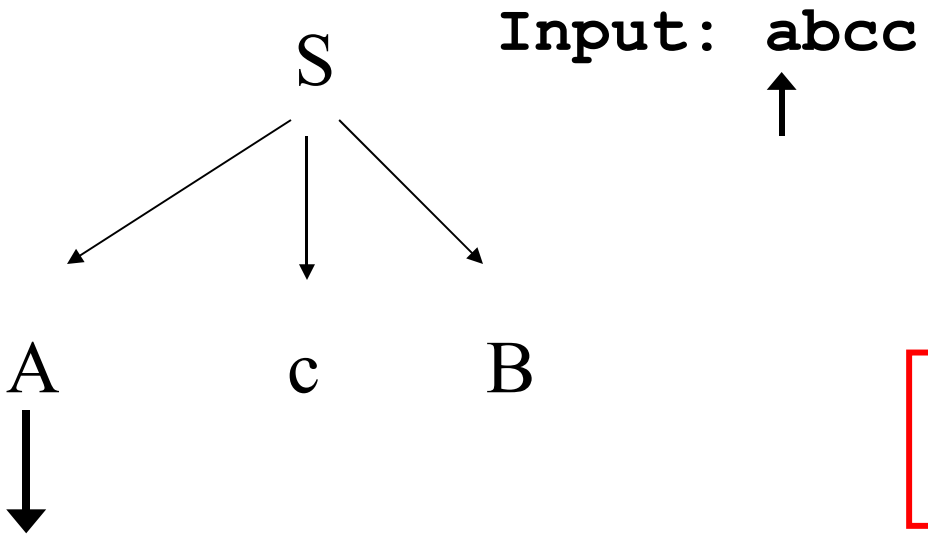
- FIRST(A) =
- FIRST(B) =
- FIRST(S) =
- FIRST(AcB) =
- FIRST(aAb) =
- FIRST(ε) =
- FIRST(aBa)
- FIRST(c) =

S -> AcB
A -> aAb
A -> ε
B -> aBb
B -> c

FOLLOW

When do we choose which rule to use to expand A?
(And avoid lots of backtracking.)

S -> AcB
A -> aAb
A -> ε
B -> aBb
B -> c



Base our choice on what could possibly follow A

FOLLOW

- For A ∈ V, FOLLOW(A) consists of *terminals*, immediately following A in any intermediate step in a derivation
  - ε is never in FOLLOW
- Algorithm

  1) A = S or A is rightmost symbol in any intermediate step then $ ∈ FOLLOW A.

  2) Q -> aAB, B ∈ {T, V}*, **A ∈ V**, Q ∈ V

     a) B begins with a terminal x, add x to FOLLOW(A)

     b) B = ε or B -*> ε include FOLLOW(Q) in FOLLOW(A)

Example

- FOLLOW(A) =
- FOLLOW(B) =
- FOLLOW(S) =

S -> AcB
A -> aAb
A -> ε
B -> aBb
B -> c

Constructing Parse Tables

- For X on the stack and input *a,* select a righthand replacement that begins with *a* or can lead to something beginning with *a*
- Algorithm

  For each X -> B

  a) For each a ∈ FIRST(B), add B to Parse(X, a)

  b) If ε ∈ FIRST(B), add B to Parse(X, b) for each b ∈ FOLLOW(X)

  c) If $ ∈ FOLLOW(X), Parse(X, $) = B

Parse Tables

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- Algorithm

  For each X -> B

  a) For each a ∈ FIRST(B), add B to Parse(X, a)

  b) If ε ∈ FIRST(B), add B to Parse(X, b) for each b ∈ FOLLOW(X)

Example

- Parse: abcacb

Top-Down Parsing

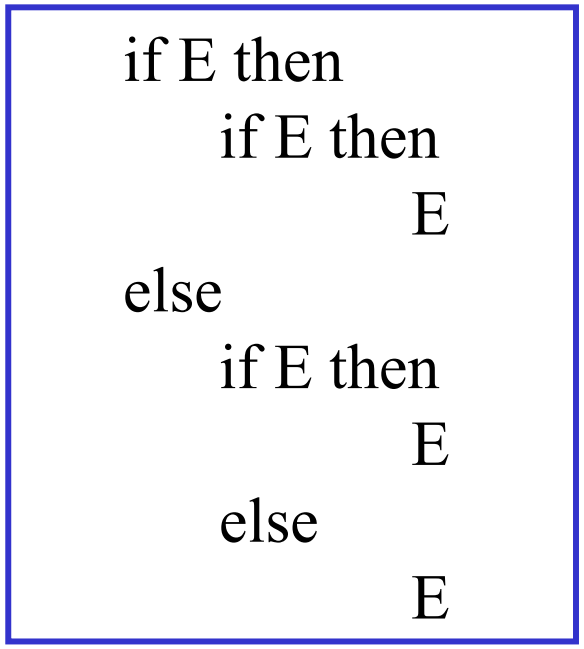
- LL(1) parser
  - parse from Left to right
  - produces a Leftmost derivation
    - always replace the left-most nonterminal first
  - with 1 lookahead symbol
- LL(1) Grammars
  - FIRST and FOLLOW uniquely determine which productions to use to parse a string
  - not all grammars are LL(1)
    - common prefixes
    - left recursion

Common Prefixes

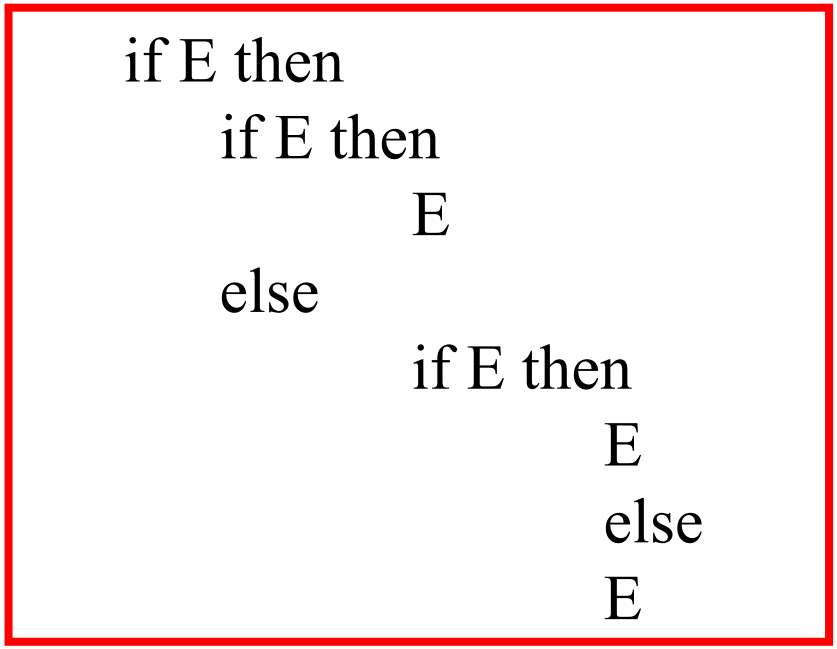
- Lead term not sufficient to decide how to expand a nonterminal

  S -> if E then S else S | if E then S | E

  Parse: if E then if E then E else if E then E else E



or



Remove Common Prefixes

Remove: $A \rightarrow aB_1 \mid aB_2 \mid Y$

Add: $A \rightarrow aT \mid Y$

$T \rightarrow B_1 \mid B_2$