Check-In

Scope Review

Does this program compile in a static scoping scheme? In a dynamic scoping scheme? What is the output for each scheme in which it compiles?

```
a : int;
v : () void {
    a = a + 1;
    give a;
}
w : () void {
    a = 7;
    v();
    give a;
}
main : () void {
    int a;
    w();
    give a;
}
```

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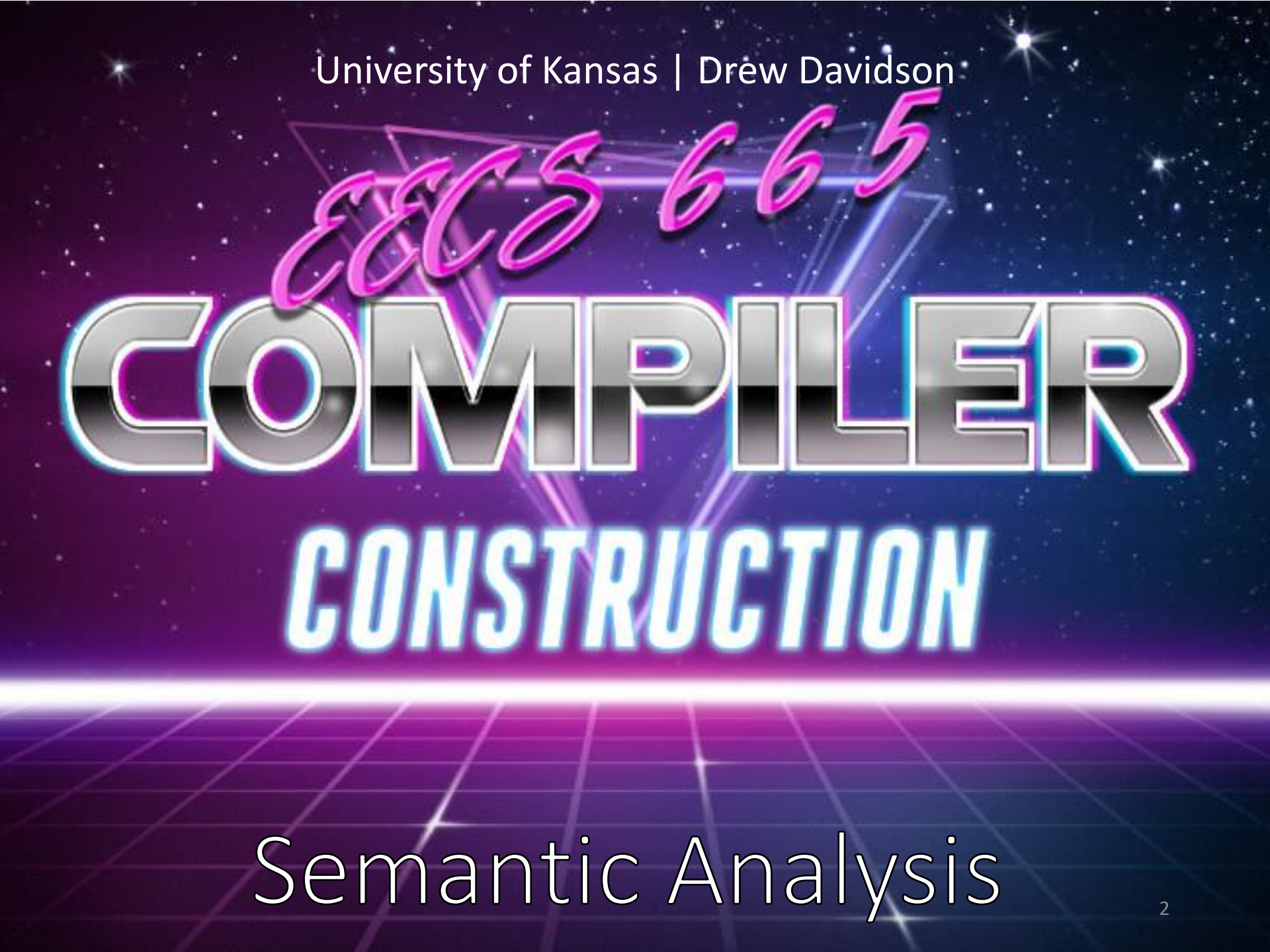


Semantic Analysis

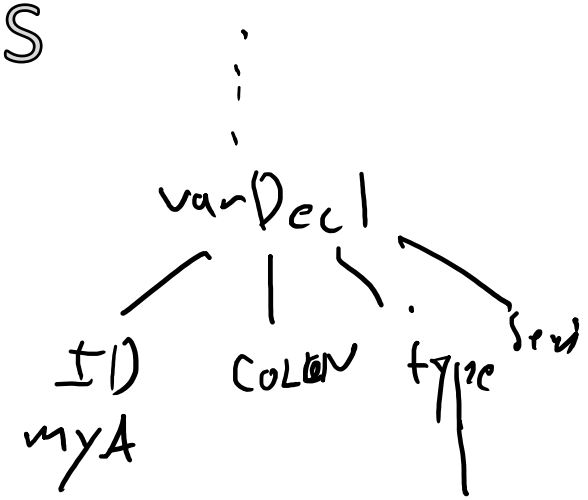
Announcements

Administrivia

Announcements

Administrivia

- P3 Questions
  - The POSTDec operator
- → The MAGIC operator
  - Class-type variables and declarations




```
class A{
    int b
};

int main(){
    A myA;
    a.b = 2;
}
```

```
A : class {
    b : int;
};

main : () int {
    myA : A;
    a--b = 2;
}
```

Last Lecture

Lecture Review – Scope

Issues of Scope

- Scheme
- Shadowing
- Overloading

```
int a;
if (true) {
    int a;
    ⋮
    a := 4
}
```

You Should Know

- Scope properties
- How scope affects semantics
- High-level scope rules for our language

Semantics

Lecture Outline

Lecture Overview – Semantic Analysis

Name Analysis

- Enforcing scope

Symbol Table

- What it is
- What it does

Semantics

Name Analysis

Semantic Analysis

Idea:

- Associates IDs with their uses in the program
  - i.e. Emplace symbol table entries
- Implemented as an AST pass

Purpose:

- Needed for code generation
- Catch some obvious errors
  - (undeclared IDs)

Recognizing Identifier Context

Semantic Analysis

A Context-Free Grammar is… context free

- A node needs information from outside of its subtree
- The definition of a identifiers needs to be connected to its occurrences
- We need a data structure to propagate such context

There's lots of ways to do this!
We'll just cover 1 way

The Compiler's Symbol Table

Semantic Analysis

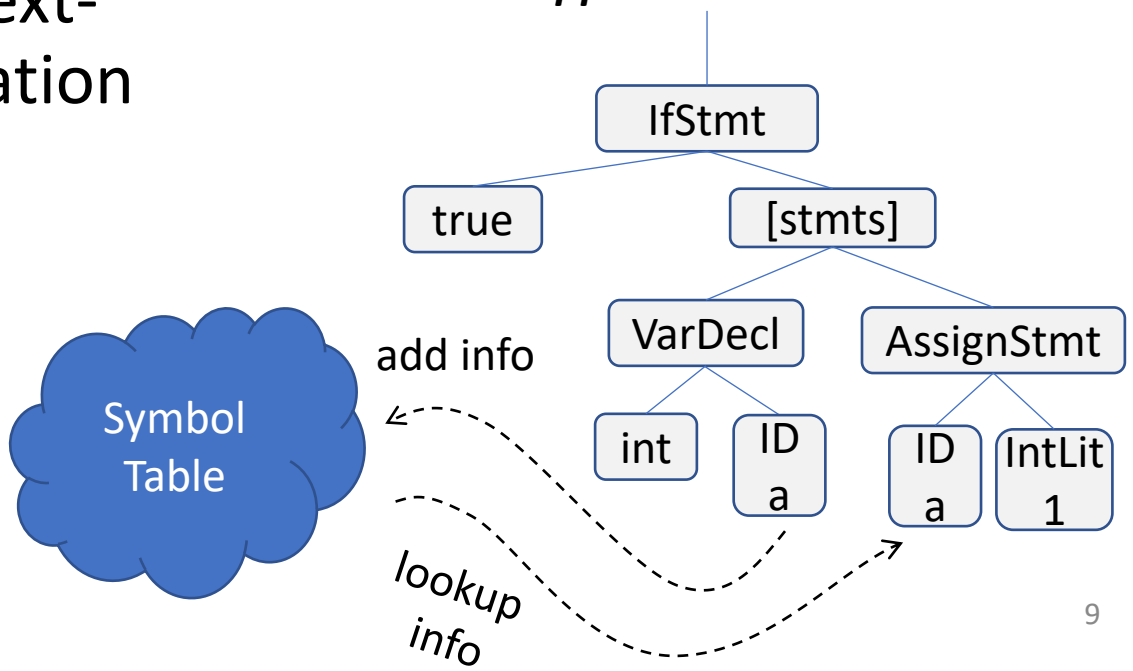
Repository of semantic symbol information

- Populated during a walk of the AST
- Propagates context-sensitive information

Program Snippet

```
if(true){
   int a;
   a = 1;
}
```

AST Snippet



The Compiler's Symbol Table

Semantic Analysis

What's in the symbol table:

- Depends on the language

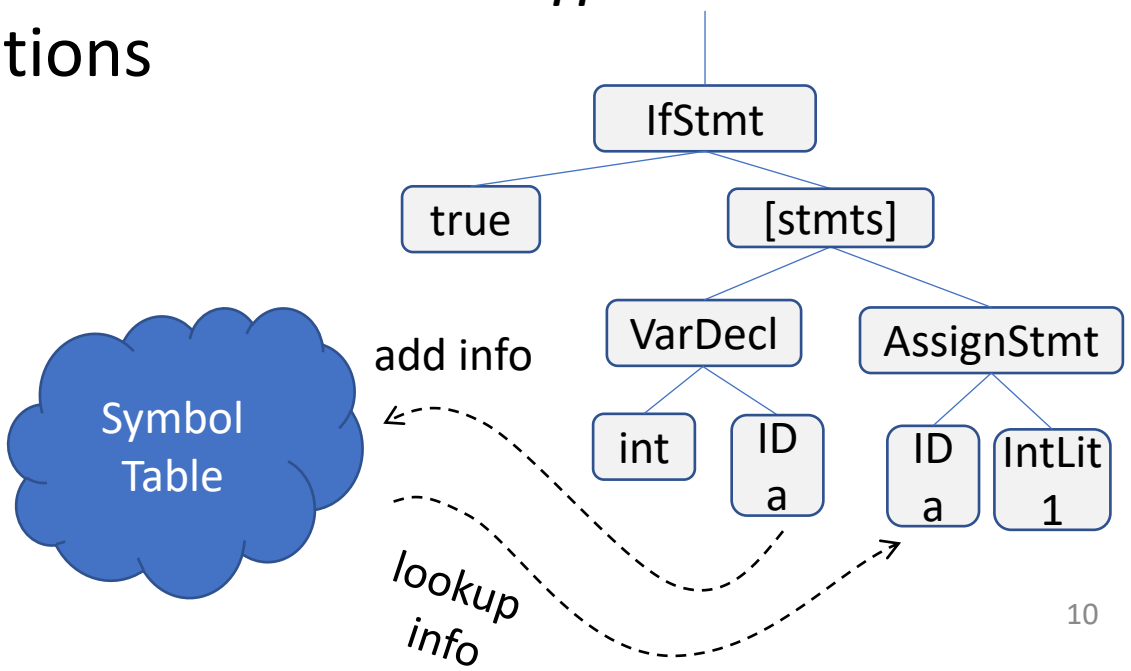
Kinds of entries we need:

- Variable Declarations
- Function Declarations

Program Snippet

```
if(true){
  int a;
  a = 1;
}
```

AST Snippet



The Compiler's Symbol Table

Semantic Analysis

MyA : A;

What's in the symbol table:

- Depends on the language

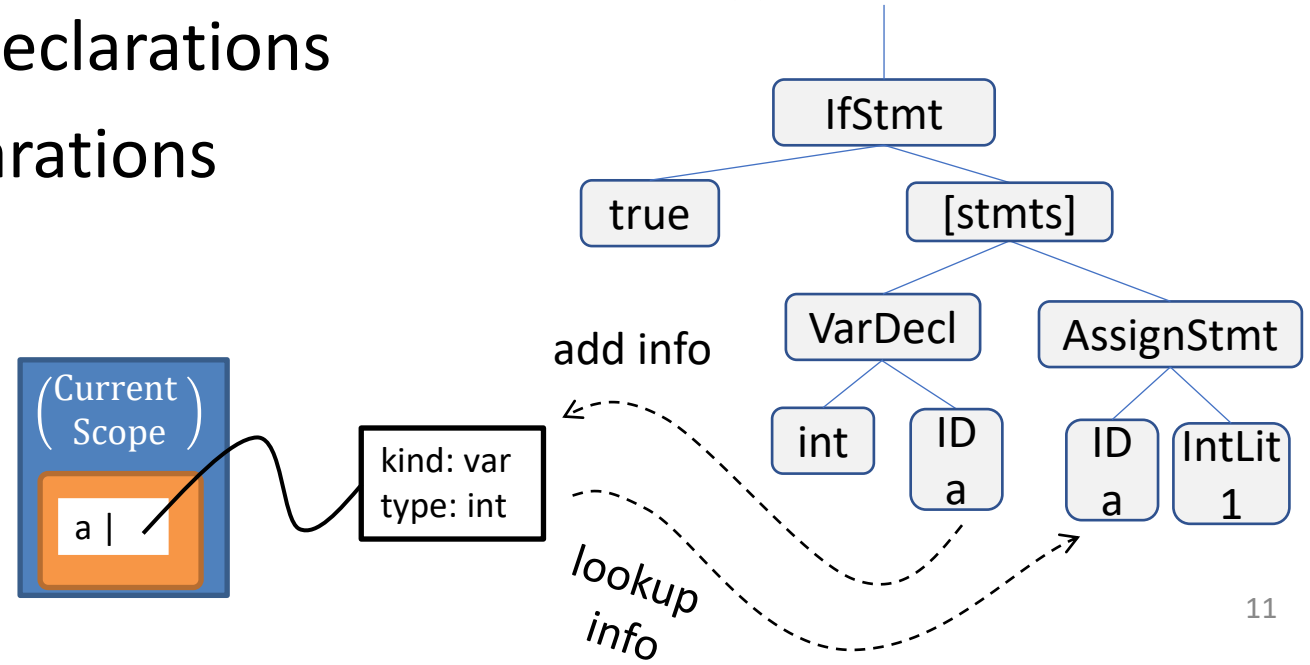
Kinds of entries we need:

- Variable Declarations
- Function Declarations
- Class Declarations

Program Snippet

```
if(true){
  int a;
  a = 1;
}
```

AST Snippet



Symbol Table: A "Snapshot" of Scope

At any (static) program point

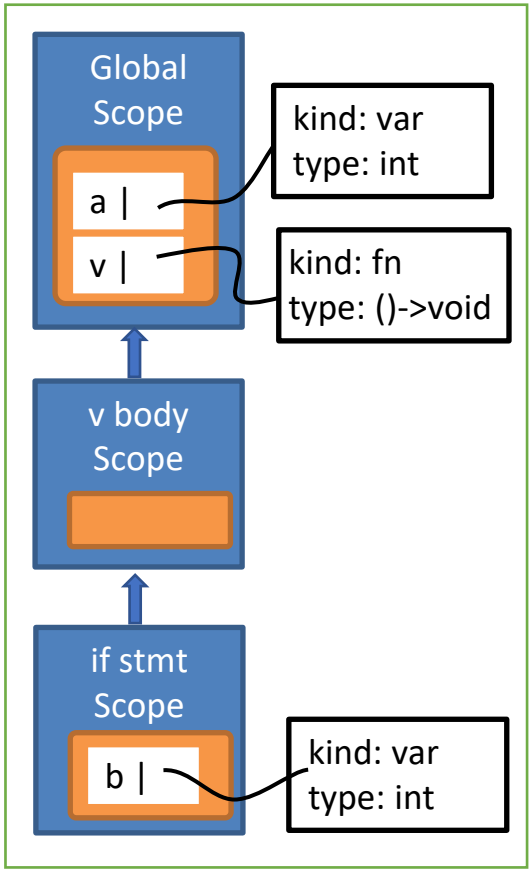
- Symbol table shows *what's* in scope
- Symbol table shows which scope contains the entry

Implementation:

- A list of hashmaps (1 map per scope)

```
1. int a;
2. void v(){
3.    if (a){
4.       int b;
5.    }
6. }
```

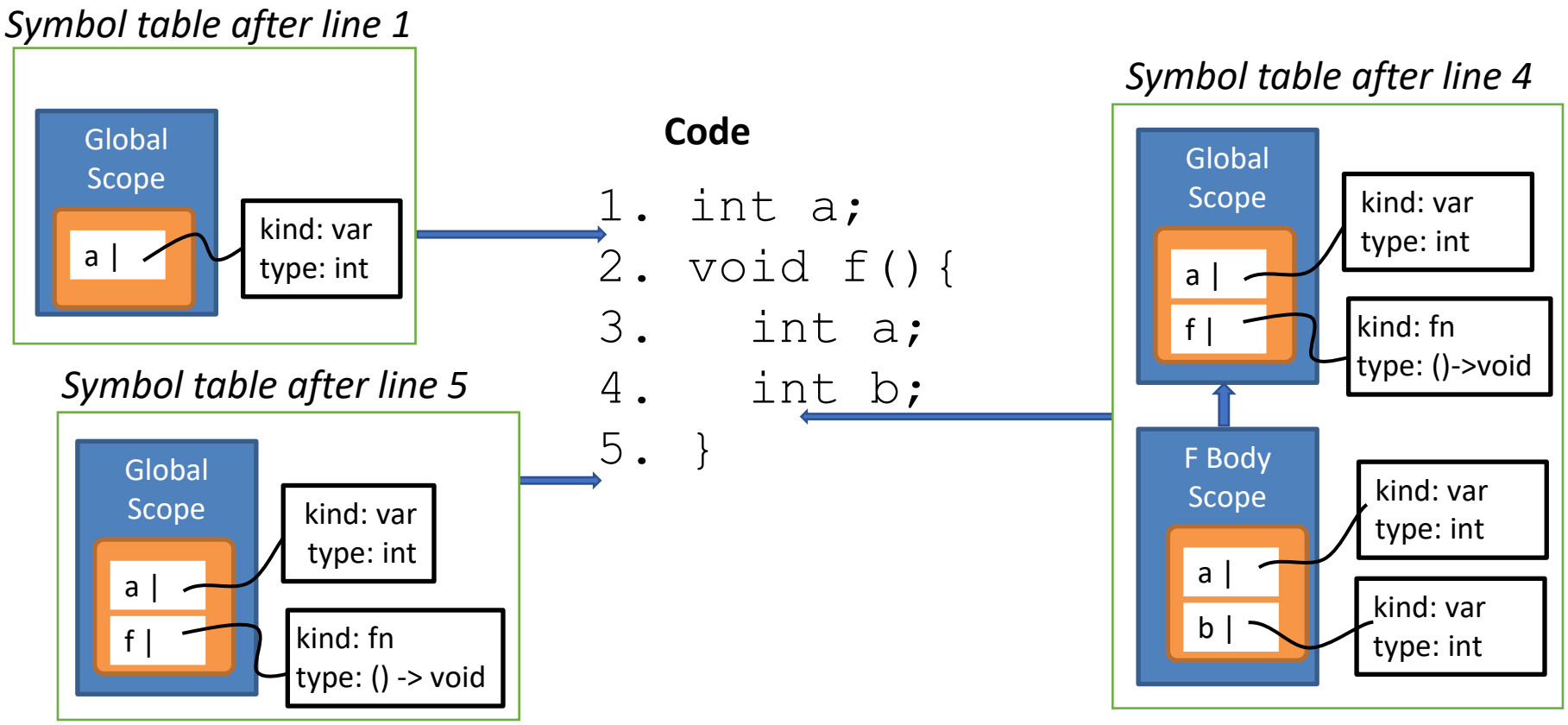
Symbol table after line 4



Symbol Table: Scopes "Sub-tables"

Semantic Analysis - Name Analysis

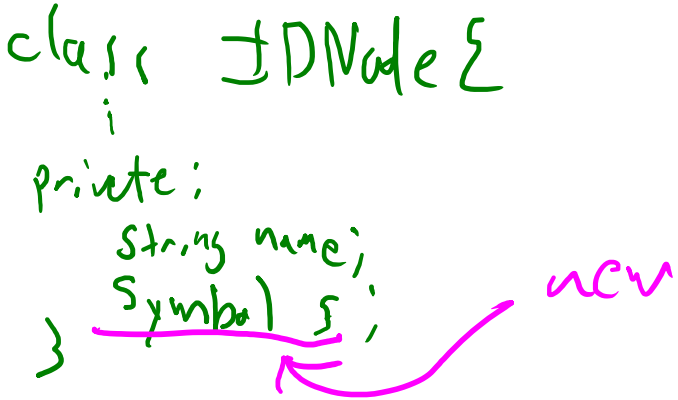
Create one hashmap per scope



Implementation

Semantic Analysis - Name Analysis

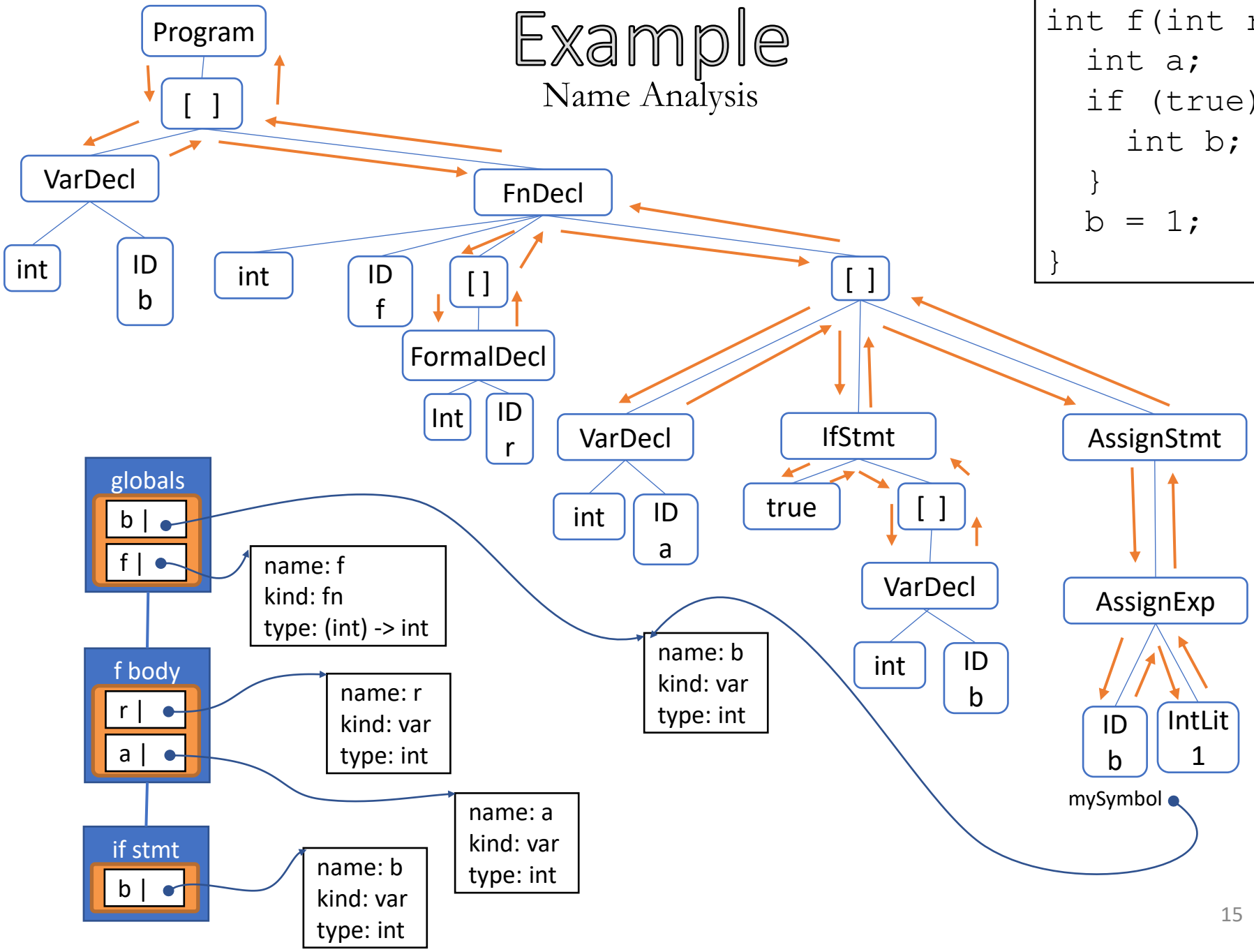
- Walk the AST, much like the unparse() method
  - Augment AST nodes with a link to the relevant name in the symbol table
  - Build new entries into the symbol table when a declaration is encountered
  - Connect AST nodes to the entry they add or reference in the symbol table



Example

Name Analysis

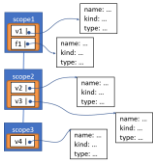
```
int b;
int f(int r){
  int a;
  if (true){
    int b;
  }
  b = 1;
}
```



(My) Terminology

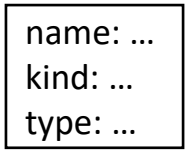
Name Analysis - Implementation

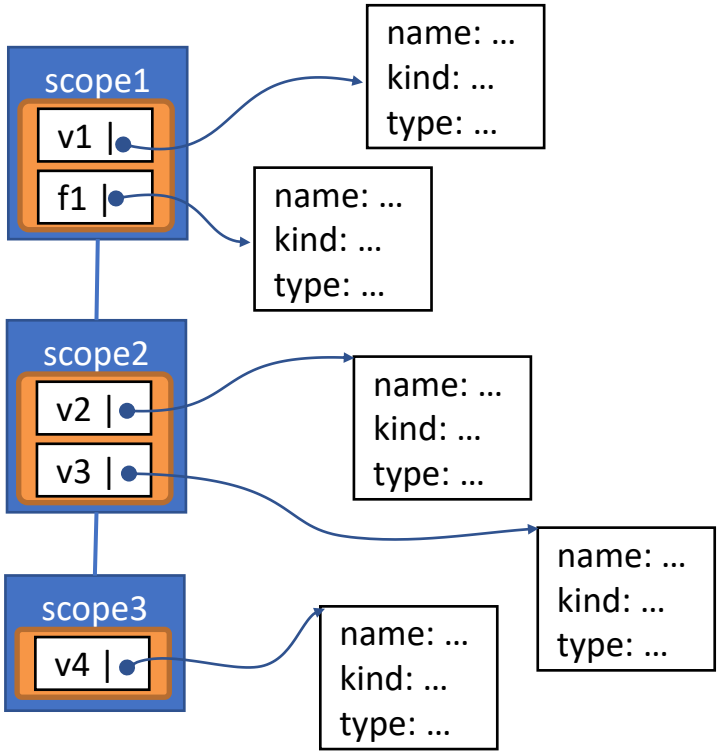
- Symbol Table – the whole structure



- Scope Table – A single map

- Symbol Table Entry (AKA “Semantic Symbol”)





Implementation Suggestions

Name Analysis - Implementation

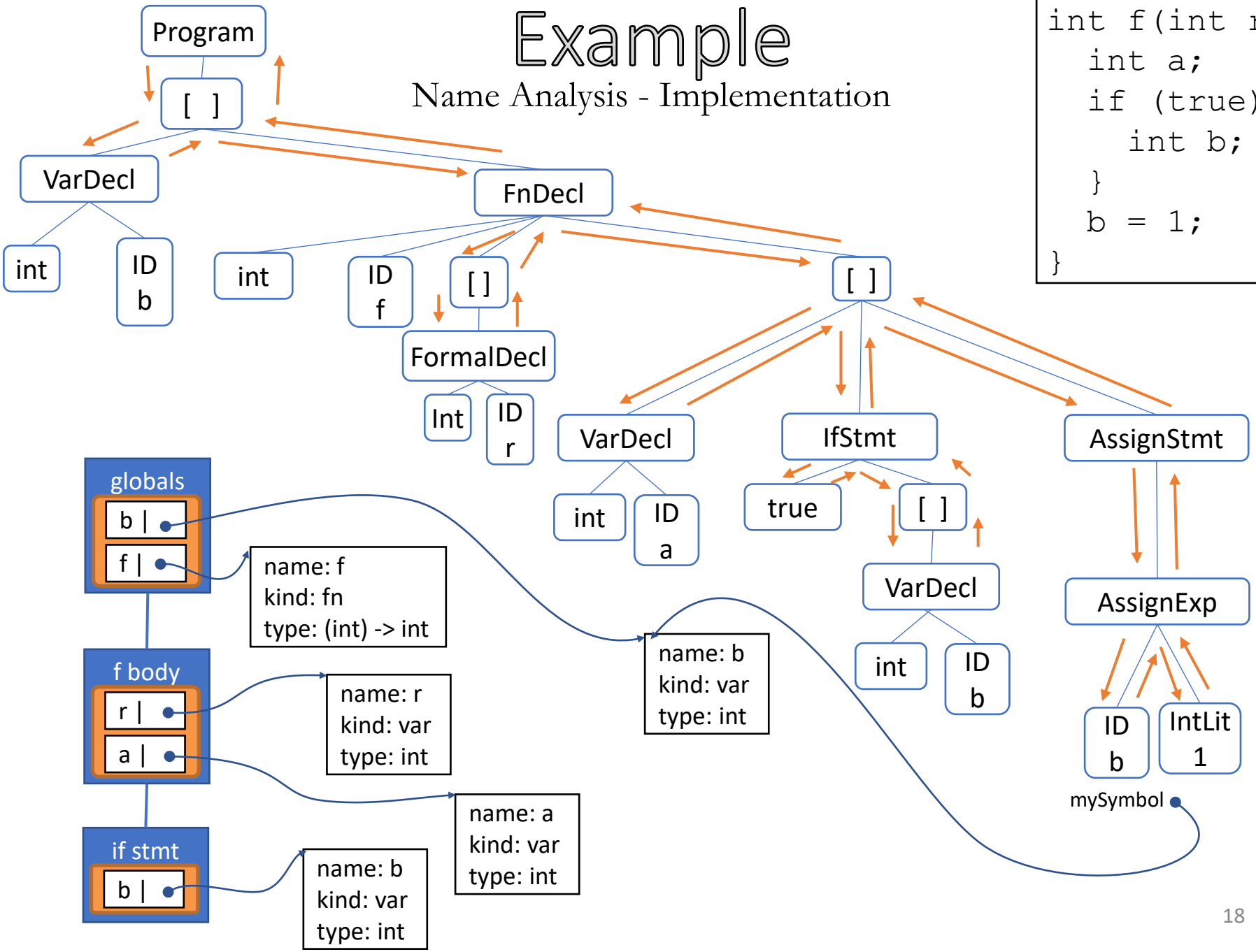
Two approaches

- A nameAnalysis method for each ASTNode subclass
  - Override as appropriate
- The use of the visitor pattern

Example

Name Analysis - Implementation

```
int b;
int f(int r){
  int a;
  if (true){
    int b;
  }
  b = 1;
}
```



Summary

Name Analysis – Wrap-Up

- Described an analysis for enforcing static scoping
- Demonstrated a way to implement the analysis as a walk over the AST

Next Time

Name Analysis – Wrap-Up

Type Systems

- What type systems are
- Why we use them
- The type system for our language

Scratch Page

Name Analysis – Scratch

Scratch Page

Name Analysis – Scratch

Scratch Page

Name Analysis – Scratch

Scratch Page

Name Analysis – Scratch

Scratch Page

Name Analysis – Scratch