Class 10: Shift-reduce Parsing and CFSMs

SI 413 - Programming Languages and Implementation

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Bottom-up Parsing

A bottom-up (LR) parser reads tokens from left to right and maintains a stack of terminal *and* non-terminal symbols.

At each step it does one of two things:

- **Shift**: Read in the next token and push it onto the stack
- **Reduce**: Recognize that the top of the stack is the r.h.s. of a production rule, and replace that r.h.s. by the l.h.s., which will be a non-terminal symbol.

The question is how to *build* an LR parser that applies these rules *systematically*, *deterministically*, and of course *quickly*.

Simple grammar for LR parsing

Consider the following example grammar:

$S \rightarrow E$
$E \rightarrow E + T$
$E \rightarrow T$
$T \rightarrow \texttt{n}$

Examine a bottom-up parse for the string `n + n`.

How can we model the "state" of the parser?

Parser states

At any point during parsing, we are trying to expand one or more production rules.

The state of a given (potential) expansion is represented by an "LR item".

For our example grammar we have the following LR items:

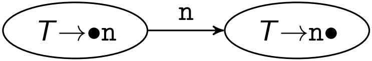
$$
\begin{array}{llll}
S & \rightarrow \bullet\ E & E & \rightarrow E + T\ \bullet \\
S & \rightarrow E\ \bullet & E & \rightarrow \bullet\ T \\
E & \rightarrow \bullet\ E + T & E & \rightarrow T\ \bullet \\
E & \rightarrow E\ \bullet + T & T & \rightarrow \bullet\ \mathtt{n} \\
E & \rightarrow E + \bullet\ T & T & \rightarrow \mathtt{n}\ \bullet
\end{array}
$$

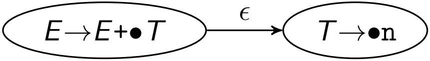
The $\bullet$ represents "where we are" in expanding that production.

Pieces of the CFSM

The CSFM (Characteristic Finite State Machine) is a FA representing the *transitions* between the LR item "states".

There are two types of transitions:

- **Shift**: consume a terminal *or non-terminal* symbol and move the • to the right by one.
  Example: 

- **Closure**: If the • is to the left of a non-terminal, we have an ϵ-transition to any production of that non-terminal with the • all the way to the left.
  Example: 

Nondeterministic CFSM for example grammar