Class 8: Parsing: Top-down and Bottom-up

SI 413 - Programming Languages and Implementation

Dr. Daniel S. Roche

United States Naval Academy

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Structure of a Scanner

How does a scanner generation tool like flex actually work?
Structure of a Scanner

How does a scanner generation tool like flex actually work?

1. An NDFA is generated from each regular expression. Final states are marked according to which rule is used.

2. These NDFAs are combined into a single NDFA.

3. The big NDFA is converted into a DFA. *How are final states marked?*

4. The final DFA is minimized for efficiency. The DFA is usually represented in code with a *state-character array*.
Look-ahead in scanners

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But how can the DFA tell if it has the maximal munch?
Look-ahead in scanners

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But how can the DFA tell if it has the maximal munch?

Usually, just stop at a transition from accepting to non-accepting state. This requires one character of look-ahead.

Is this good enough for any set of tokens?
Parsing

Parsing is the second part of syntax analysis.

We use grammars to specify how tokens can combine. A parser uses the grammar to construct a parse tree with tokens at the leaves.

**Scanner**: Specified with regular expressions, generates a DFA

**Parser**: Specified with context-free grammar, generates a . . .
Parsing

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**Parser**: Specified with context-free grammar, generates a PDA
Generalize or Specialize?

Parsing a CFG \textit{deterministically} is hard: requires lots of computing time and space.

By (somewhat) restricting the class of CFGs, we can parse much faster.

For a program consisting of \( n \) tokens, we want \( O(n) \) time, using a single stack, and not too much look-ahead.
Parsing Strategies

**Top-Down Parsing:**
- Constructs parse tree starting at the root
- “Follow the arrows” — carry production rules forward
- Requires *predicting* which rule to apply for a given nonterminal.
- LL: Left-to-right, Leftmost derivation
Parsing Strategies

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**Bottom-Up Parsing:**
- Constructs parse tree starting at the leaves
- “Go against the flow” — apply reduction rules *backwards*
- Requires
- LR: Left-to-right, Rightmost derivation
Parsing example

Simple grammar

\[
\begin{align*}
S & \rightarrow T \ T \\
T & \rightarrow aa \\
T & \rightarrow bb
\end{align*}
\]

Parse the string \texttt{aabb}, top-down and bottom-up.
Handling Errors

How do scanning errors occur?
How can we handle them?

How do parsing errors occur?
How can we handle them?

“Real” scanners/parsers also tag *everything* with filename & line number to give programmers extra help.