CPSC-354 Report

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Abstract

Short summary of purpose and content.

Contents

1 Introduction

```
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```

This document is a collection of homework assignment answers as requested by Prof. Kurz. This report will replace a generic midterm and final exam and will be thought of as a take home exam to be worked on throughout the semester in addition to a final project.

2 Homework

This section will contain your solutions to homework. For every week, you will have a subsection that contains your answers.

2.1 Week 1

```
print("Please enter integer A")
aString = input("a: ")
while True:
    try:
        a = int(aString)
        break
    except ValueError:
        print("Not an integer. Please try again.")
        print("Please enter INTEGER A")
        aString = input("a: ")

print("Please enter integer B")
bString = input("b: ")
while True:
    try:
        b = int(bString)
        break
    except ValueError:
        print("Not an integer. Please try again.")
        print("Please enter INTEGER B")
        bString = input("b: ")

a = int(aString)
b = int(bString)

while (a != b):
    if (a > b):
        a = a - b
    elif (b > a):
        b = b - a

print ("The greatest common divisor is: " + str(a))
```

This program works by first asking the user to input an integer named "A". The program stores this input in a variable called "aString" and then utilizes error checking to make sure the user's input can be converted into an integer. If the input cannot be converted into an integer, the program loops until the user enters valid input. If the user's input passes error checking, the program then prompts the user for an integer named "B" and follows the same error-checking process. Once the user passes error checking for both variables, the program enters a loop. In the loop, if integer A is greater than integer B, then integer A is replaced with the value of integer A - integer B. If integer B is greater than integer A, then integer B is replaced with the value of integer B - integer A. This process repeats until integer A is equal to integer B. When this is reached, the greatest common divisor of the original integer A and original integer B is printed out to the user.

For example, if we took A to be an integer representing the value of 9, and B to be an integer representing the value of 33, the program would follow this process: Because B, which equals 33 is greater than A, which equals 9. B's value would be replaced with B - A, which is 24. B is still greater than A, so B's value would be replaced by B - A again which now equals 15. 15 is still greater than 9, so B would become 6. Now, A with a value of 9 is greater than B which has a value of 6. A would be replaced with A - B which equals 3. This makes B greater than A again. B is now replaced with B - A, or 6 - 3, which equals 3. Now that A and B are equal, the greatest common divisor, which is 3 because both A and B equal 3, is output to the user.

2.2 Week 2

```
import Data.List
import System.IO

select_evens :: [Int] -> [Int]
select_evens (x:xs) = [(x:xs)!!y | y <- (y:ys)]
  where (y:ys) = [1,3..(length (x:xs)-1)]

select_odds :: [Int] -> [Int]
select_odds (x:xs) = [(x:xs)!!y | y <- (y:ys)]
  where (y:ys) = [0,2..(length (x:xs)-1)]

member :: Int -> [Int] -> Bool
member _ _ = False
member x (y:ys)
  | x == y = True
  | otherwise = member x ys

append :: [Int] -> [Int] -> [Int]
append (x:xs) (y:ys) = x:xs ++ y:ys

revert :: [Int] -> [Int]
revert [] = []
revert (x:xs) = revert (xs) ++ [x]

less_equal :: [Int] -> [Int] -> Bool
less_equal (x:xs) (y:ys)
  | x >= y = False
  | length (xs) == 0 && length (ys) == 0 = True
  | otherwise = less_equal xs ys

Select_Evens Computation:
select_evens [1,2,3,4,5] =
[] : [(1,2,3,4,5)!!1 | 1 <- ([1,3]) =
2 : [(1,2,3,4,5)!!3 | 3 <- ([1,3]) =
[2, 4]

Select_Odds Computation:
select_odds [1,2,3,4,5] =
[] : [1,2,3,4,5)!!0 | 0 <- ([0,2,4]) =
1 : [(1,2,3,4,5)!!2 | 2 <- ([2,4]) =
1 : (3 : [(1,2,3,4,5)!!4 | 4 <- ([4]) =
[1,3,5]

Member Computation:
```

```
member 1 [3, 2, 1] =
1 == 3 = False, so member 1 [2,1] =
1 == 2 = False, so member 1 [1] =
1 == 1 = True, so 1 is a member of [3, 2, 1]

Append Computation:
append [1,2] [3,4,5] =
1 : (append [2] [3,4,5]) =
1 : (2 : (append [] [3,4,5]) =
1: (2: [3,4,5]) =
[1,2,3,4,5]

Revert Computation:
revert [1,2,3,4,5] =
append (revert [2,3,4,5]) ([1]) =
append (append (revert [3,4,5]) ([2])) ([1]) =
append (append (append (revert [4,5]) ([3])) ([2])) ([1]) =
append (append (append (append (revert [5]) ([4])) ([3])) ([2])) ([1]) =
append (append (append (append (append (revert []) ([5])) ([4])) ([3])) ([2])) ([1]) =
append (append (append (append (append [] ([5])) ([4])) ([3])) ([2])) ([1]) =
append (append (append (append (append [] ([5])) ([4])) ([3])) ([2])) ([1]) =
append (append (append (append ([5]) ([4])) ([3])) ([2])) ([1]) =
append (append (append ([5,4]) ([3])) ([2])) ([1]) =
append (append ([5,4,3]) ([2])) ([1]) =
append ([5,4,3,2]) ([1]) =
[5,4,3,2,1]

Less_Equal Computation:
less_equal [1,2,3] [2,3,4] =
1 >= 2 = False, so less_equal [2,3] [3,4] =
2 >= 3 = False, so less_equal [3] [4] =
3 >= 4 = False, so less_equal [] [] =
True
```

2.3 Week 3

```
Tower Of Hanoi correct computations for a tower of 5
hanoi 5 0 2
  hanoi 4 0 1
    hanoi 3 0 2
      hanoi 2 0 1
        hanoi 1 0 2 = move 0 2
        move  0 1
        hanoi 1 2 1 = move 2 1
      move 0 2
      hanoi 2 1 2
        hanoi 1 1 0 = move 1 0
        move  1 2
        hanoi 1 0 2 = move 0 2
    move 0 1
```

```
    hanoi 3 2 1
      hanoi 2 2 0
        hanoi 1 2 1 = move 2 1
        move 2 0
        hanoi 1 1 0 = move 1 0
      move 2 1
      hanoi 2 0 1
        hanoi 1 0 2 = move 0 2
        move 0 1
        hanoi 1 2 1 = move 2 1
  move 0 2
  hanoi 4 1 2
    hanoi 3 1 0
      hanoi 2 1 2
        hanoi 1 1 0 = move 1 0
        move 1 2
        hanoi 1 0 2 = move 0 2
      move 1 0
      hanoi 2 2 0
        hanoi 1 2 1 = move 2 1
        move 2 0
        hanoi 1 1 0 = move 1 0
    move 1 2
    hanoi 3 0 2
      hanoi 2 0 1
        hanoi 1 0 2 = move 0 2
        move 0 1
        hanoi 1 2 1 = move 2 1
      move 0 2
      hanoi 2 1 2
        hanoi 1 1 0 = move 1 0
        move 1 2
        hanoi 1 0 2 = move 0 2
```

Hanoi appears in the computation 31 times. We can express the number of times "hanoi" appears for any number n of disks with the formula:
$numHanoi = 2^{numDisks} - 1$

2.4 Week 4

```
Concrete Syntax Trees

1. 2+1
           Exp
         /       \
       Exp  +   Exp1
        |        |
      Num        Num
        |          |
        2          1
```

```
2. 1+2*3
           Exp
         /       \
       Exp  +   Exp1
        |          |
      Num          Exp1
        |          /   \
        1        Exp1 * Exp2
                   |       |
                 Num      Num
                  |         |
                  2         3
```

```
3. 1+(2*3)
           Exp
         /       \
       Exp  +   Exp2
        |          |
      Num        ( Exp 1 )
        |          /   \
        1        Exp1 * Exp2
                   |       |
                 Num      Num
                  |         |
                  2         3
```

```
4. (1+2)*3
           Exp1
         /       \
       (Exp)  *   Exp2
      /       \      |
    Exp  +  Exp1     Num
      |      |        |
      Num   Num       3
      |       |
      1       2
```

```
5. 1+2*3+4*5+6
                  Exp
               /       \
            Exp    +     Exp1
            /                 \
         Exp                       Exp
        /     \                /         \
      Num       Exp1            Exp1        Num
       |      /      \         /      \       |
       1    Exp1 * Exp2       Exp1 *  Exp2    6
              |       |        |        |
             Num   Num       Num      Num
              |         |       |        |
             2         3       4         5
```

```
Abstract Syntax Trees

1. 2+1
        +
      /   \
     2      1

2. 1+2*3
             +
           /   \
          1     *
               /   \
             2      3

3. 1+(2*3) (Same as 2 because parantheses are not in the grammar)
             +
           /   \
          1     *
               /   \
             2      3

4. (1+2)*3 (Same as 2 because parantheses are not in the grammar)
             +
           /   \
          1     *
               /   \
             2      3

5. 1+2*3+4*5+6
                  +
            /          \
          +             +
       /     \       /      \
     1        *       *      6
           /   \    /  \
          2    3    4  5
```

2.5 Week 5

```
1. x
EVar
  |
Ident
  |
  x

2. x x
EApp
|    \
```

```
EVar  EVar
|       |
Ident   Ident
|       |
x       x

3. x y
EApp
|    \
EVar  EVar
|       |
Ident   Ident
|       |
x       y

4. x y z
EApp
|    \
EApp  EVar
|   \     \
EVar  EVar Ident
|       |     |
Ident Ident   z
|       |
x       y

5. \ x.x
EAbs
|    \
Ident EVar
|      |
x      Ident
        |
        x

6, \ x.x x
EAbs
|    \
Ident EApp
|     |   \
x    Evar   Evar
      |     |
      x     x

7. (\ x . (\ y . x y)) (\ x.x) z
EApp
|      \
EApp      EVar
|      \          \
EAbs      EAbs       Ident
|     \    \    \           \
```

```
Ident  EAbs Ident EVar        z
|       |   \    \    \
x       y   EApp  x   Ident
             |  \         \
             EVar  EVar     x
             |       |
             Ident Ident
             |       |
             x       y
```

8. (\ x . (\ y . x y)) (\ x.x) z

```
EApp
|   -------------------\
EApp                 EVar
|   ---------\          -----------\
EApp         EVar                  Ident
|    \            -------------\      |
EAbs    EAbs             Ident        c
|   \      |   \             |
Ident EVar Ident  EApp       b
|      |     |     |    \
x   Ident    y   EApp    EVar
      |      |    \      |
      a     EVar  EVar   Ident
             |     |       |
            Ident Ident    z
             |     |
             x     y
```

Part 2

1. (\x.x) a -> a

2. \x.x a -> a (Short form)

3. (\x. \y.x) a b -> a

4. (\x.\y.y) a b -> b

5. (\x.\y.x) a b c -> a

6. (\x.\y.y) a b c -> b

6. (\x.\y.x) a (b c) -> a

7. (\x.\y.y) a (b c) -> (b c)

8. (\x.\y.x) (a b) c -> (a b)

9. (\x.\y.y) (a b) c -> c

```
10. (\x.\y.x) (a b c) -> (abc)

11. (\x.\y.y) (a b c) -> Not enough arguments

12. (\x.x)((\y.y)a)
evalCBN(\x.x)((\y.y)a) =
evalCBN(\x.x)((\y0.y0)a) =
(\x.x)(a)
```

2.6 Week 6

```
(\exp . \two . \three . exp two three)
(\m.\n. m n)
(\f.\x. f (f x))
(\f.\x. f (f (f x)))

((\m.\n. m n) (\f.\x. f (f x)) (\f2.\x2. f2 (f2 (f2 x2))))
=
((\n. (\f.\x. f (f x)) n) (\f2.\x2. f2 (f2 (f2 x2))))
=
(((\f.\x. f (f x)) (\f2.\x2. f2 (f2 (f2 x2)))))
=
(((\x. (\f2.\x2. f2 (f2 (f2 x2))) ((\f2.\x2. f2 (f2 (f2 x2))) x))))
=
(((\x. (\x2. ((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))
=
(((\x. (\x2. ((\x2. x (x (x x2)))) (((\f2.\x2. f2 (f2 (f2 x2))) x) (((\f2.\x2. f2 (f2 (f2 x2))) x) x2))
=
(((\x. (\x2. (x (x (x (((\f2.\x2. f2 (f2 (f2 x2))) x))))) (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))
=
(((\x. (\x2. (x (x (x (((\x2. x (x (x x2)))))))) (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))
=
(((\x. (\x2. (x (x (x (((x (x (x (((\f2.\x2. f2 (f2 (f2 x2))) x) x2)))))))))))))
=
(((\x. (\x2. (x (x (x (((x (x (x (((\x2. x (x (x x2)))) x2)))))))))))))
=
(\x.(\x2.(x(x(x(x(x(x(x(x(x x2))x2)))))))))
```

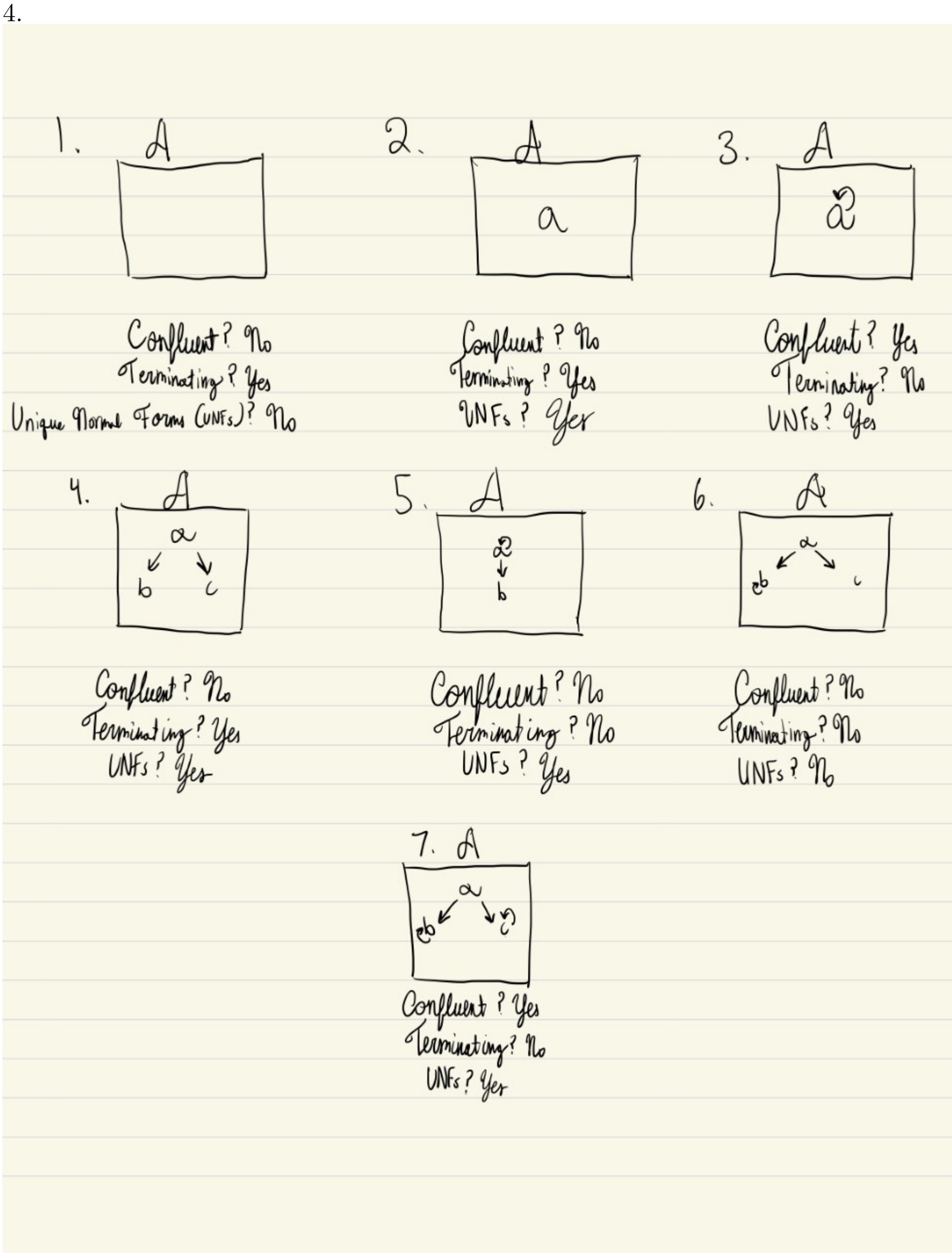
2.7 Week 7

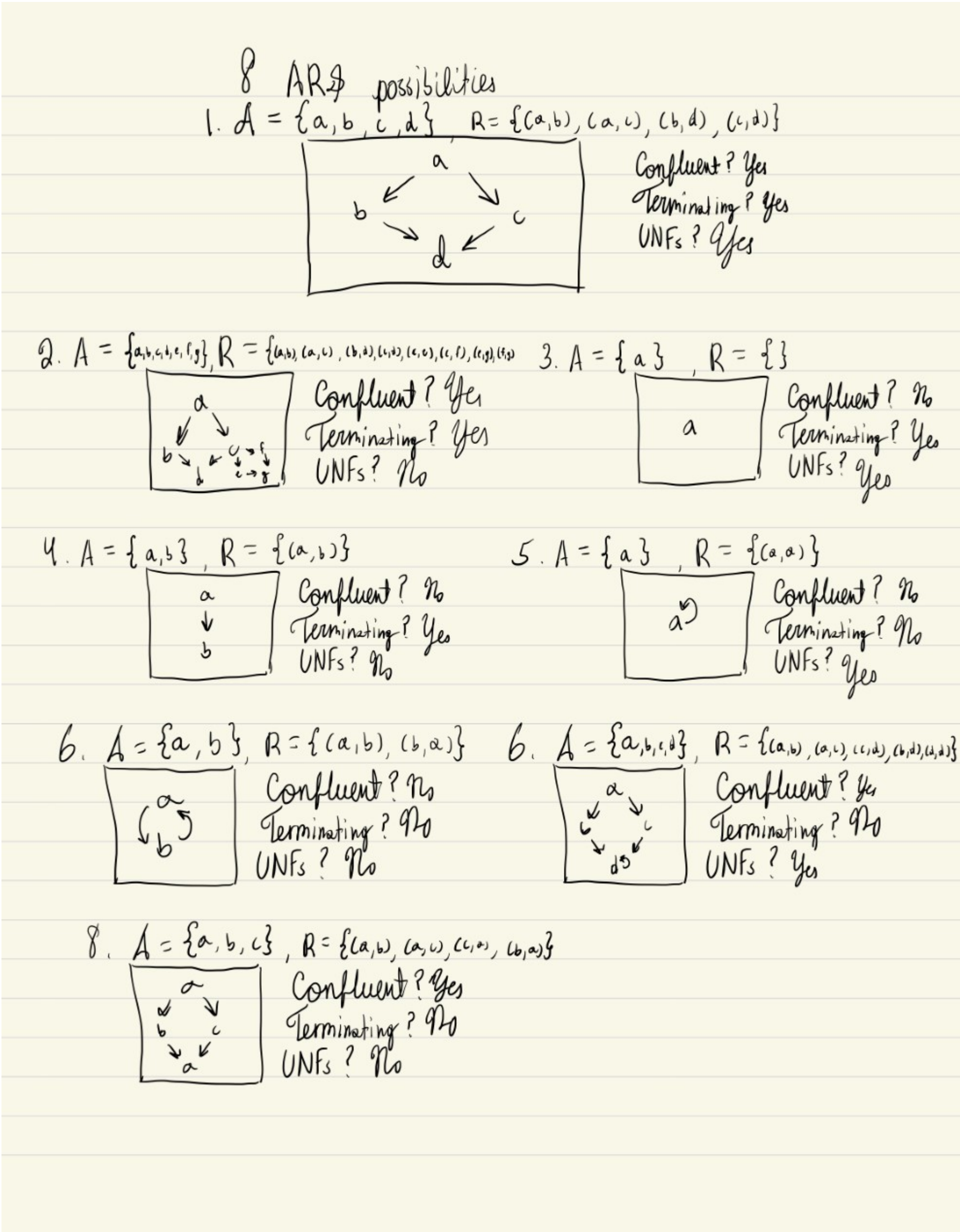
```
evalCBN: Bound variable
Binder: evalCBN :: Exp -> Exp
Scope:
evalCBN (EApp e1 e2) = case (evalCBN e1) of
    (EAbs i e3) -> evalCBN (subst i e2 e3)
    e3 -> EApp e3 e2
evalCBN x = x

e1: Bound variable
```

```
Binder: (EApp e1 e2)
Scope:
(EApp e1 e2) = case (evalCBN e1) of
    (EAbs i e3) -> evalCBN (subst i e2 e3)
    e3 -> EApp e3 e2

e2: Bound variable
Binder: (EApp e1 e2)
Scope:
(EApp e1 e2) = case (evalCBN e1) of
    (EAbs i e3) -> evalCBN (subst i e2 e3)
    e3 -> EApp e3 e2

e3: Free variable

subst: Bound variable
Binder: subst :: Id -> Exp -> Exp -> Exp
Scope:
subst id s (EAbs id1 e1) =
    let f = fresh (EAbs id1 e1)
        e2 = subst id1 (EVar f) e1 in
        EAbs f (subst id s e2)

id: Free variable

s: Free variable

id1: Bound variable
Binder: (EAbs id1 e1)
Scope:
let f = fresh (EAbs id1 e1)
     e2 = subst id1 (EVar f) e1 in
     EAbs f (subst id s e2)

e1: Bound variable
Binder (Eabs id1 e1)
Scope:
let f = fresh (EAbs id1 e1)
     e2 = subst id1 (EVar f) e1 in
     EAbs f (subst id s e2)

f: Bound variable
Binder: let f = fresh (EAbs id1 e1)
Scope:
e2 = subst id1 (EVar f) e1 in
EAbs f (subst id s e2)

3. '(\x\y.x) y z'
(\x\y.x) (y z) = evalCBN (subst i (\x(\y.x))) y z
(Line 26 and 27)
```

```
evalCBN (subst i (\x(\y.x))) y z = evalCBN (EApp (subst i (\x(\y.x)) y) (subst i (\x(\y.x)) x))
(Line 49)

evalCBN (EApp (subst i (\x(\y.x)) y) (subst i (\x(\y.x)) x)) = evalCBN (EApp (\x(\y.x)) (\x(\y.x)))
(Line 47)
```

4.





2.8 Week 8

1. The ARS does not terminate because the rewrite rules ba -> ab and ab -> ba allow for an infinite loop

2. The normal forms are an empty word, a, and b.

3.We are unable to change this ARS to have unique normal forms while maintaining the same equivalence re

4. The normal forms here mean that two of the same character are rewritten to just one of the characters

2.9 Week 9

PEG.js Calculator Extension Project Milestones

1. Get a grasp on Javascript by following the tutorials on learnjavascript.online.
- There is no direct deliverable for this requirement. I will need to learn Javascript in order to work
- A potential deliverable would be showing completion of Chapters 1 - 7 (The free chapters) in screensh
Milestone 1 is due by November 13th

2. Implement assignment, exponentiation, in the calculator project. Use this time to gain a foothold in
- This can be tested through the PEG.js parser generator website.
- This can also be physically submitted as a .pegjs file containing my calculator's grammar. I can incl
Milestone 2 is due by November 30th

3. Implement integrals and derivatives in the calculator.
- This can be verified via a submitted .pegjs file containing the calculator's grammar, similar to the
Milestone 3 is due by December 16th

4. Finalize the project by verifying that everything works as expected. Create basic documentation that

ARS Exercise

```
1.
ba -> ab
ab -> ba
ac -> ca
ca -> ac
bc -> cb
cb -> bc
aa -> b
ab -> c
ac ->
bb ->
cb -> a
cc -> b
```

This ARS is not terminating because there is possibility for infinite loops.

The normal forms in this ARS are the empty word, a, b, and c.

We can characterize equivalence classes in this case by normal forms.

Equivalence Classes: ab, ba, ac, ca, bc, cb, (ac, bb), (aa, cb), (ab), (cc), empty word

This ARS is not confluent because of the only one-step computations that compute to the same element (a

2.10 Week 10

$$fix_F 2$$

```
fix_F2 = \y.\n. if n == 0 then 1 else f(2-1)*2(fix_F2)
```

```
\y.\n. if n == 0 then 1 else f(2-1)*2(fix_F2) = fix_F1 * 2
fix_F1 * 2 = ((fix_F0 * 1) * 2)
((fix_F0 * 1) * 2) = ((1) * 2)
((1) * 2) = 2
```

2.11 Week 11

Answers:

1. I think it's beneficial for them to learn because they'll be able to gain a different perspective on how to view contracts. Because we all think differently, it might be easier for some people to visualize contracts through this language. Additionally, they could potentially end up learning this language and then using their knowledge to create a program that will allow people to administer and create contracts with others in an easy-to-understand digital format.

2. I agree with Eli. I think the use of combinators is able to account for only contracts able to be constructed with the set of combinators and data types that we have available to us in the implementation.

Question:

What are the tests listed in appendix A of Contract.hs symbolizing? Along with that, what is the tolerance symbolizing? Do the tests and tolerance have a connection to real world tests used in finance?

2.12 Week 12

Apply the method of analysis from the Hoare logic lecture to:

```
while (x != 0) do z:=z*y; x:x-1 done
```

Precondition: {z = 1 ∧ x = n}

Postcondition: $\{z = y^n\}$

Table of the Execution

t	x	y	z
0	100	2	1
1	99	2	2
2	98	2	4
3	97	2	8

Therefore, we can give the following invariants:

$t + x = 100$

$z = y^t$

Loop invariant: $z = y^{(x-100)}$

The precondition implies the invariant: $z = 1 \wedge x = n \implies z = y^{(x-n)}$

The invariant implies the postcondition: $z = y^{(x-n)} \implies z = y^n$

This is true because at the end of the loop, $x = 0$

3 Project

Introductory remarks ...

The following structure should be suitable for most practical projects.

3.1 Specification

For my course project, I will be using the parser generator PEG.js in order to create a calculator similar to the one we implemented in class, but with a few major differences. My parser generator will be able to integrate functions and take the derivative of them as well. My parser will additionally be able to work with assignment, including assigning functions.

3.2 Prototype

3.3 Documentation

3.4 Critical Appraisal

...

4 Conclusions

(approx 400 words)

In the conclusion, I want a critical reflection on the content of the course. Step back from the technical details. How does the course fit into the wider world of programming languages and software engineering?

References

[PL] Programming Languages 2022, Chapman University, 2022.