

Shen - Programming Language

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Cash & Candy

Setting variables

```
(set *candy* [snickers hersheys twix])  
(set *currency* [quarter dime nickel dollar])
```

Getting variables

```
(value *candy*)  
=> [snickers hersheys twix]
```

Mutating variables

```
(set *candy* (append [payday] (value *candy*)))  
(value *candy*)  
=> [payday snickers hersheys twix]
```

Pricing & Denominations

- Notice type signatures

Denominations

```
(define faceValue  
  {currency --> number}  
  quarter -> 25  
  dime    -> 10  
  nickel  -> 5  
  dollar  -> 100)
```

Candy cost

```
(define candy-cost  
  {candy --> number}  
  snickers -> 100  
  twix     -> 125  
  hersheys -> 75  
  payday   -> 95)
```

Typing Cash & Candy

```
(datatype items
  if (element? X (value *currency*)) \\ premise
  -----
  X : currency;                      \\ conclusion

  if (element? X (value *candy*))
  -----
  X : candy;)
```

- Notice commenting syntax
- Shen was developed on Windows

$a^{n>0}$

```
(defcc <as>
  a <as>;
  a;)
(compile (function <as>) [a a a])
=> [a a a]
(compile (function <as>) [a a b])
=> parse error
```

$a^{n>0}b^{m>0}$

```
(defcc <bs>  
  b <bs>;  
  b;)
```

```
(defcc <asbs>  
  <as> <bs>;)
```

```
(compile (function <asbs>) [a a a])  
=> parse error  
(compile (function <as>) [a a b])  
=> [a a b]
```

Vending Machine Grammar

```
(defcc <instruction>  
  list <vending-machine-state>;)
```

```
(defcc <vending-machine-state>  
  candy;  
  money;)
```

Try it!

```
> list money  
> list candy
```

Vending Machine Grammar

```
(defcc <instruction>
  add <inputs>;)

(defcc <inputs> <currencies> := [[currency| [<currencies>]]];)

(defcc <currencies>
  <currency> <currencies>; <currency>;)

(defcc <currency> C := [C
  where (element? C (value *currency*))];)
```

Try it!

```
> add quarter dollar nickel
```


Vending Machine Grammar

```
(defcc <instruction> ...;)  
(defcc <sudo>  
  sudo;  
  := [user];)  
(defcc <instructions>  
  <sudo> <instruction> := (append <sudo> [<instruction>]));)
```

Parsing to an AST

```
(compile (function <instructions>) [add quarter dollar])  
=> [user [add [currency [quarter dollar]]]]  
(compile (function <instructions>) [sudo add quarter dollar])  
=> [sudo [add [currency [quarter dollar]]]]
```

Internal Representation

Machine state

```
(@p [(@p snickers 2)
      (@p twix 20)
      ..]
  [(@p dollar 3)
    (@p quarter 10)
    ...])
```

Types

```
(synonyms state      (candyStore * coinStore)
  candyStore (list (candy * number))
  coinStore  (list (currency * number)))
```

Adding coins

Add instruction

```
> add quarter dollar
```

Add coin routine

```
(define add-coins
  { coinStore --> (list currency) --> coinStore }
  CoinStore []    -> CoinStore
  CoinStore Coins -> (add-coins
                      (add-coin CoinStore (head Coins))
                      (tail Coins)))

(define add-coin
  { coinStore --> currency --> coinStore }
  CoinStore Coin -> (with-key CoinStore Coin (+ 1)))
```

Updating A Lookup Table

```
(define with-key
  { (list (A * B)) --> A --> (B --> B) --> (list (A * B)) }
  [(@p K V) | KVs] K F -> (append [(@p K (F V))]
                                   (with-key KVs K F))
  [KV | KVs] K F      -> (append [KV]
                                   (with-key KVs K F))
  [] K F              -> [])
```

Typing commands

Sample untyped commands from 'defcc'

```
> [sudo [add [currency [quarter dollar]]]]  
> [user [list money]]
```

Typing a command

```
(datatype command-line  
-----  
[sudo X] : command-line;  
  
-----  
[user X] : command-line;)
```

Processing a command

Command processor

```
(define process-request
  { state --> command-line --> state -->
    (string * state * state)})
...
VM [sudo [list money]] US -> (@p (show-coins VM) VM US)
VM [user [list money]] US -> (@p (show-coins US) VM US)
...
)
```

Processing a command

Processing currencies

```
(define process-request
  { state --> command-line --> state -->
    (string * state * state)}
  VM [user [add [currency Currencies]]] US
      > (@p "Success."
          VM
          (@p (fst US)
              (add-coins (snd US) Currencies)))
)
```

Typing currency commands

Currency command type

```
(datatype currency
```

```
-----  
[currency X] : blah;
```

```
[currency X] : blah;
```

```
-----  
X : (list currency);)
```


Generating currency command type

```
(defmacro connector-type-macro
  [connect-type Name TypeA X TypeB] ->
  (let Connector (gensym connector-)
    [datatype Name
     -----
     TypeA : Connector;

     TypeA : Connector;
     -----
     X : TypeB;]));
```

Generating types

Example Usage

```
(connect-type currency [currency X] X (list currency))
```

Type Generated

```
(datatype currency  
-----  
[currency X] : connector-3047;  
  
[currency X] : connector-3047;  
-----  
X : (list currency);)
```

Type Required

```
(datatype currency  
-----  
[currency X] : blah;  
  
[currency X] : blah;  
-----  
X : (list currency);)
```

Currency Macro loading

```
(tc -)                \\ turn off typechecking
(defmacro connector-type-macro ...) \\ declare macro
(tc +)                \\ turn on typechecking
(connect-type [currency X] ...)    \\ generate type
(define process-request ...)       \\ use type
```

Concurrency Layer

- Each connection gets a thread
- Each thread has a state
`(candyStore * coinStore)`
- Each connection is stored globally in:
`*connectionStore*`
- Synchronized via SBCL's mailbox

Concurrency Layer

Global Mailbox For Concurrency

```
(set *mailbox* (((protect READ-FROM-STRING)
                  "SB-CONCURRENCY::MAKE-MAILBOX"))))
```

Sending/Receiving a message

```
(define send-message
  Mailbox Message -> (((protect READ-FROM-STRING)
                        "SB-CONCURRENCY::SEND-MESSAGE")
                      Mailbox Message))

(define receive-message
  Mailbox -> (((protect READ-FROM-STRING)
                "SB-CONCURRENCY::RECEIVE-MESSAGE")
             Mailbox))
```

In Common Lisp

```
(package-name:function arg1 arg2 ...)
```

Same thing in Shen

```
((protect READ-FROM-STRING) "PACKAGE-NAME::FUNCTION")  
  arg1 arg2 ..)
```

- Couldn't figure out the macro

Wrapping socket listener

```
(define socket-listen
  Host Port -> (((protect READ-FROM-STRING)
                  "USOCKET::SOCKET-LISTEN")
                 Host
                 Port))
```

Calling from Shen

```
(define open-socket
  Host Port -> (let Sock (socket-listen Host Port)
                 (do (add-to *connectionStore* Sock)
                     Sock)))
```

Threading

Wrapping thread maker

```
(define make-thread  
  Function -> (((protect READ-FROM-STRING)  
                "SB-THREAD::MAKE-THREAD") Function))
```

Creating a thread

```
(make-thread  
  (freeze (do (... request-response loop ...)  
              (... close connection .... ))))
```


Typing CL Functions

An IP Address

```
if (is-ip-address X)
-----
X : ip-address;
```

Parsing an IP Address

```
(defcc <ip-address>
  <octet-1> shen.<stop>
  ..
  <octet-4> := [<octet-1> <octet-2> <octet-3> <octet-4>];
  <e>;)
```

Typing open-socket

```
(declare open-socket [ip-address --> [number --> socket]])
```

Conclusion

- <http://shenlanguage.org>
- <http://github.com/deech/ShenVendingMachine>