Homework 4 (Runtime Stack, Scoping, Parameter Passing)

CS 381, Spring 2019

June 16, 2019

Prepared by

Adam Stewart *(stewaada)*
Anish Asrani *(asrania)*
Lucas Frey *(freyl)*
Mazen Alotaibi *(alotaima)*
Sergei Poliakov *(poliakos)*

CONTENTS

1 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 }
```

```
1 { int x;                      [<x:?>]
2     int y;                    [<y:?,x:?>]
3     y := 1;                   [<y:1, x:?>]
4     { int f(int x) {          [<f:{}>,<y:1, 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);              [<x:2,f:{}>,<y:1, x:?>]
                                [<f:{}>,<f:{}>,<y:1, x:?>]
                                [<x:2>,<f:{}>,<y:1, x:?>]
                                [<x:1>,<x:2>,<f:{}>,<y:1, x:?>]
                                [<x:0>,<x:1>,<x:2>,<f:{}>,<y:1, x:?>]
                                [<x:1>,<x:2>,<f:{}>,<y:2, x:?>]
                                [<x:2>,<f:{}>,<y:5, x:?>]
                                [<f:{}>,<y:26, x:26>]
       };                       [<y:26, x:26>]
13 }                            [<>]
```

2 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 }
```

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

```
1 { int x;                              {x:?}
2     int y;                            {y:?,x:?}
3     int z;                            {z:?,y:?,x:?}
4     x := 3;                           {z:?,y:?,x:3}
5     y := 7;                           {z:?,y:7,x:3}
6     { int f(int y) { return x*y };    {f:{},z:?,y:7,x:3}
7         int y;                        {y:?,f:{},z:?,y:7,x:3}
8         y := 11;                      {y:11,f:{},z:?,y:7,x:3}
9         { int g(int x) { return f(y) };{g:{},y:11,f:{},z:?,y:7,x:3}
10            { int y;                  {y:?,g:{},y:11,f:{},z:?,y:7,x:3}
11                y := 13;              {y:13,g:{},y:11,f:{},z:?,y:7,x:3}
12                z := g(2);            {y:13,g:{},y:11,f:{},z:?,y:7,x:3}
                                        {x:2,y:13,g:{},y:11,f:{},z:?,y:7,x:3}
                                        {y:11,x:2,y:13,g:{},y:11,f:{},z:?,y:7,x:3}
                                        {y:13,g:{},y:11,f:{},z:33,y:7,x:3}
13            };
14        };
15    };
16 }
```

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

```
1  { int x;                             {x:?}
2     int y;                            {y:?,x:?}
3     int z;                            {z:?,y:?,x:?}
4     x := 3;                           {z:?,y:?,x:3}
5     y := 7;                           {z:?,y:7,x:3}
6     { int f(int y) { return x*y };    {f:{},z:?,y:7,x:3}
7         int y;                        {y:?,f:{},z:?,y:7,x:3}
8         y := 11;                      {y:11,f:{},z:?,y:7,x:3}
9         { int g(int x) { return f(y) };{g:{},y:11,f:{},z:?,y:7,x:3}
10            { int y;                  {y:?,g:{},y:11,f:{},z:?,y:7,x:3}
11                y := 13;              {y:13,g:{},y:11,f:{},z:?,y:7,x:3}
12                z := g(2);            {y:13,g:{},y:11,f:{},z:?,y:7,x:3}
                                        {x:2,y:13,g:{},y:11,f:{},z:?,y:7,x:3}
                                        {y:13,x:2,y:13,g:{},y:11,f:{},z:?,y:7,x:3}
                                        {y:13,g:{},y:11,f:{},z:26,y:7,x:3}
13            };
14        };
15    };
16 }
```

3 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 }
```

3.1 Call-by-Name

```
1 { int y;                [<y:?>]
2   int z;                [<z:?,y:?>]
3   y := 7;               [<z:?,y:7>]
4   { int f(int a) {      [<f:{}>,<z:?,y:7>]
5         y := a+1;
6         return (y+a)
7         };
8         int g(int x) {  [<g:{},f:{}>,<z:?,y:7>]
9             y := f(x+1)+1;
10            z := f(x-y+3);
11            return (z+1)
12         }
13         z := g(y*2);   [<x:y*2>,<g:{},f:{}>,<z:?,y:7>]
                          [<a:x+1>,<x:y*2>,<g:{},f:{}>,<z:?,y:7>]
                          [<a:x+1>,<x:y*2>,<g:{},f:{}>,<z:?,y:16>]
                          [<x:y*2>,<g:{},f:{}>,<z:?,y:49>]
                          [<a:x-y+3>,<x:y*2>,<g:{},f:{}>,<z:?,y:49>]
                          [<a:x-y+3>,<x:y*2>,<g:{},f:{}>,<z:?,y:53>]
                          [<x:y*2>,<g:{},f:{}>,<z:109,y:53>]
                          [<g:{},f:{}>,<z:110,y:53>]
14     };
15 }
```

3.2 Call-by Need

```
1 { int y;                [<y:?>]
2   int z;                [<z:?,y:?>]
3   y := 7;               [<z:?,y:7>]
4   { int f(int a) {      [<f:{}>,<z:?,y:7>]
5         y := a+1;
```

```
6           return (y+a)
7           };
8           int g(int x) {  [<g:{},f:{}>,<z:?,y:7>]
9               y := f(x+1)+1;
10              z := f(x-y+3);
11              return (z+1)
12           }
13           z := g(y*2);   [<x:y*2>,<g:{},f:{}>,<z:?,y:7>]
                            [<a:x+1>,<x:14>,<g:{},f:{}>,<z:?,y:7>]
                            [<a:15>,<x:14>,<g:{},f:{}>,<z:?,y:16>]
                            [<x:14>,<g:{},f:{}>,<z:?,y:32>]
                            [<a:x-y+3>,<x:14>,<g:{},f:{}>,<z:?,y:32>]
                            [<a:-15>,<x:14>,<g:{},f:{}>,<z:?,y:-14>]
                            [<x:14>,<g:{},f:{}>,<z:-29,y:-14>]
                            [<g:{},f:{}>,<z:-28,y:-14>]
14      };
15  }
```