Lecture 20:

- Semantic Analysis (cont)

Announcements:

- HW-3 due
- HW-4 out
- Proj Part 1 due Mon after Spring Break
- Quiz 5 Fri (visitor pattern, type checking basics)

The `SemanticChecker` implements the visitor pattern

- includes a symbol table and the "current" inferred type (as `DataType`)

Basic layout:

```
class SemanticChecker(Visitor):

    def __init__(self):
        self.structs = {}               # struct name -> StructDef
        self.functions = {}             # fun name -> FunDef
        self.symbol_table = SymbolTable()
        self.curr_type = None           # AST DataType object

    ... additional helpers ...
```

Inferred types recorded in `curr_type` member variable

Recall the AST DataType class:

```
@dataclass
class DataType:
    is_array: bool
    type_name: Token
    def accept(self, visitor):
        visitor.visit_data_type(self)
```

Example for simple (literal) rvalues:

```
def visit_simple_rvalue(self, simple_rvalue):
    val = simple_rvalue.value
    line = val.line
    col = val.column
    type_token = None
    if val.token_type == TokenType.INT_VAL:
        type_token = Token(TokenType.INT_TYPE, 'int', line, col)
    elif val.token_type == TokenType.DOUBLE_VAL:
        type_token = Token(TokenType.DOUBLE_TYPE, 'double', line, col)
    elif val.token_type == TokenType.STRING_VAL:
        type_token = Token(TokenType.STRING_TYPE, 'string', line, col)
    elif val.token_type == TokenType.BOOL_VAL:
        type_token = Token(TokenType.BOOL_TYPE, 'bool', line, col)
    elif val.token_type == TokenType.NULL_VAL:
        type_token = Token(TokenType.VOID_TYPE, 'void', line, col)
    self.curr_type = DataType(False, type_token)
```

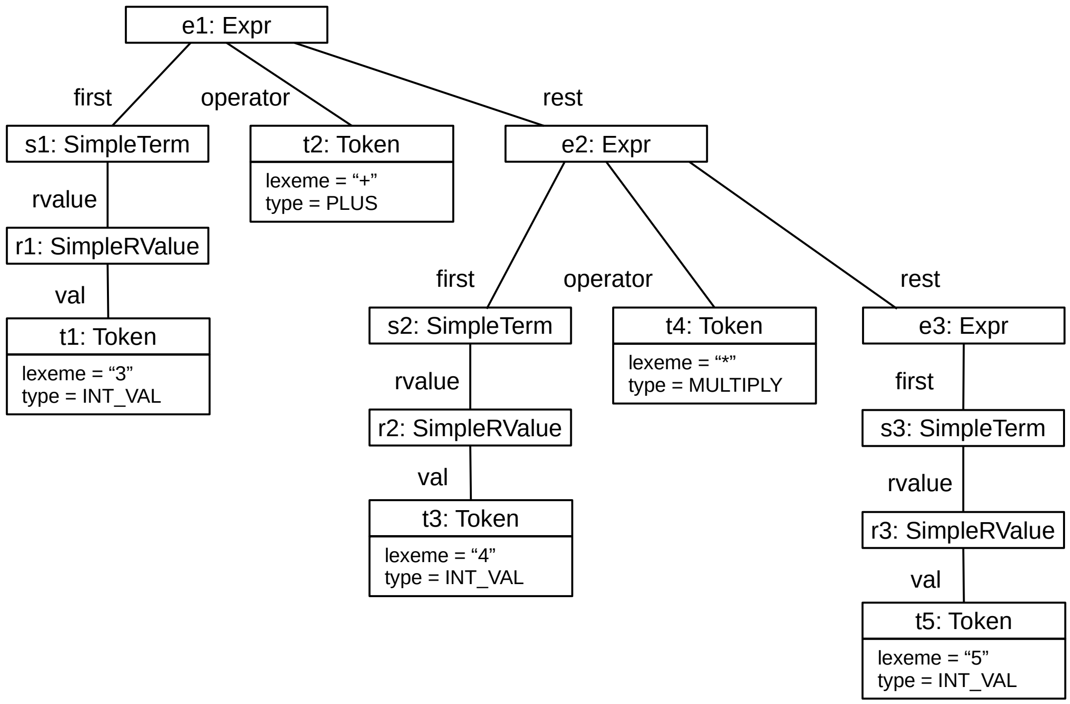
Inferred types help check more complex statements and expressions

For example, part of expression checking:

```
def visit_expr(self, expr)
  # check the first term
  expr.first.accept(self)
  # record the lhs type
  lhs_type = self.curr_type
  # check if more to expression
  if expr.op:
      # check rest of expression
      expr.rest.accept(self)
      # record the rhs type
      rhs_type = self.curr_type

      # ... check lhs and rhs against op, set new curr_type ...

  # check not operation
  if expr.not_op:

      # ... ensure bool type ...
```

More Involved Expression Example ...

AST fragment for the complex expression `3 + 4 * 5`



High-level overview of the basic steps:

1. **`accept`** called on **`e1`**, which calls **`visit`** function
2. **`accept`** called on **`s1`**, calls **`visit`**, eventually sets **`curr_type`** (as **`int`**)
3. store **`curr_type`** in temporary **`lhs_type`**
4. **`accept`** called on **`e2`**, calls **`visit`**, eventually sets **`curr_type`** (as **`int`**)
5. store **`curr_type`** in temporary **`rhs_type`**
6. check that **`rhs_type`** and **`rhs_type`** are compatible with operator
7. check if the expression is logically negated (requires **`bool`** expression)
8. update **`curr_type`** to new inferred type (in this case, **`int`**)

Type Inference Rules

Purpose

- like grammar rules, give rules for infering types
- the "legal" inferences (from which implies type errors)
- not all semantic errors captured (e.g., shadowing, use-before-def)

Basics

- "$e : t$" states that expression e has type t ... e.g., `42 : int`
- Γ denotes the typing context (the environment)
- $\vdash$ stands for "implies"
- $\Gamma \vdash e : t$ means it is implied from the given typing context that e has type t

An example typing rule (not from `MyPL`) ...

$$\frac{\Gamma \vdash e_1 : t \quad \Gamma \vdash e_2 : t}{\Gamma \vdash e_1 + e_2 : t}$$

"If expressions e_1 and e_2 have type t in the current context, then expression $e_1 + e_2$ has the type t as well

- typing rules allow us to infer the types of complex expressions
- which help us to assign types to names
- and type check statements

For MyPL: `www.cs.gonzaga.edu/bowers/courses/cpsc326/type-rules.pdf`