

CMSC330 Fall 2009 Midterm #1 Solutions

1. (9 pts) Programming languages

- a. (3 pts) Explain the difference between interpretation and compilation.

Interpretation evaluates a program one line at a time. Compilation translates a program into a different form that can be executed.

- b. (6 pts) Explain the difference between static and dynamic types. Write a small piece of Ruby code that relies on dynamic types.

With static types, variable types are checked at compile time and thus generally remain **fixed. With dynamic types, variable types are checked at run time (right before they are used), and can thus **change** during program execution.**

Example: `x = 1 ; x = "a" ;`

2. (15 pts) Regular expressions and finite automata

- a. (5 pts) Give a regular expression for all binary numbers (strings of 0s and 1s) with an odd number of 0s.

Many possible answers, some examples are:

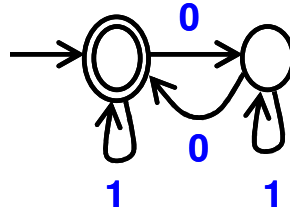
$1^* 0 (1^* 01^* 0)^* 1^*$

$1^* 0 1^* (01^* 01^*)^*$

Basically a single 0, combined w/ RE for even # of 0s, mixed with lots of 1^*

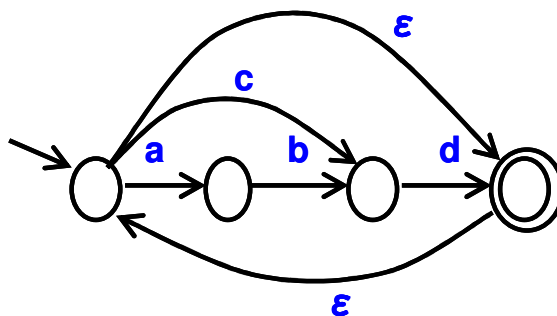
- b. (4 pts) Give a NFA that accepts all binary numbers (strings of 0s and 1s) with an even number of 0s.

Many possible answers, one example:



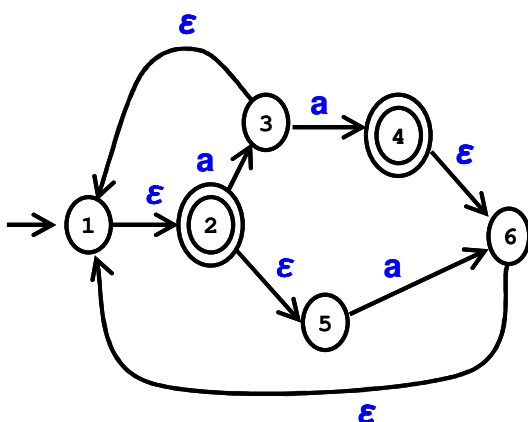
- c. (6 pts) Create a NFA for the regular expression $((abc)d)^*$ using any method.

Many possible answers, one example:

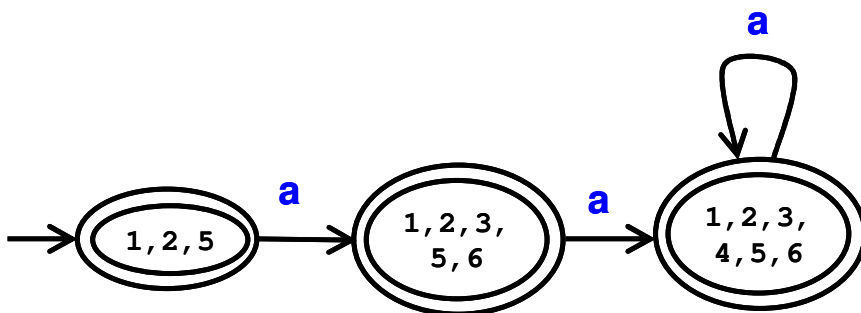


3. (18 pts) NFA to DFA

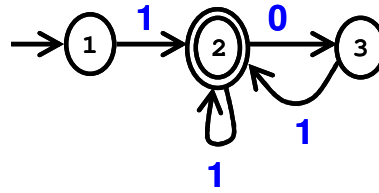
Apply the subset construction algorithm to convert the following NFA to a DFA. Show the NFA states associated with each state in your DFA.



Answer:



(8 pts) DFA Minimization. Consider the following DFA.



- a. (2 pts) What criterion is used to initially place DFA states in one of 2 partitions?

Whether state is a final state.

- b. (6 pts) Assume states 1 & 3 are in one partition, and state 2 is in a different partition. Are states 1 & 3 distinct (i.e., should be placed in 2 different partitions)? Explain.

No, states 1 & 3 are not distinct. Both states behave in the same manner for all transitions: reject for input “0” and enter partition containing 2 for input “1”,

4. (8 pts) Context free grammars

- a. (4 pts) Provide a *rightmost* derivation of the string “110” for the following grammar: $S \rightarrow SS \mid 1 \mid 0$

$S \Rightarrow SS \Rightarrow S0 \Rightarrow SS0 \Rightarrow S10 \Rightarrow 110$ OR $S \Rightarrow SS \Rightarrow SSS \Rightarrow SS0 \Rightarrow S10 \Rightarrow 110$

- b. (4 pts) Create a context free grammar for binary numbers (strings of 0s and 1s) with exactly one more 1 than 0s. Your grammar may be ambiguous.

Many possible answers, one example:

$S \rightarrow E1E$

$E \rightarrow E1E0E \mid E0E1E \mid EE$

Same numbers of 0 & 1s

5. (6 pts) Ruby features

What is the output (if any) of the following Ruby programs? Write FAIL if code does not execute.

- a. `“330” =~ /(3+)/` # **Output = 33 nil**

`puts $1`

`puts $2`

- b. `a = { }` # **Output = b**

`a[“b”] = 3`

`a.keys.each{ |x| puts x }`

6. (36 pts) Ruby programming

In this problem, you will write a short Ruby program that analyzes an assembly-like program stored in a text file. Each line in the file should have the form:

<label>: <opcode> <operands...>

I.e., label followed by instruction (every line must have a label). There is one space to the right of the :, and one to the right of the opcode. Line numbers start at 1. The following table lists the three kinds of instructions and their operand formats

Instructions	ldc <reg>, <int> sub <reg>, <reg> bz <reg>, <label>
<label>	Sequence of lower case letters
<opcode>	ldc, sub, bz
<reg>	r0, r1, ..., r9
<int>	Sequence of digits

Implement a class *AssemblyProgram* with the following methods:

- (22 pts). *compile*(filename) reads the contents of file "filename" and returns false if "filename" doesn't match the format above, or true if it does.
- (7 pts) *find_label*(x) takes a label x and returns the line number of the statement with label x. If label x does not exist for any instruction, then *find_label* should return nil
- (7 pts) *verify_labels* checks that all branch target labels exist (these are labels that are operands of bz instructions). It returns true if all labels are verified to exist, and false otherwise.

For example, for the following program in file "prog"

```
start: ldc r0, 42      # p = AssemblyProgram.new
a: ldc r1, 37          # p.compile("prog") = true, since prog has correct syntax
b: sub r0, r1          # p.find_label("a") = 2
c: sub r0, r2          # p.find_label("start") = 1
branch: bz r0, b       # p.find_label("branch") = 5
                     # p.verify_labels = true, since branch target "b" exists
```

You may assume that all instructions will have unique labels, and the functions *find_label* and *verify_labels* will be invoked only for programs for which *compile* returned true. The function *compile* may store information for use by *find_label* and *verify_labels*.

Helpful functions:

File.new(filename, mode)	// opens filename in mode, returns File
file.eof?	// is File object file at end?
file.readline	// read & return single line from file
file.readlines	// read entire file, return array of lines

Many possible answers, one example:

```
class AssemblyProgram

  def initialize
    @label = {}
    @targets = []
  end

  def compile(filename)
    lineNum = 1
    file = File.new(filename, "r")          # open file
    until file.eof? do                      # repeat until EOF
      line = file.readline                  # read lines from file
      if line =~ /^([a-z]+): ldc r[0-9], [0-9]+$/
        @label[$1] = lineNum
      elsif line =~ /^([a-z]+): sub r[0-9], r[0-9]$/
        @label[$1] = lineNum
      elsif line =~ /^([a-z]+): bz r[0-9], ([a-z])+$/
        @label[$1] = lineNum
        @targets.push $2
      else
        puts "Syntax error #{line}"
        false
      end
      lineNum += 1
    end
    true
  end

  def find_label(name)
    @label[name]
  end

  def verify_labels
    @targets.each { |x| return false if @label[x] == nil }
    true
  end

end
```