The Swine Before Perl

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Brown University and PLT

Why We're Here

Any sufficiently complicated C or Fortran program contains an ad hoc, informally-specified, bug-ridden, slow implementation of half of Common Lisp.

—Phil Greenspun's
Tenth Law of Programming

Our Corollary

Any sufficiently useful C or Fortran program needs to be “sufficiently complicated”

We’re here to provide the heavy lifting

I’m here to motivate how Scheme does this

The Swine: PLT Scheme

“Whatever: can you *program* in it?”

Books

- *Teach Yourself Scheme in Fixnum Days*
- *How to Use Scheme*
- Extensive manuals and user support
- It’s all **free of cost**

Software #1: MzScheme

- Quick, textual shell: ideal for scripting
- Rich module system
- Rich mixin-based object system
- Embeddable in applications
- Garbage collection across C/C++/Scheme
- Libraries for lots of 3- and 4-letter acronyms (XML, CGI, ODBC, COM, …)

MzScheme

```
Welcome to MzScheme version 103, Copyright (c) 1995-2000 PLT (Matthew Flatt)
> (require-library "function.ss")
> (require-library "url.ss" "net")
>


(foldl + 0 (map file-size (directory-list)))
3887958
>


(call/input-url (string->url "http://www.cs.brown.edu/~sk/test.html")
                get-pure-port display-pure-port)
<html>
  <head><title>Test</title></head>

  <body><p>Hello!</p></body>
</html>
>
```

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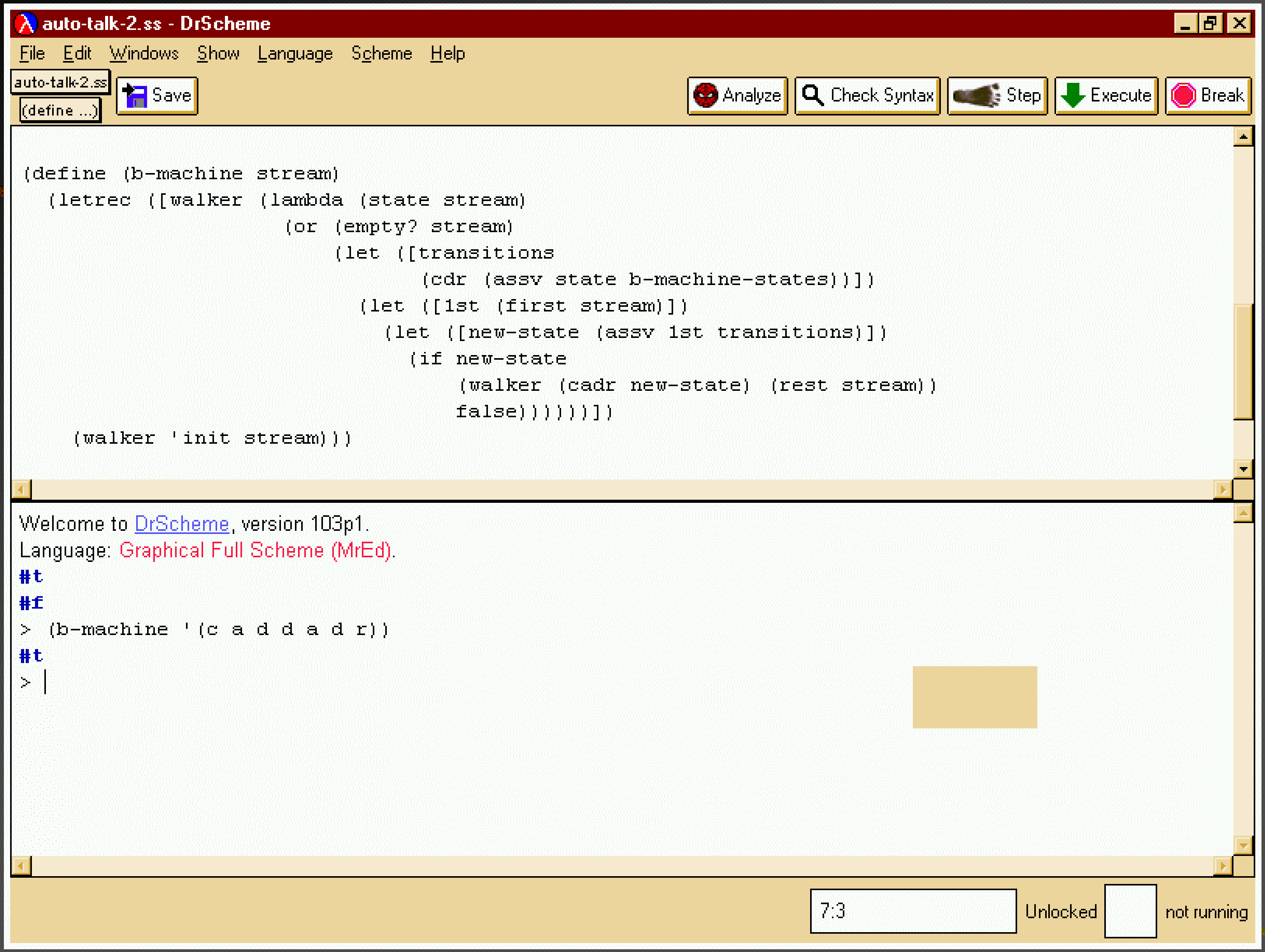
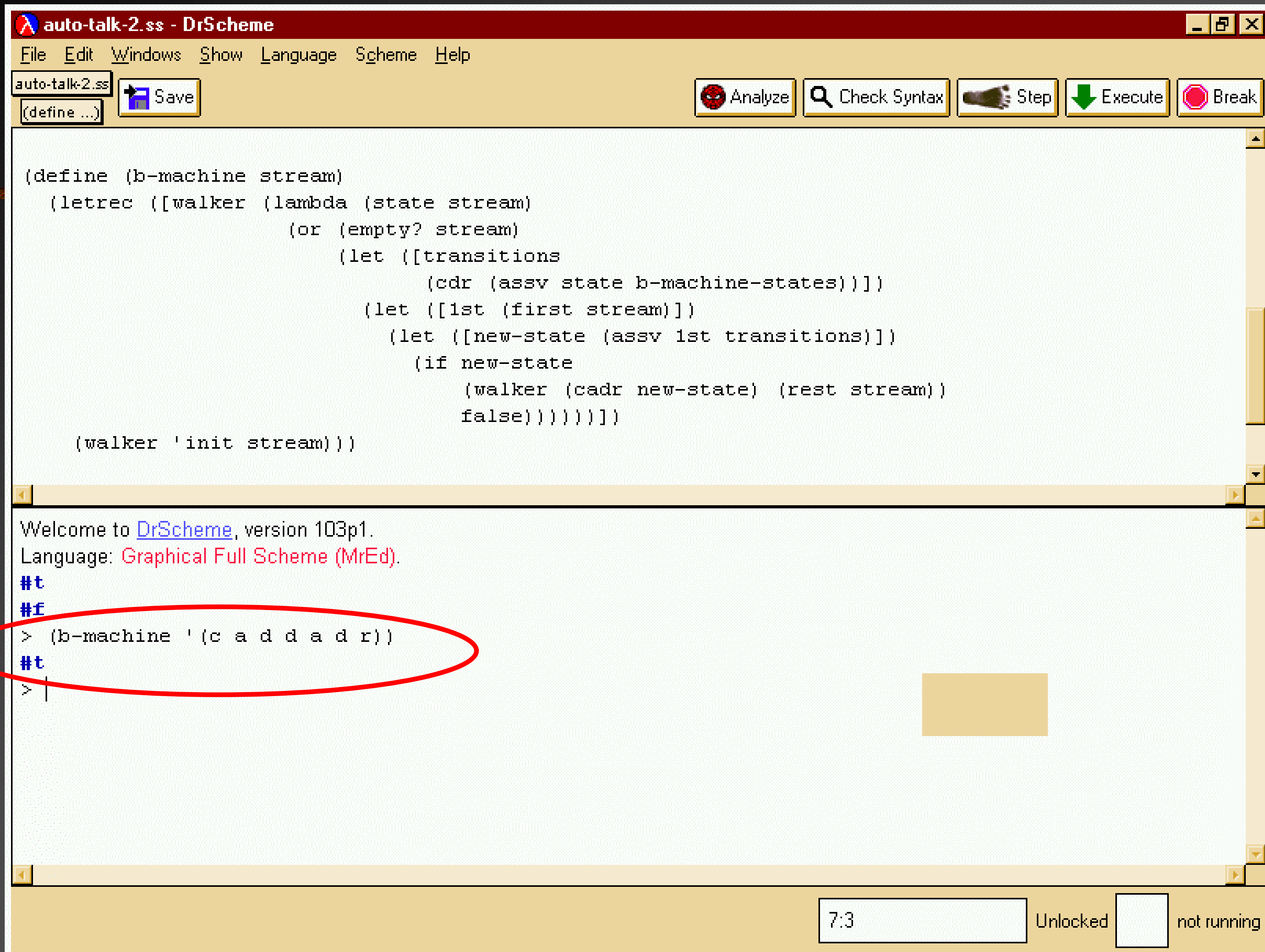
Software #2: DrScheme

- Fully-graphical programming environment
- Full portability: Unix, Mac and Windows
- Special support for beginning Schemers


auto-talk-2.ss - DrScheme
File Edit Windows Show Language Scheme Help
auto-talk-2.ss
(define ...)
Save
Analyze
Check Syntax
Step
Execute
Break
(define (b-machine stream)
  (letrec ([walker (lambda (state stream)
                     (or (empty? stream)
                         (let ([transitions
                                (cdr (assv state b-machine-states))])
                           (let ([1st (first stream)])
                             (let ([new-state (assv 1st transitions)])
                               (if new-state
                                   (walker (cadr new-state) (rest stream))
                                   false))))))])
    (walker 'init stream)))
Welcome to DrScheme, version 103p1.
Language: Graphical Full Scheme (MrEd).
#t
#f
> (b-machine '(c a d d a d r))
#t
>
7:3
Unlocked
not running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Software #3: Type Inference

- Two PhD theses and counting
- Graphically displays inferred types
- Let’s see how it works …

auto-talk-2.ss - MrSpidey

File Edit Windows Actions Show Clear Filter Help

```
(define b-machine-states
  '((init (c loop))
    (loop (a loop)
          (d loop)
          (r end))
    (end (r end))))

(define (b-machine stream)
  (letrec ([walker (lambda (state stream)
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                         (let ([transitions
                                (cdr (assv state b-machine-states))])
                           (let ([1st (first (car stream))])
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(b-machine '(c a d a d r))
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Welcome to MrSpidey, version 103p1.

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CHECKS:
car check in file "auto-talk-2.ss": line 1, column 15
cdr check in file "auto-talk-2.ss": line 18, column 34
car check in file "auto-talk-2.ss": line 19, column 47
```

Unlocked

auto-talk-2.ss - MrSpidey

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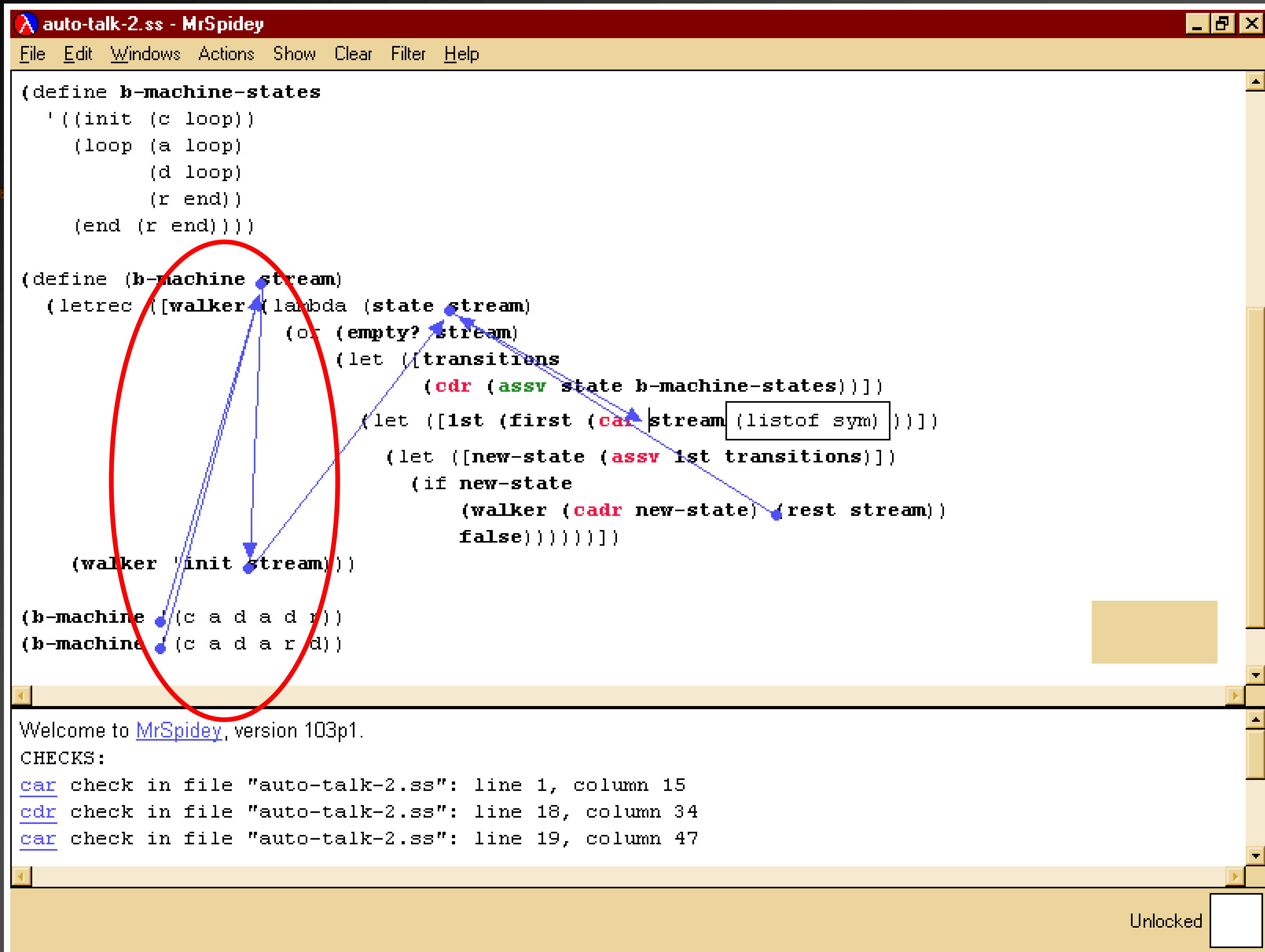
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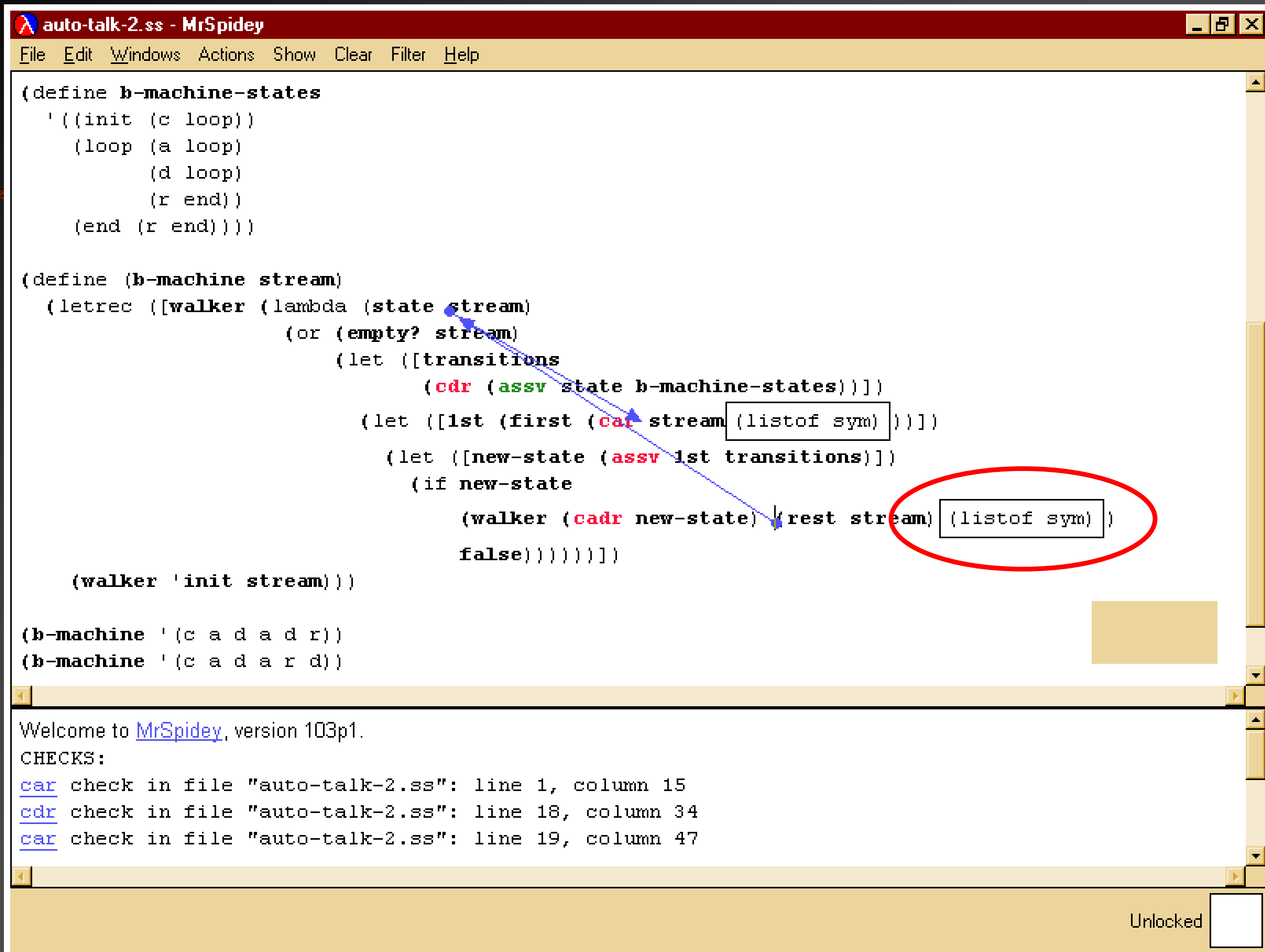
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Software #4: Web Server

- Dynamic content generation is a breeze
- HTML/XML transformation is a breeze
- Trivially build use-once security policies
- For dynamic content, 8x speed of Apache

The Gems

The Gems

- Closures
- Continuations

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The Crown Jewels

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- That stupid parenthetical syntax
- Macros
- Tail calls

The Gems

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The Lesser Gems

A Pearl

On Stealing Beauty –

Where you should start

Problem

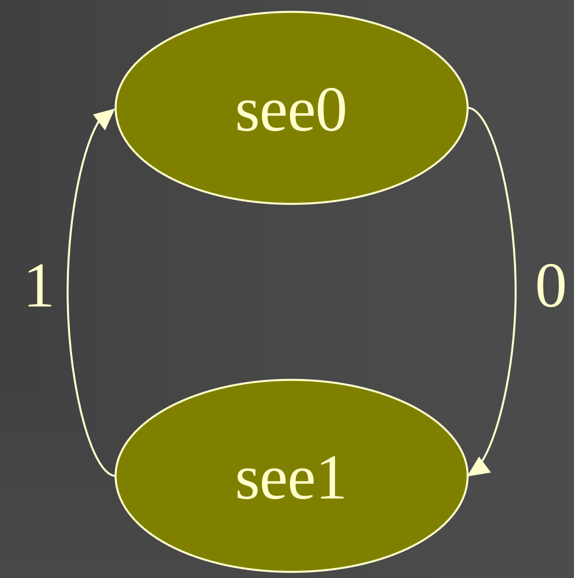
Pattern-matcher for streams:

- Consumes a stream of input tokens
- Must be easy to write and read
- Must be fairly fast
- Must integrate well into rest of code

Let’s Think About Automata

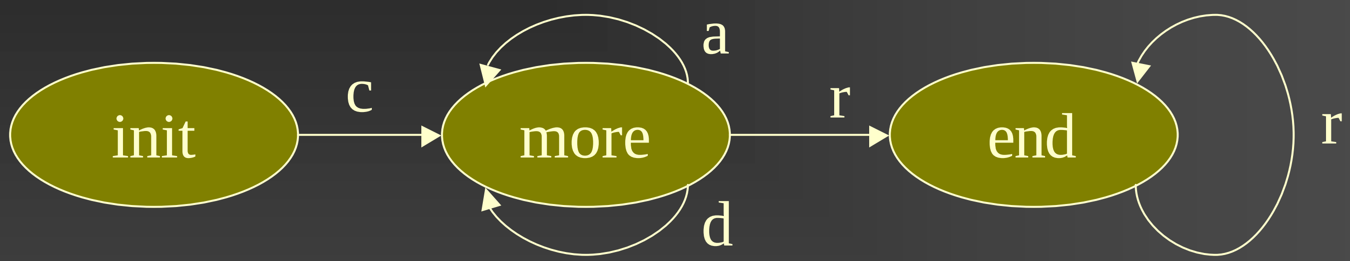
I want to be able to write

```
automaton see0
   see0 : 0 → see1
   see1 : 1 → see0
```



Another Example

`car`, `cdr`, `cadr`, `cddr`, `cdar`, `caddr`, …



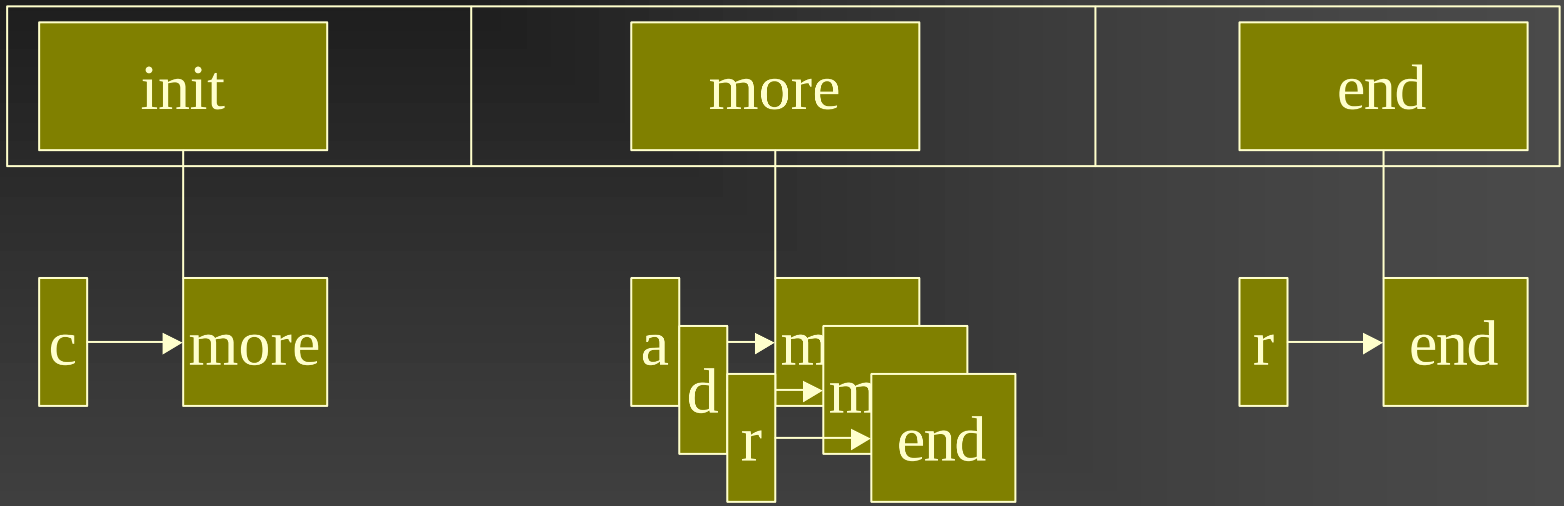

```
init : c → more      more : a → more
                            d → more
end : r → end               r → end
```

Let's Look at That Again

```
automaton init
  init : c → more
  more : a → more
         d → more
         r → end
  end  : r → end
```

How would **you** implement it?

Natural Solution



If stream ends, accept

If no next state found, reject

If next state found, continue

First Version

- Development time: 12 minutes
- Bugs: 2
- Performance (PLT Scheme):
  - 10000 elements: 50 ms
  - 100000 elements: 440 ms
  - 1000000 elements: 4316 ms

The Code

```
(define b-machine-states
  '((init (c more))
    (more (a more)
          (d more)
          (r end))
    (end (r end))))

(define (b-machine stream)
  (letrec ([walker (lambda (state stream)
                     (or (empty? stream)
                         (let ([transitions
                                (cdr (assv state b-machine-states))])
                           (let ([1st (first stream)])
                             (let ([new-state (assv 1st transitions)])
                               (if new-state
                                   (walker (cadr new-state) (rest stream))
                                   false))))))])
    (walker 'init stream)))
```

What’s The Essence?

- Per state, fast conditional dispatch table
- An array of states
- Quick state transition

A Message From Our Sponsors

We will encourage you to develop the three great virtues of a programmer: laziness, impatience, and hubris.

—Larry Wall and Randal L Schwartz

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Thinking Virtuously

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  Compiler writers call this “case … switch”
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  Function pointers offer random access
- Quick state transition

Thinking Virtuously

- Per state, fast conditional dispatch table

  Compiler writers call this “case … switch”
- An array of states

  Function pointers offer random access
- Quick state transition

  If only function calls were implemented as “goto”s ...

In Other Words: `init` State Would Become

```
init ≡
(procedure (stream)
  (or (empty? stream)
      (case (first stream)
        [c (more (rest stream))]
        [else false])))
```

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```

more

In Other Words:
more State Would Become

```
more ≡
(procedure (stream)
  (or (empty? stream)
      (case (first stream)
        [a (more (rest stream))]
        [d (more (rest stream))]
        [r (end (rest stream))]
        [else false])))
```

In Other Words: `more` State Would Become

```
more ≡
(procedure (stream)
  (or (empty? stream)
      (case (first stream)
        [a (more (rest stream))]
        [d (more (rest stream))]
        [r (end (rest stream))]
        [else false]))))
```

end

In Other Words: The Whole Code Would Become

```
(define b
  (letrec ([init
            (procedure (stream)
                       (or (empty? stream)
                           (case (first stream)
                             [c (more (rest stream))]
                             [else false])))]
           [more
            (procedure (stream)
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    init))
```

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    init))
```

Scoreboard

- Laziness: ✔
- Impatience: nope; too much code
- Hubris: …

In General

```
(state : (label → target) ...)
→
(procedure (stream)
  (or (empty? stream)
      (case (first stream)
        [label (target (rest stream))]
        ...
        [else false])))
```

In General

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(state : (label → target) ...)
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```

Even More Generally

```
(_ init-state
   (state : (cndn -> new-state) ...)
   ...)
```

→

```
(letrec ([state
          (procedure (stream)
                     (or (empty? stream)
                         (case (first stream)
                           [cndn (new-state (rest stream))]
                           ...
                           [else false])))]
         ...)
  init-state)
```

Even More Generally

```
(_ init-state
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→

```
(letrec ([state
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                         (case (first stream)
                           [cndn (new-state (rest stream))]
                           ...
                           [else false])))]
         ...)
  init-state)
```

In Fact, That's the Code!

```
(define-syntax automaton
  (syntax-rules (-> :)
    [input pattern
     output pattern]))
```

This is a Scheme macro

The Automaton

```
automaton init
  init :  c → more
  more :  a → more
          d → more
          r → end
  end  :  r → end
```

In Scheme

```
(automaton init
  (init : (c → more))
  (more : (a → more)
          (d → more)
          (r → end))
  (end  : (r → end)))
```

What a Schemer really sees

```
(automaton init
  (init : (c → more))
  (more : (a → more)
          (d → more)
          (r → end))
  (end  : (r → end)))
```

With Clients

```
(define (v s)
  ((if (eq? (first s) 'c)
       (automaton init
        (init : (c -> loop))
        (loop : (a -> loop)
              (d -> loop)
              (r -> end))
        (end : (r -> end)))
       (automaton see0
        (see0 : (0 -> see1))
        (see1 : (1 -> see0))))
   s))
```

Second Version

- Development time: 5 minutes
- Bugs: 0
- Performance:
  - 10000 elements: 30 ms
  - 100000 elements: 310 ms
  - 1000000 elements: 3110 ms

Scoreboard

- Laziness: ✓
- Impatience: ✓
- Hubris: stay tuned

What Really Happened

The traditional implementation is an

Interpreter

The macro system implements a

Compiler

from Scheme++ to Scheme – and lets you reuse the existing Scheme compiler

Macros

- Clean, convenient spec of automata
- Permits *nested* ... – “pattern matching”
- Easy to create domain-specific language
- Each module can have different macros

Tail Calls

Ensures that

state transition =

goto =

loop for free!

Notice tail *recursion* isn't enough!

(Oh, and try generating loop code …)

Stupid Parenthetical Syntax

```
(automaton see0
  (see0 (0 -> see1))
  (see1 (1 -> see0)))
```

is clearly ugly, evil, and an insidious plot hatched by misbegotten academics

Smart Parenthetical Syntax

```
<automaton see0
  <state name="see0">
    <trn> <from> 0 </from>
         <to> see1 </to> </trn> </state>
  <state name="see1">
    <trn> <from> 1 </from>
         <to> see0 </to> </trn> </state>
</automaton>
```

is a hip, cool, great new idea

Python vs. Scheme (python.org)

- Standard object system
- Regular expressions, Internet connectivity
- Many builtin data types
- One standard implementation
- Relatively main-stream syntax
- Main-stream control structures

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- ✔ One standard implementation
- Relatively main-stream syntax – at what price?
- Main-stream control structures
  - We got macros – you got five minutes?
  - Real Programmers use map/filter/fold, tail calls, …

Take-Home Morals

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Take-Home Morals

- If you claim to be smart, be *really* smart about reuse
- Scheme fits together particularly cleverly – you won't get it just by reading about it, you'll only *think* you did
- People who don't understand this use of tail calls don't get it
- Take a real languages course in college

Scoreboard

- Laziness:
- Impatience:
- Hubris:

A Parting Thought

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- A REPL is a Read-Eval-Print Loop:
  Read, then Evaluate, then Print, then Loop

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- In code:

A Parting Thought

- A REPL is a Read-Eval-Print Loop:

  Read, then Evaluate, then Print, then Loop
- In code:

  Print (Eval (Read ())); Loop

A Parting Thought

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  Read, then Evaluate, then Print, then Loop
- In code:

  Print (Eval (Read ())); Loop
- A Print-Eval-Read Loop

A Parting Thought

- A REPL is a Read-Eval-Print Loop:

  Read, then Evaluate, then Print, then Loop
- In code:

  Print (Eval (Read ())); Loop
- A Print-Eval-Read Loop
- A Print-Eval-Read Loop

Obligatory URL

http://www.plt-scheme.org/

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