CS310

Parsing with Context Free Grammars

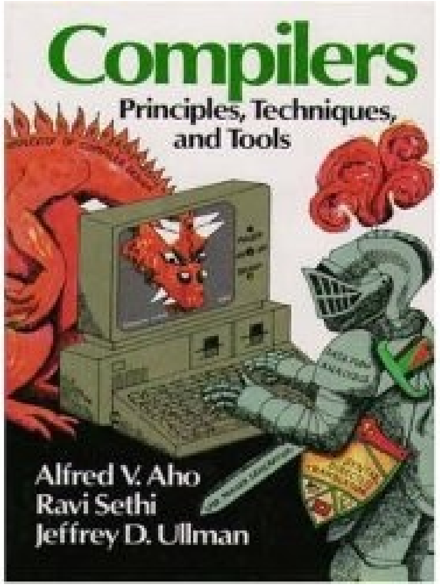
Today's reference:

Compilers: Principles, Techniques, and Tools

by: Aho, Sethi, Ullman

aka: The Dragon Book

ISBN: 0-201-10088-6



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Parsing

- Can a string, s, be generated by a grammar?
  - does source code conform to the C grammar?

- For any CFG, we can parse in **$O(n^3)$**, $n = |s|$
  - O(n) algorithms exist for languages that arise in practice
  - Single left to right scan with one look ahead character
- Top-down vs. Bottom-up
  - describes how you construct the parse tree

Parsing

Example
A -> 0A1
A -> B
B -> #

- Top-down
  - efficient parsers that are more easily constructed by hand
  - We will be concerned with these for now
- Bottom-up
  - handles a larger class of grammars
  - often used in software tools that produce a parser from a grammar

Top Down Parsing

- For some grammars, this can be done with a single left to right scan of the input
  - looking at a single character/token at a time
  - the *lookahead* character

TYPE -> SIMPLE
| id
| array [SIMPLE] of TYPE
SIMPLE -> integer
| char
| num dotdot num *

*from Aho, Sethi, Ullman

Let's build the parse tree

array [num dotdot num] of integer

Recursive-descent Parsing

- Top down parsing
  - execute a set of recursive procedures to parse
  - one procedure per nonterminal
- Predictive parsing
  - special case of Recursive-descent parsing
  - the lookahead character ***unambiguously*** determines how to choose the next step
    - not all grammars will work

Example

```
procedure type
begin

  if lookahead is in { integer, char, num } then
     simple()
  else if lookahead = id then
     match(id);
  else if lookahead = array then
     match(array); match([); simple; match(]);
     match(of); type;
  else
     error
  endif
end type
```

TYPE –> SIMPLE
| id
| array [SIMPLE] of TYPE

Left Recursion

T -> T a x | x

what does this produce?

- Left Recursive Grammar
- What would **`procedure type`** look like?
- Problem?

- Rewrite as *right recursive*

  T **->** x R

  R **->** ax R | ε

First

- The lookahead character ***unambiguously*** determines how to choose the next step

- We calculate FIRST(A)
- FIRST(A) is the set of characters that appear as the first symbols of one or more strings generated from A ♦
- For predictive parsing to work without backtracking when A->X and A ->Y exist, FIRST(X) and FIRST(Y) must be disjoint
  - Why?

♦from Aho, Sethi, Ullman

First

- What is FIRST() for each of the nonterminals?

```
TYPE -> SIMPLE
        | id
        | array [ SIMPLE ] of TYPE
SIMPLE -> integer
        | char
        | num dotdot num                    *
```

*from Aho, Sethi, Ullman

Simple Parse Table

- Instead of a function, we can build a table to tell us how to parse.

	(	)	0	1
S	2	-	1	1
Q	-	-	4	3

Parse Error!

(1) S -> Q
(2) S -> (S)
(3) Q -> 1
(4) Q -> 0

Build the Parse Table

Does the grammar need transformed?

(1) **S -> AB**

(2) **S -> B**

(3) **A -> a | cA**

(4) **B -> b | dB**

Parse the strings

ccadb

b

ddb