CS410/510 Advanced Programming
Lecture 7:

Regular Expressions in Smalltalk

Just Like Haskell

```
data RE
  = Empty
  | Union RE RE
  | Concat RE RE
  | Star RE
  | C Char

instance Show RE where
  show Empty = "#"
  show (C x) = [x]
  show (Union x y) = "("++showU x++"+"++showU y++")"
    where showU (Union x y) = show x++"+"++showU y
          showU x = show x
  show (Concat x y) = show x++show y
  show (Star (x@(Concat _ _))) = "("++show x++")*"
  show (Star (x@(Union _ _))) = "("++show x++")*"
  show (Star x) = show x++"*"
```


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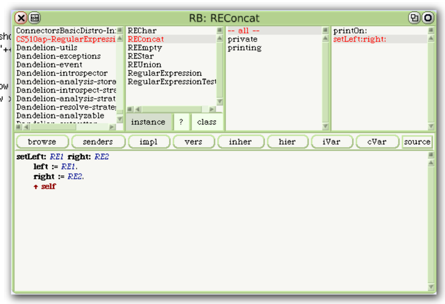
```



Just Like Haskell

One subclass for each alternative representation

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instance Show RE where
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```
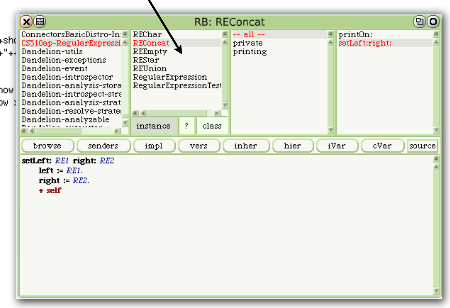
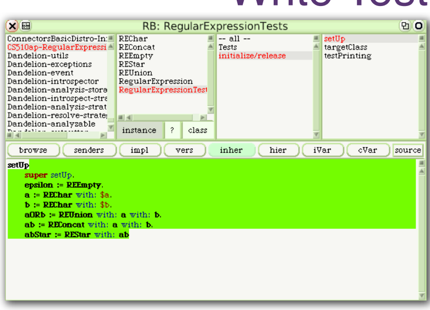
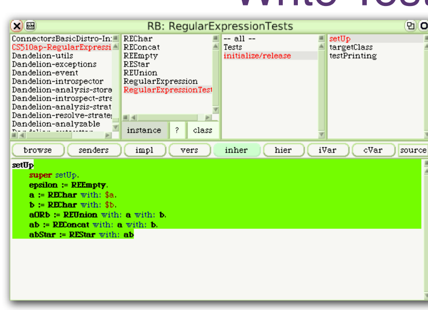



Write Tests



Write Tests

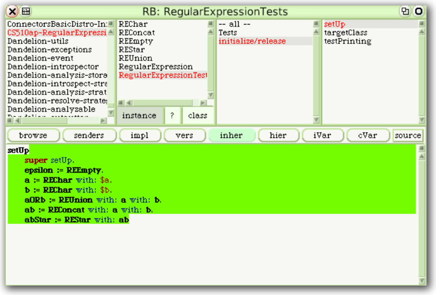


1. Run tests
2. get *message not understood*
3. define method
4. repeat from 1

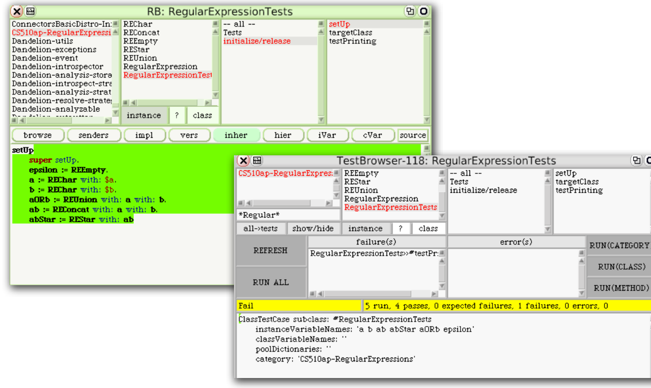
…

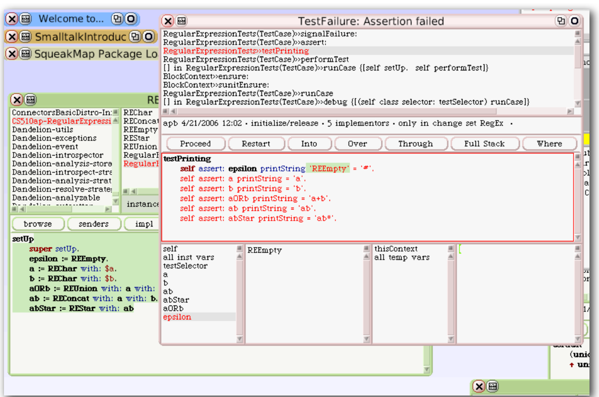
19. get real failure

Write Tests



Write Tests





What's the problem?

I need an instance, not the class

- But there need be only one instance of REEmpty
- Enter: the Singleton pattern.
  - make a class instance-variable called uniqueInstance
  - make a class-side method named default

```
default
    uniqueInstance ifNil: [uniqueInstance := self basicNew].
    ↑ uniqueInstance
```

  - override new to be an error

What do we have so far?

Convenience Operations

```
alpha = Union (C 'a')
              (Union (C 'b') (C 'c'))
digit = Union (C '0')
              (Union (C '1') (C '2'))
key = Union (string "if")
            (Union (string "then")
            (string "else"))
punc = (C ',')
ident = Concat alpha
              (Star (Union alpha digit))
number = Concat digit (Star digit)
lexer = Union ident (Union number (Union key punc))

val re1 = Concat(Union (C '+')(Union (C '-')Empty))
                (Concat (C 'D')(Star (C 'D')))

string :: String -> RE
string [] = Empty
string [c] = C c
string (c:cs) = Concat (C c) (string cs)
```

- Write tests:

  self assert: $a asRE printString = 'a'

  self assert: (a + b) printString = 'a+b'

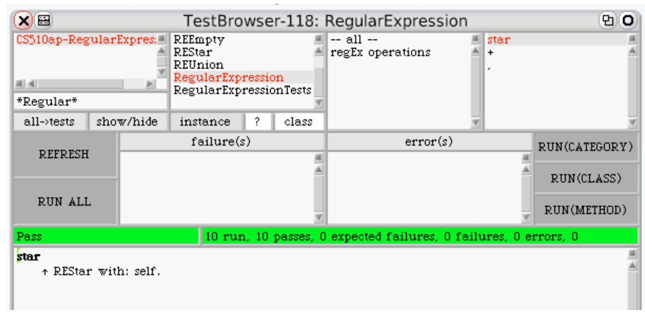
- Why compare *printStrings*?

Where do the operation methods go?

- In the abstract superclass RegularExpression
  - so that they work for all the subclasses

Where do the operation methods go?

- In the abstract superclass RegularExpression

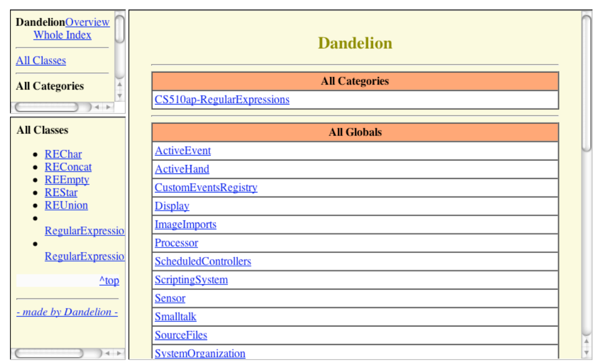


Refactor *tests* to remove duplication

testPrinting
self assert: epsilon printsAs: '#'.
self assert: a printsAs: 'a'.
self assert: b printsAs: 'b'.
self assert: aORb printsAs: 'a+b'.
self assert: ab printsAs: 'ab'.
self assert: abStar printsAs: 'ab*'.

assert: anExpression printsAs: aprintString
self assert: anExpression printString = aprintString

which brings us to…



meaning1: sets of strings

- Code very similar to Tim's Haskell version
- Only tricky part is star
  - Haskell version:

```
meaning1 (Star r) = norm(zero ++ one ++ two ++ three)
  where zero = [""]
        one = meaning1 r
        two = [x++y | x <- one, y <- one]
        three = [x++y | x <- one, y <- two]
```


Smalltalk

REStar

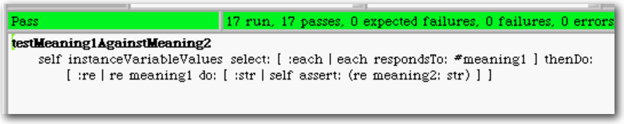
```
meaning1
   | zero one two three |
   zero := ''.
   one := base meaning1.
   two := self anyOf: one followedByAnyOf: one.
   three := self anyOf: one followedByAnyOf: two.
   ↑ (Set with: zero) addAll: one;
        addAll: two;
        addAll: three;
        yourself
```

RegularExpression

```
anyOf: m1 followedByAnyOf: mr
   | result |
   result := Set new.
   m1 do: [:l | mr do: [:r | result add: l , r]].
   ↑result
```

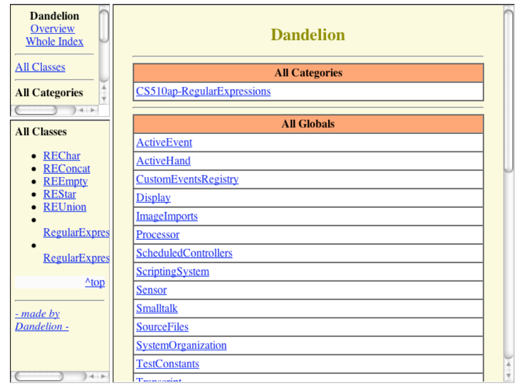
- Complicated enough to need a helper method
- Is there a simpler way to calculate * ?

Cross tests

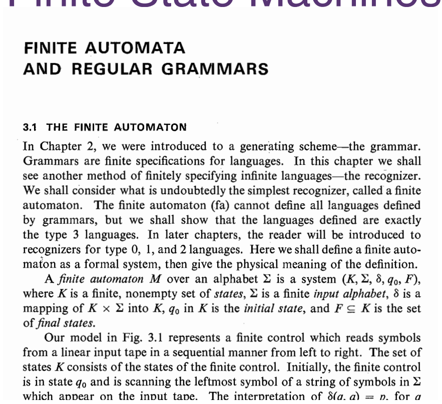


- introspect on the instance variables of the test case
  - select those that respond to the meaning1 message
  - check that for every string str in re meaning1
    - re meaning2: str is true

Now RE's pass the tests



Finite State Machines



FINITE AUTOMATA AND REGULAR GRAMMARS

3.1 THE FINITE AUTOMATON

In Chapter 2, we were introduced to a generating scheme—the grammar. Grammars are finite specifications for languages. In this chapter we shall see another method of finitely specifying infinite languages—the recognizer. We shall consider what is undoubtedly the simplest recognizer, called a finite automaton. The finite automaton (fa) cannot define all languages defined by grammars, but we shall show that the languages defined are exactly the type 3 languages. In later chapters, the reader will be introduced to recognizers for type 0, 1, and 2 languages. Here we shall define a finite automaton as a formal system, then give the physical meaning of the definition.

A *finite automaton* M over an alphabet Σ is a system $(K, \Sigma, \delta, q_0, F)$, where K is a finite, nonempty set of *states*, Σ is a finite *input alphabet*, δ is a mapping of $K \times \Sigma$ into K, q_0 in K is the *initial state*, and $F \subseteq K$ is the set of *final states*.

Our model in Fig. 3.1 represents a finite control which reads symbols from a linear input tape in a sequential manner from left to right. The set of states K consists of the states of the finite control. Initially, the finite control is in state q_0 and is scanning the leftmost symbol of a string of symbols in Σ which appear on the input tape. The interpretation of $\delta(q, a) = p$, for a

The code with NFSM