Name Analysis

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Compiler Construction (CSCI-GA.2130-001) Spring 2014
NYU Courant Institute

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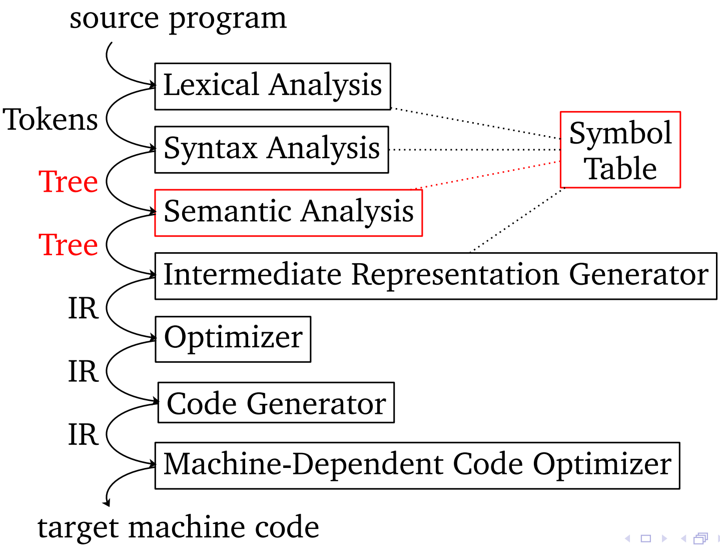
Outline

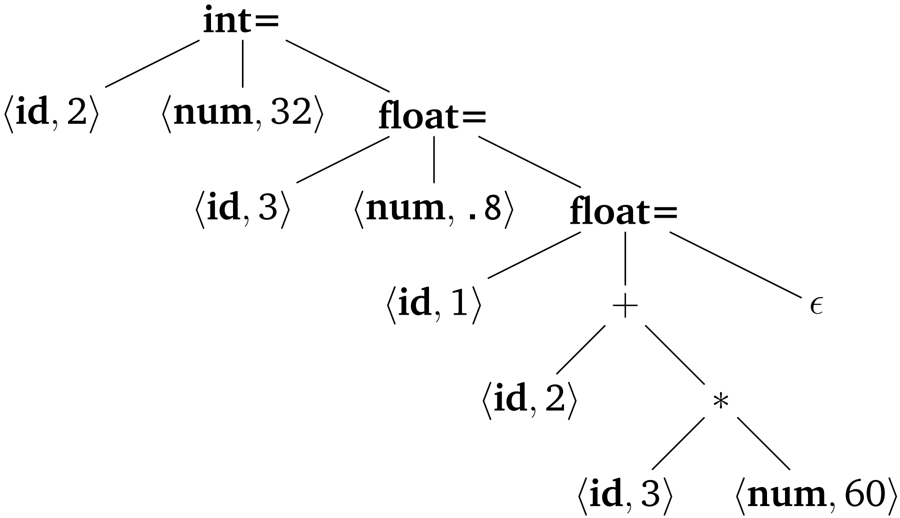
Context


source program
Lexical Analysis
Tokens
Syntax Analysis
Tree
Semantic Analysis
Tree
Intermediate Representation Generator
IR
Optimizer
IR
Code Generator
IR
Machine-Dependent Code Optimizer
target machine code
Symbol Table

Example Code

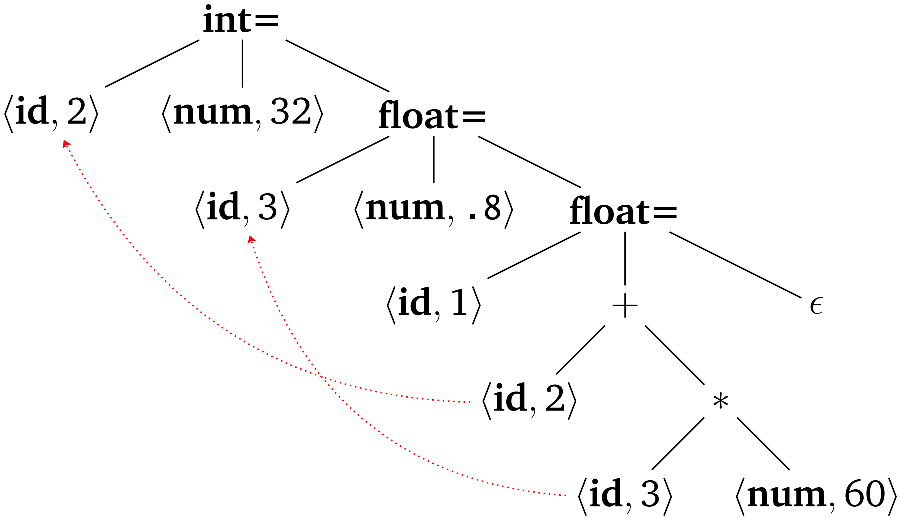
```
int initial = 32;
float rate = .8;
float position = initial + rate * 8;
```

Example Abstract Syntax Tree (AST)



id	*lexeme*
1	`position`
2	`initial`
3	`rate`

Example Abstract Syntax Tree (AST) + “def-use”



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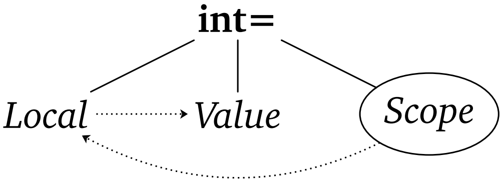
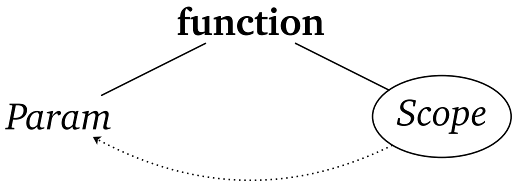
2	`initial`
3	`rate`

Binding Construct



Binding Construct II



Outline

Compile time *vs* Runtime Values

$$\begin{tikzcd} \textit{Variable Use} \arrow[r, bend right, "\text{Compile-time Environment}"'] & \textit{Variable Definition} \arrow[r, bend right, "\text{Run-time Stack/Heap}"'] & \textit{Memory Location} \end{tikzcd}$$

Shadowing

```
int x = 32;
int y;
{
  float x = .8;
  float y = x + x * 8;
}
y = y + x;
```

Symbol Tables

- Traditional method for managing binders in system.
- Logically one symbol table per scope.
  …really messy to manage with imperative SDTs!
- *We shall fix this!*

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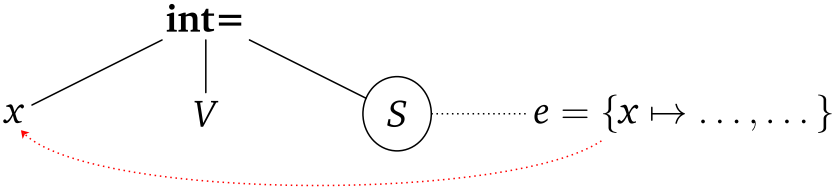
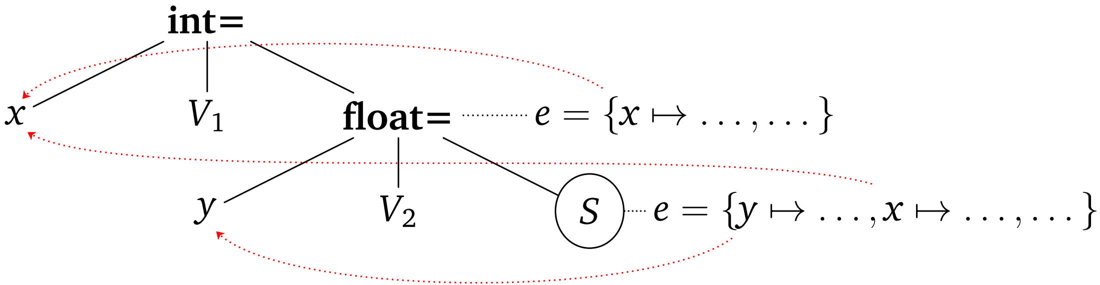
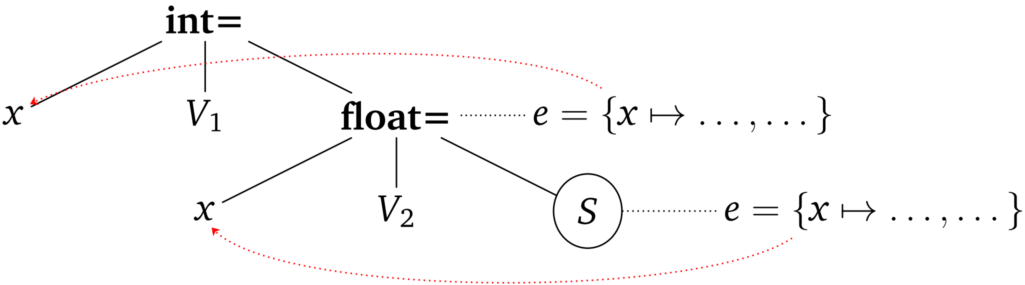
Binding Construct *with Local Symbol Table = Environment*



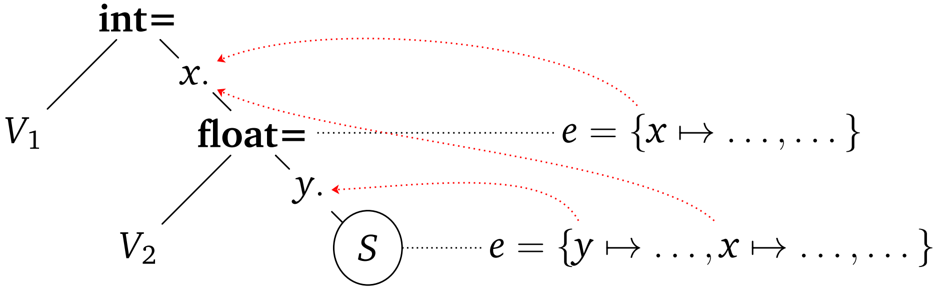
Binding Construct *with Local Symbol Table = Environment* II



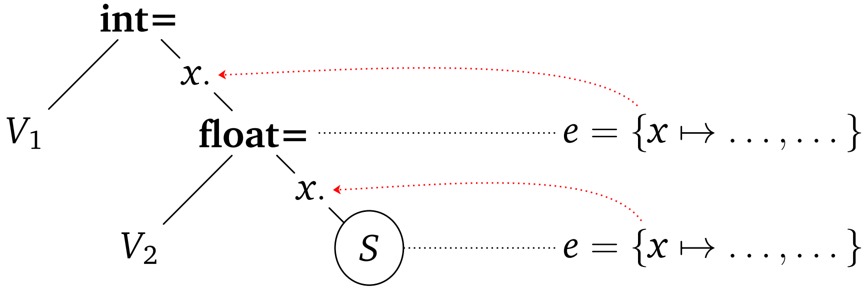
Binding Construct *with Local Symbol Table = Environment* III



Binding Construct *à la HACS*



Binding Construct *à la HACS*



HACS is *Higher-order* Attribute Contraction Schemes

- Traditional:

$$P \to S^*$$
$$S \to \textbf{int}\ V = E; \mid \textbf{print}\ V;$$

- Combine Scoping and Grammar:

$$P \to S$$
$$S \to \textbf{int}\ V = E;\ S \mid \textbf{print}\ V;\ S \mid \epsilon$$

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Outline

1. Introduction
2. Symbol Tables = Environments
3. HACS
4. Extending hw4 Question 2.2 with Declarations

HACS is *Higher-order* Attribute Contraction Schemes II

$$P \to S$$

$$S \to \mathbf{int}\ V_{x.} \ \mathbf{=}\ E;\ S^{x} \mid \mathbf{print}\ V;\ S \mid \epsilon$$

$$\textbf{sort } V \quad \mid \ \textbf{symbol } \llbracket \langle ID \rangle \rrbracket \ ;$$

$$\textbf{sort } P \quad \mid \ \llbracket \langle S \rangle \rrbracket \ ;$$

$$\begin{aligned} \textbf{sort } S \quad & \mid \ \llbracket\ int\ \langle x{:}V \rangle = \langle E \rangle;\ \langle S[x{:}V] \rangle\ \rrbracket \\ & \mid \ \llbracket\ print\ \langle V \rangle;\ \langle S \rangle\ \rrbracket \\ & \mid \ \llbracket\rrbracket \ ; \end{aligned}$$

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$$\begin{aligned} \textbf{sort}\ S \quad & \mid\ [\![\ int\ \langle x{:}V \rangle\ =\ \langle E \rangle;\ \langle S[x{:}V] \rangle\ ]\!] \\ & \mid\ [\![\ print\ \langle V \rangle;\ \langle S \rangle\ ]\!] \\ & \mid\ [\![]\!]\ ; \end{aligned}$$

Example

Production	Semantic Rules
$S \rightarrow \textbf{id} := E$	$E.e = S.e; S.sym = \textbf{id}.sym; S.t = E.t$
$\mid \{ \ S^* \ \}$	$S^*.e = S.e; S.sym = \epsilon; S.t = \epsilon$
$S^* \rightarrow S_1 \ S_2^*$	$S_1.e = S^*.e$ $S_2^*.e = \text{if } S_1.sym \neq \epsilon \text{ then extend}(S^*.e, S_1.sym, S_1.t) \text{ el}$
$\mid \epsilon$	

Outline

Transition

. . . On To The Blackboard!

The following two slides have a sanitized version of the file we wrote together in class.

Extending hw4 Question 2.2 with Declarations (I)

module "edu.nyu.cims.cc.Lecture0303" {
space [\t\n\r\f] ;

token *ID* | [*a*−*z*]+ ('_' [0−9]+)∗ ;
sort *V* | **symbol** $[\![\langle ID\rangle]\!]$;

sort *YesNo* | *Yes* | *No* ;
attribute $\uparrow z(YesNo)$;
attribute $\downarrow e\{V{:}YesNo\}$;

sort *E* | $[\![$ (*let* $\langle[x{:}V]\rangle$ $\langle E\rangle$ $\langle E[x{:}V]\rangle$) $]\!]$ | $[\![$ $\langle V\rangle$ $]\!]$
| $\uparrow z$ | **scheme** $Z(E){\downarrow}e$ | **scheme** $Z2(E){\downarrow}e$;

Extending hw4 Question 2.2 with Declarations (II)

$$Z(\llbracket\ (\ \mathit{let}\ \ x\ \langle E\#2\rangle\ \langle E\#3[x]\rangle\ )\ \rrbracket)$$
$$\quad\to Z2(\llbracket\ (\ \mathit{let}\ \ x\ \langle E\ Z(\#2)\rangle\ \langle E\#3[x]\rangle\ )\ \rrbracket)\ ;$$

$$Z2(\llbracket\ (\ \mathit{let}\ \ x\ \langle E\#2\uparrow z(\#z2)\rangle\ \langle E\#3[x]\rangle\ )\ \rrbracket)$$
$$\quad\to \llbracket\ (\ \mathit{let}\ \ x\ \langle E\#2\rangle\ \langle E\ Z(E\#3[x])\downarrow e\{x{:}\#z2\}\rangle\ )\ \rrbracket;$$

$$\llbracket\ (\ \mathit{let}\ \ x\ \langle E\#2\rangle\ \langle E\#3[x]\uparrow z(\#z3)\rangle\ )\ \rrbracket\uparrow z(\#z3)\ ;$$

$$Z(\llbracket\ x\ \rrbracket\ )\downarrow e\{x{:}\#z\}\to\llbracket x\ \rrbracket\uparrow z(\#z)\ ;$$
$$\}$$

Note: Notation still subject to change.

Questions?

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