RECURSIVE DESCENT PARSER

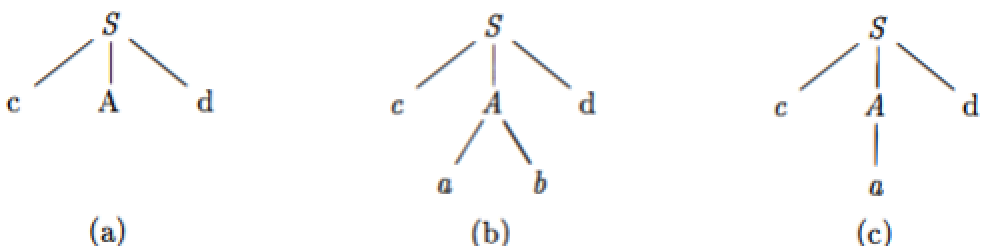
- These parsers use a procedure for each nonterminal. The procedure looks at its input and decides which production to apply for its nonterminal.
- Terminals in the body of the production are matched to the input at the appropriate time, while nonterminals in the body result in calls to their procedure.
- General recursive-descent may require backtracking; that is, it may require repeated scans over the input. However, backtracking is rarely needed to parse programming language constructs.

Example : Consider the grammar

$S \rightarrow cAd$

$A \rightarrow ab \mid a$

To construct a parse tree top-down for the input string w = cad



Step 1:

- Initially create a tree with single node labeled S. An input pointer points to ‘c’, the first symbol of w. Expand the tree with the production of S.

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Step 2:

- The leftmost leaf ‘c’ matches the first symbol of w, so advance the input pointer to the second symbol of w ‘a’ and consider the next leaf ‘A’.

Step 3:

- The second symbol ‘a’ of w also matches with second leaf of tree. So advance the input pointer to third symbol of w ‘d’. But the third leaf of tree is b which does not match with the input symbol d.

Hence discard the chosen production and reset the pointer to second position. This is called backtracking.

FIRST( ) & FOLLOW( ):

- First(α) is defined as set of terminals that begins strings derived from α.
- If $\alpha \overset{*}{\Rightarrow} \epsilon$, then ε is also in First(α)
- In predictive parsing when we have A-> α|β, if First(α) and First(β) are disjoint sets then we can select appropriate A-production by looking at the next input.
- Follow(A), for any nonterminal A, is set of terminals a that can appear immediately after A in some sentential form.

Algorithm to compute FIRST(X)

To compute **FIRST(X)** for all grammar symbols X, apply the following rules until no more terminals or ε can be added to any FIRST set.

1. If X is a terminal, then FIRST(X) = {X}.
2. If X is a nonterminal and X → $Y_1Y_2...Y_k$ is a production for some k≥1, then place a in FIRST(X) if for some i, a is in FIRST(Y_i), and **ε** is in all of FIRST(Y_1),..., FIRST(Y_{i-1}); that is, $Y_1 \cdots Y_{i-1} \overset{*}{\Rightarrow} \epsilon$. (If **ε** is in FIRST($Y_j$) for all j = 1,2, . . . , k, then add **ε** to FIRST(X). For example, everything in FIRST(Y_1) is surely in FIRST(X). If Y_l does not derive **ε**, then we add nothing more to FIRST(X), but if $Y_1 \overset{*}{\Rightarrow} \epsilon$, then we add F1RST($Y_2$), and So on.
3. If X→ **ε** is a production, then add **ε** to FIRST(X).

Algorithm to compute FOLLOW(A)

To compute **FOLLOW(A)** for all non-terminals A, apply the following rules until nothing can be added to any FOLLOW set.

1. Place $ in FOLLOW(S), where S is the start symbol, and $ is the input right endmarker.
2. If there is a production A→αBβ, then everything in FIRST(β) except **ε** is in FOLLOW(B).
3. If there is a production A→αB, or a production A→αBβ, where FIRST(β) contains **ε**, then everything in FOLLOW (A) is in FOLLOW (B).

Example : To compute FIRST and FOLLOW

Consider again the non-left-recursive grammar

E →TE'

E' →+ T E' | ε

T →F T'

T' →* F T' | ε

F →(E) | id

- FIRST(F) = FIRST(T) = FIRST(E) = {(, id}. To see why, note that the two productions for F have bodies that start with these two terminal symbols, id and the left parenthesis. T has only one production, and its body starts with F. Since F does not derive ε, FIRST(T) must be the same as FIRST(F). The same argument covers FIRST(E).
- FIRST(E') = {+, ε }. The reason is that one of the two productions for E' has a body that begins with terminal +, and the other's body is ε. Whenever a nonterminal derives ε, we place ε in FIRST for that nonterminal.
- FIRST(T') = {* , t}. The reasoning is analogous to that for FIRST(E').
- FOLLOW(E) = FOLLOW(E') = {), $}. Since E is the start symbol, FOLLOW(E) must contain $. The production body (E) explains why the right parenthesis is in FOLLOW(E) . For E' , note that this nonterminal appears only at the ends of bodies of E-productions. Thus, FOLLOW(E') must be the same as FOLLOW(E).
- FOLLOW(T) = FOLLOW(T') = {+,), $}. Notice that T appears in bodies only followed by E' . Thus, everything except ε that is in FIRST(E') must be in FOLLOW(T) ; that explains the symbol +.

PREDICTIVE PARSER – LL(1) PARSER

- Predictive parsing is a special case of recursive descent parsing where no backtracking is required.

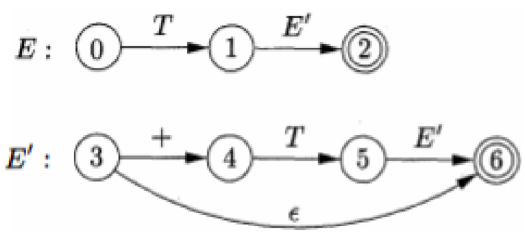
- The key problem of predictive parsing is to determine the production to be applied for a non-terminal in case of alternatives.
- This parser looks up the production in parsing table.
- The table-driven predictive parser has an input buffer, stack, a parsing table and an output stream.

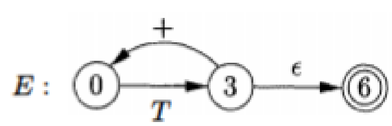
Transition Diagrams for Predictive Parsers:

- Transition diagrams are useful for visualizing predictive parsers.
- For example, the transition diagrams for nonterminals E and E' of expression grammar

E → TE'
E' → + T E' | ε
T → F T'
T' → * F T' | ε
F → (E) | id

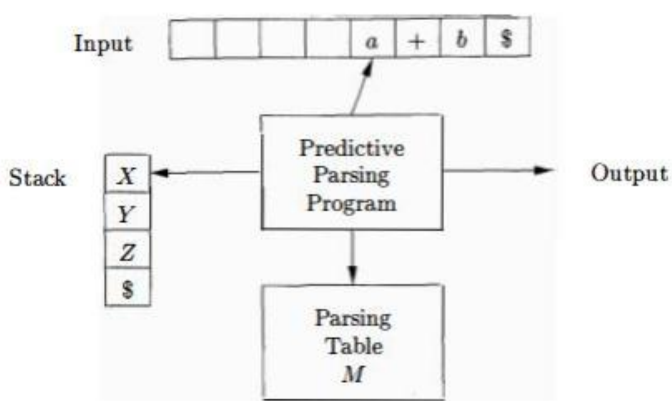
- To construct the transition diagram from a grammar, first eliminate left recursion and then left factor the grammar.
- Transition diagrams for predictive parsers differ from those for lexical analyzers.
- Parsers have one diagram for each nonterminal.
- The labels of edges can be tokens or nonterminals.
- A transition on a token (terminal) means that we take that transition if that token is the next input symbol.





Predictive Parsing Program:

The predictive parser has an input, a stack, a parsing Table and an output.



Input: Contains the string to be parsed, followed by right end marker $.
Stack: Contains a sequence of grammar symbols, preceded by $, the bottom of stack marker. Initially the stack contains the start symbol of the grammar preceded by $.
Parsing Table: It is a two dimensional array M[A,a], where A is a non-terminal and a is a terminal or $.
Output: Gives the output whether the string is valid or not.