CS 381 Spring 2017

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Homework 4 "Runtime Stack, Scoping, Parameter Passing"

**Exercise 1. Runtime Stack**

Consider the following block. Assume static scoping and call-by-value parameter passing.

1 { int x;  
2 int y;  
3 y:=1;

4 {int f(int x){

5 if x=0 then {

6 y := 1 }

7 else {

8 y := f(x-1)\*y+1 };

9 return y;

10 };

11 x := f(2);

12 };

13 }

Illustrate the computations that take place during the evaluation of this block, that is, draw a sequence of pictures each showing the complete runtime stack with all activation records after each statement or function call.

0 []

1 [x:?]

2 [y:?, x:?]

3 [y:1, x:?]

4 [f:{}, y:1, x:?]

11 >>

[f{}, f{}, y:1, x:?]

5 [x:2, f{}, y:1, x:?]—skip to else

8 [x:2, f{}, y:1, x:?]

>>

5 [x:1, x:2, f{}, y:1, x:?]—skip to else

8 [x:1, x:2, f{}, y:1, x:?]

>>

5 [x:0, x:1, x:2, f{}, y:1, x:?]

6 [x:0, x:1, x:2, f{}, y:1, x:?]

9 [res:1, x:0, x:1, x:2, f{}, y:1, x:?]

<<

8 [x:1, x:2, f{}, y:2, x:?]

9 [res:2, x:1, x:2, f{}, y:2, x:?]

<<

8 [x:1, x:2, f{}, y:2, x:?

9 [res:5, x:2, f{}, y:2, x:?]

<<

11 [f{}, y:5, x:5]

12 [y:5, x:5]

13 []

***Note.*** Do ***not*** use the alternative model of “temporary stack evaluation” that was briefly illustrated on slides 20 and 25 to explain the implementation given in FunStatScope.hs and FunRec.hs. Rather use one stack onto which a new activation record is pushed on each recursive function call.

**Exercise 2. Static and Dynamic Scope**

Consider the following block. Assume call-by-value parameter passing.

1 { int x;

2 int y;

3 int z;

4 x := 3;

5 y := 7;

6 { int f(int y) { return x\*y };

7 int y;

8 y := 11;

9 { int g(int x) { return f(y) };

10 { int y;

11 y := 13;

12 z := g(2);

13 };

14 ;}

15 ;}

16 }

1. Which value will be assigned to z in line 12 under static scoping?

0 []

1 [x:?]

2 [y:?, x:?]

3 [z:?, y:?, x:?]

4 [z:?, y:?, x:3]

5 [z:?, y:7, x:3]

6 [f{}, z:?, y:7, x:3]

7 [y:?, f{}, z:?, y:7, x:3]

8 [y:11, f{}, z:?, y:7, x:3]

9 [g{}, y:11, f{}, z:?, y:7, x:3]

10 [y:?, g{}, y:11, f{}, z:?, y:7, x:3]

11 [y:13, g{}, y:11, f{}, z:?, y:7, x:3]

>>

9 [x:2, y:13, g{}, y:11, f{}, z:?, y:7, x:3]

>>

6 [res:21, y:7, x:2, y:13, g{}, y:11, f{}, z:?, y:7, x:3]

<<

9 [res:21, x:2, y:13, g{}, y:11, f{}, z:?, y:7, x:3]

<<

12 [y:13, g{}, y:11, f{}, z:21, y:7, x:3]

13 [g{}, y:11, f{}, z:21, y:7, x:3]

14 [y:11, f{}, z:21, y:7, x:3]

15 [z:21, y:7, x:3]

16 []

In line 12, z = 21.

1. Which value will be assigned to z in line 12 under dynamic scoping?

0 []

1 [x:?]

2 [y:?, x:?]

3 [z:?, y:?, x:?]

4 [z:?, y:?, x:3]

5 [z:?, y:7, x:3]

6 [f{}, z:?, y:7, x:3]

7 [y:?, f:{}, z:?, y:7, x:3]

8 [y:11, f:{}, z:?, y:7, x:3]

9 [g:{}, y:11, f:{}, z:?, y:7, x:3]

10 [y:?, g:{}, y:11, f:{}, z:?, y:7, x:3]

11 [y:13, g:{}, y:11, f:{}, z:?, y:7, x:3]

>>

9 [x:2, y:13, g{}, y:11, f:{}, z:?, y:7, x:3]

>>

6 [res:26, y:13, x:2, y:13, g:{}, y:11, f:{}, z:?, y:7, x:3]

<<

9 [res:26, x:2, y:13, g{}, y:11, f{}, z:?, y:7, x:3]

<<

12 [y:13, g:{}, y:11, f:{}, z:26, y:7, x:3]

13 [g:{}, y:11, f:{}, z:26, y:7, x:3]

14 [y:11, f:{}, z:26, y:7, x:3]

15 [z:26, y:7, x:3]

16 []

It might be instructive to draw the runtime stack for different times of the execution, but it is not strictly required.

**Exercise 3. Parameter Passing**

Consider the following block. Assume dynamic scoping.

1 { int y;

2 int z;

3 y := 7;

4 { int f(int a) {

5 y := a+1;

6 return (y+a)

7 ;}

8 int g(int x) {

9 y := f(x+1) +1;

10 z := f(x-y+3);

11 return (z+1)

12 }

13 z := g(y\*2)

14 };

15 }

What are the values of y and z at the end of the above block under the assumption that both parameters a and x are passed:

(a) Call-by-Name

0 []

1 [y:?]

2 [z:?, y:?]

3 [z:?, y:7]

4 [f:{}, z:?, y:7]

8 [g:{}, f:{}, z:?, y:7]

13

>>

8 [x:y\*2, g:{}, f:{}, z:?, y:7]

>>

4 [a:x+1, x:y\*2, g:{}, f:{}, z:?, y:7]

5 [a:x+1, x:y\*2, g:{}, f:{}, z:?, y:16]

6 [res:49, a:x+1, x:y\*2, g:{}, f:{}, z:?, y:16]

<<

9 [x:y\*2, g:{}, f:{}, z:?, y: 50]

>>

4 [a:x-y+3, x:y\*2, g:{}, f:{}, z:?, y:50]

5 [a:x-y+3, x:y\*2, g:{}, f:{}, z:?, y:54]

6 [res:111, a:x-y+3, x:y\*2, g:{}, f:{}, z:?, y:54]

<<

10 [x:y\*2, g:{}, f:{}, z:111, y: 50]

11 [res:112, x:y\*2, g:{}, f:{}, z:111, y: 50]

<<

13 [g:{}, f:{}, z:112, y:54]

14 [z:112, y:54]

15 []

(b) Call-by Need

0 []

1 [y:?]

2 [z:?, y:?]

3 [z:?, y:7]

4 [f:{}, z:?, y:7]

8 [g:{}, f:{}, z:?, y:7]

13

>>

8

It might be instructive to draw the runtime stack for different times of the execution, but it is not strictly required.