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Generating Code for Arithmetic Expressions

COP-3402 Systems Software

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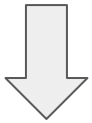
- go through parsing
- go through code generation
- print -5 + 2 * 3;
- print 3 * ((4 - 1) * (7) + 50 / (2 - 4));

Expressions Use Intermediate Values

- Project 0: statements only have one operation
- Project 1: arbitrary expressions use many
- LLVM IR (and machine code): one operation at a time
- Compiler needs to emit and store each operation

Expressions Use Intermediate Values

```
print -5 + 2 * 3;
```



```
%t1 = mul nsw i32 2, 3
%t2 = add nsw i32 -5, %t1
call void @print_integer(i32 %t2)
```

Predictive Parsing Grammar

- Remove left recursion
- Parsing begins at starting symbol
- Parser choose a production at each step
- Parser uses a token lookahead to predict

```
expression
  = term expression_prime

expression_prime
  = PLUS term expression_prime
  | epsilon

term
  = factor term_prime

term_prime
  = TIMES factor term_prime
  | epsilon

factor
  = LPAREN expression RPAREN
  | NUMBER
```

Recursive Descent Parsing

- Each nonterminal is a function
- Each function body contains the productions
- Use lookahead to predict production
- Parse the production by either
  - consuming a token
  - calling the next nonterminal

```
expression():
  term()
  expression_prime()

expression_prime():
  if (next is PLUS):
    consume PLUS
    term()
    expression_prime()
  else:
    // do nothing for epsilon

factor()
  if (next is LPAREN):
    consume LPAREN
    expression()
    consume RPAREN
  elif (next is NUMBER):
    consume NUMBER
  else: error()
```

Adding Code Generation

- Get parsing working first
- Add code that
  - Collects values
  - Generate temps
  - Emits code
- Create temps for nested expressions

```
expression():
  left = term()
  result = expression_prime(left)
  return result

expression_prime(left):
  if (next is PLUS):
    consume PLUS
    right = term()
    result = newtemp()
    emit result " = add " left ", " right
    return expression_prime(result)
  else:
    // do nothing for epsilon
    return left
```

Demo: Parsing and Code Generation

```
print -5;
print -5 + 2;
print -5 + 2 * 3;
print (-5 + 2) * 3;
```