Unit 9. Recursive descent parsing

Characteristics

- Used to parse LL(1) language
- Can be extended for parsing LL(k) grammars, but algorithms are complicated
- Parsing non LL(k) grammars can cause infinite loops

Recursive-descent parsing

- A top-down parsing method
- The term *descent* refers to the direction in which the parse tree is traversed (or built).
- Use a set of *mutually recursive* procedures (one procedure for each nonterminal symbol)
  - Start the parsing process by calling the procedure that corresponds to the start symbol
  - Each production becomes one branch in procedure for its LHS
- We consider a special type of recursive-descent parsing called predictive parsing
  - Use a lookahead symbol to decide which production to use

Recursive Descent Parsing

- For every BNF rule (production) of the form

  <phrase1> → E

  the parser defines a function to parse phrase1 whose body is to parse the rule E

```
void compilePhrase1( )
{   /* parse the rule E */   }
```

- Where E consists of a sequence of non-terminal and terminal symbols
- Requires no left recursion in the grammar.

Parsing a rule

- A sequence of non-terminal and terminal symbols,

  $Y_1\ Y_2\ Y_3 \dots Y_n$

  is recognized by parsing each symbol in turn
- For each non-terminal symbol, Y, call the corresponding parse function compileY
- For each terminal symbol, y, call a function

  eat(y)

  that will check if y is the next symbol in the source program
  - The terminal symbols are the token types from the lexical analyzer
  - If the variable currentsymbol always contains the next token:

```
eat(y):
    if (currentsymbol == y)
    then getNextToken()
    else SyntaxError()
```

Simple parse function example

- Suppose that there was a grammar rule
  `Prog ::= KW_PROGRAM Ident SB_SEMICOLON Block SB_PERIOD`
- Then:

```
void compileProgram(void)
{
  eat(KW_PROGRAM);
  eat(TK_IDENT);
  eat(SB_SEMICOLON);
  compileBlock();
  eat(SB_PERIOD);
}
```

Look-Ahead

- In general, one non-terminal may have more than one production, so more than one function should be written to parse that non-terminal.
- Instead, we insist that we can decide which rule to parse just by looking ahead one symbol in the input

```
BasicType ::= KW_INTEGER | KW_CHAR
```

Then compileBasicType can have the form

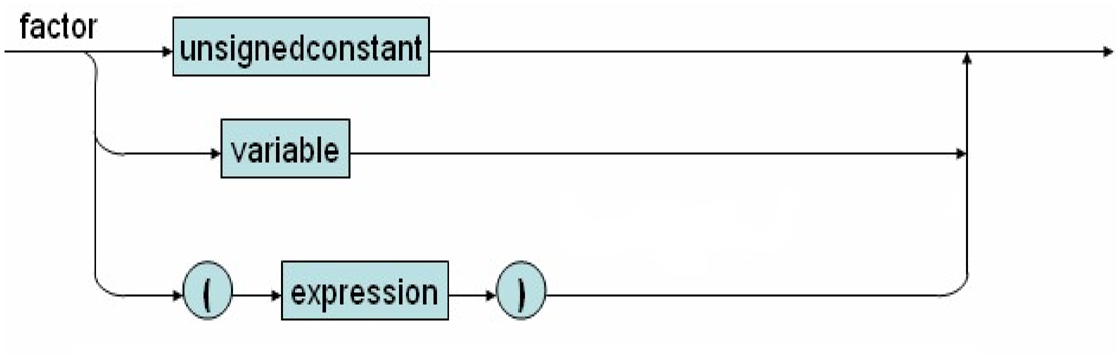
```
switch (lookAhead->tokenType) {
case KW_INTEGER:
  eat(KW_INTEGER);
  break;
case KW_CHAR:
  eat(KW_CHAR);
  break;
default:
  error(ERR_INVALIDBASICTYPE, lookAhead->lineNo, lookAhead->colNo);
  break;
}
}
```

KPL Parser

- Can be built using BNF rules or syntax diagrams
- Use syntax diagrams: consists of 13 functions, each function for a syntax diagram
- Use BNF rules: consist of approximate 50 functions, each function for a variable (non-terminal symbol)

Compile factor function

```
void compileFactor(void) {
  switch (lookAhead->tokenType) {
  case TK_NUMBER:
    eat(TK_NUMBER);
    break;
  case TK_CHAR:
    eat(TK_CHAR);
    break;
  case TK_IDENT:
    eat(TK_IDENT);
    switch (lookAhead->tokenType) {
    case SB_LSEL:
      compileIndexes();
      break;
    case SB_LPAR:
      compileArguments();
      break;
    default: break;
    }
    break;
```




```
 case SB_LPAR:
   eat(SB_LPAR);
   compileExpression();
   eat(SB_RPAR);
   break;
  default:
   error(ERR_INVALIDFACTOR,
lookAhead->lineNo, lookAhead->colNo);
  }
}
```

compileTerm function (Use BNF)

Rules for term

```
82) Term ::= Factor Term2

83) Term2 ::= SB_TIMES Factor Term2
84) Term2 ::= SB_SLASH Factor Term2
85) Term2 ::= ε
```

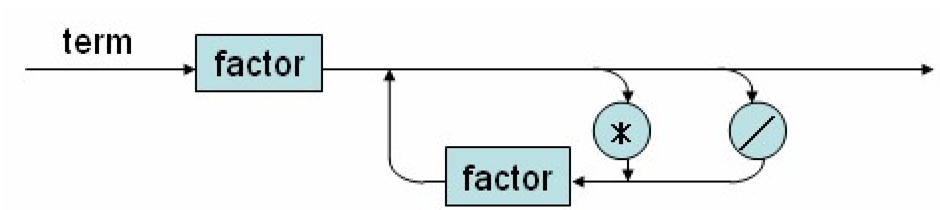
compileTerm and compileTerm2 functions

```
void compileTerm(void) {
  compileFactor();
  compileTerm2();
}
void compileTerm2(void) {
  switch (lookAhead->tokenType) {
  case SB_TIMES:
    eat(SB_TIMES);
    compileFactor();
    compileTerm2();
    break;
  case SB_SLASH:
    eat(SB_SLASH);
    compileFactor();
    compileTerm2();
    break;
```

```
  // check the FOLLOW set
  case SB_PLUS:
  case SB_MINUS:
  case KW_TO:
  case KW_DO:
  case SB_RPAR:
  case SB_COMMA:
  case SB_EQ:
  case SB_NEQ:
  case SB_LE:
  case SB_LT:
  case SB_GE:
  case SB_GT:
  case SB_RSEL:
  case SB_SEMICOLON:
  case KW_END:
  case KW_ELSE:
  case KW_THEN:
    break;
  default:
    error(ERR_INVALIDTERM, lookAhead->lineNo, lookAhead->colNo);
  }
}
```

CompileTerm function (Use SD)

```
void compileTerm(void)
{
    compileFactor();
    while(lookAhead->tokenType== SB_TIMES ||
    lookAhead->tokenType == SB_SLASH)
{switch (lookAhead->tokenType)
{
  case SB_TIMES:
    eat(SB_TIMES);
    compileFactor();
    break;
  case SB_SLASH:
    eat(SB_SLASH);
    break;
}
```



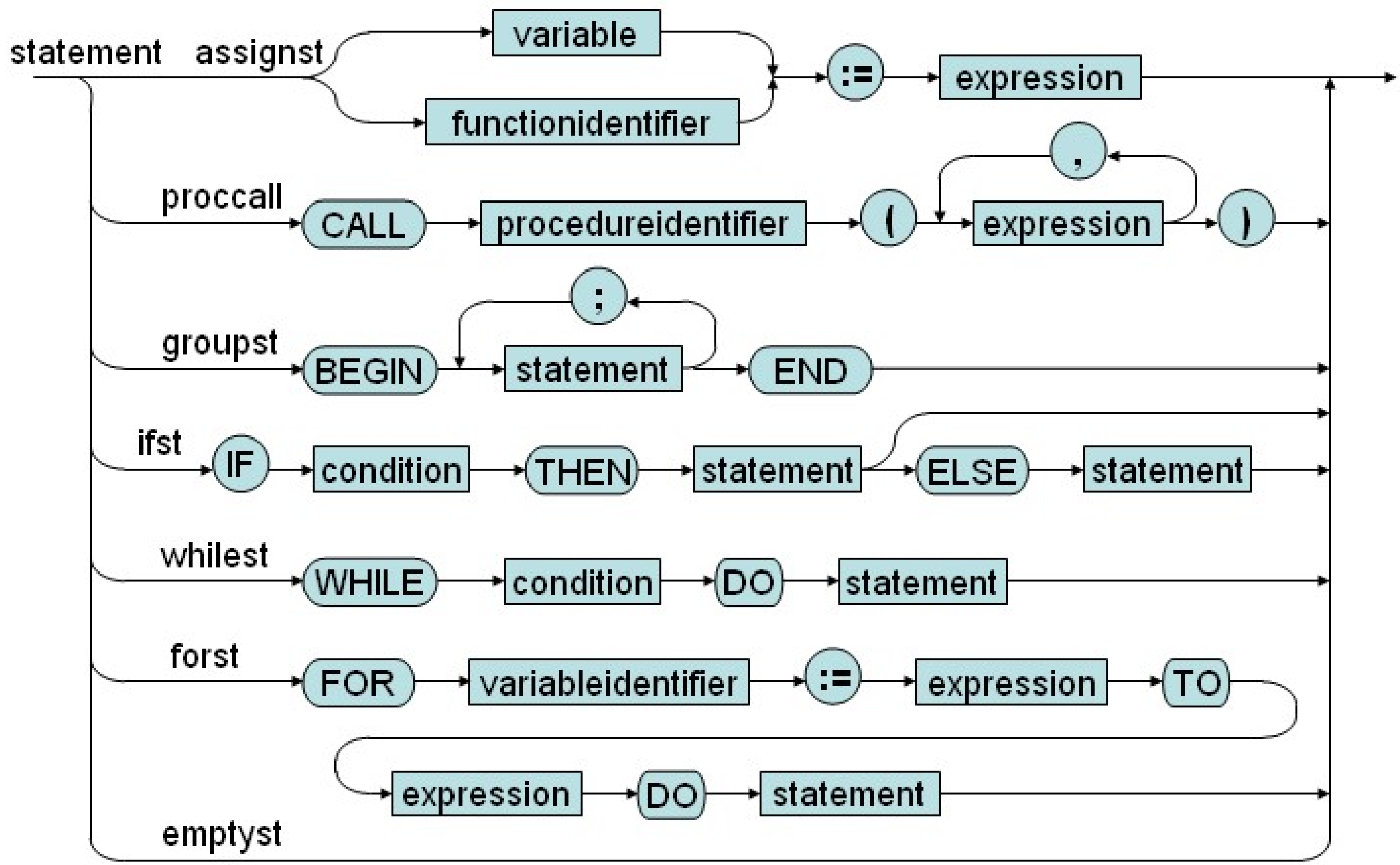
Statement

```
49) Statement ::= AssignSt
50) Statement ::= CallSt
51) Statement ::= GroupSt
52) Statement ::= IfSt
53) Statement ::= WhileSt
54) Statement ::= ForSt
55) Statement ::= ε
```

compileStatement function (using BNF)

```
void compileStatement(void) {
 switch (lookAhead->tokenType) {
 case TK_IDENT:
   compileAssignSt();
   break;
 case KW_CALL:
   compileCallSt();
   break;
 case KW_BEGIN:
   compileGroupSt();
   break;
 case KW_IF:
   compileIfSt();
   break;
 case KW_WHILE:
   compileWhileSt();
   break;
 case KW_FOR:
   compileForSt();
   break;
 // EmptySt needs to check FOLLOW tokens
 case SB_SEMICOLON:
 case KW_END:
 case KW_ELSE:
   break;
   // Error occurs
 default:
   error(ERR_INVALIDSTATEMENT, lookAhead->lineNo, lookAhead->colNo);
   break;
 }
}
```

Syntax diagram for statement



compileStatement function (using SD)

```
void compileStatement(void) {
  switch (lookAhead->tokenType) {
case TK_IDENT:
 eat(TK_IDENT);
 while (lookAhead->tokenType==SB_LSEL)
    {eat(SB_LSEL);
    compileExpression();
    eat(SB_RSEL); }
  eat(SB_ASSIGN);
  compileExpression();
  break;
 case KW_CALL:
 eat(KW_CALL);
  eat(TK_IDENT);
if (lookAhead->tokenType== SB_LPAR)
    eat(SB_LPAR);
    compileExpression();
    while (lookAhead->tokenType== SB_COMMA)
      {eat (SB_COMMA);
      compileExpression();}
    eat(SB_RPAR);
    // Check FOLLOW set …………….
break;
 case KW_BEGIN:……
   break;
  case KW_IF:……..
   break;
  case KW_WHILE:………
   break;
  case KW_FOR:……….
   break;
// EmptySt needs to check FOLLOW tokens
  case SB_SEMICOLON:
  case KW_END:
  case KW_ELSE:
   break;
   // Error occurs
  default:
   error(ERR_INVALIDSTATEMENT, lookAhead->lineNo,
lookAhead->colNo);
   break;
  }
}
```