Menu

- Introduction to Interpreters
- History of Object-Oriented Programming (time permitting)

"Trick or Treat" Protocols

"Trick or Treat" Protocols

- Trick-or-Treater must convince victim that she poses a credible threat
- Need to **prove** you know are a qualified tricker
- But, revealing trickiness shouldn't allow victim to impersonate a tricker

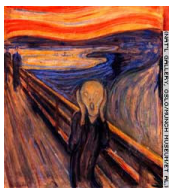
Except around Halloween, this is called an "authentication protocol".

Trick-or-Treat

Trickers?

"Trick or Treat?"

"Prove it!"



Victim

"The magic word is: shazam!"

Any problems with this?

Cryptographic Hash Functions

One-way

Given h, it is hard to find x such that $H(x) = h$.

Collision resistance

Given x, it is hard to find $y \neq x$ such that $H(y) = H(x)$.

Example One-Way-ish Function

Input: two 100 digit numbers, x_1 and x_2

Output: the middle 100 digits of $x_1 \times x_2$

Given $x = (x_1, x_2)$: easy to calculate $f(x)$.

"Easy" means there is a procedure with running time in $O(N^2)$ where N is number of digits

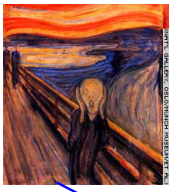
Given $h = f(x)$: hard to find an z such $h = f(z)$.

"Hard" means (we hope) the fastest possible procedure has running time in $\Omega(2^N)$.

Trick-or-Treat

Trickers?

"Trick or Treat?", H (secret)



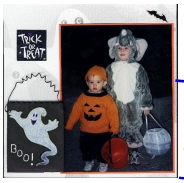
H (secret)

Trickers Bureau

Valid!

Ouch! Now victim knows enough to be a tricker: can just replay H (secret) to the next victim.

Trick-or-Treat



Trickers?

"Trick or Treat?"

Challenge: Z

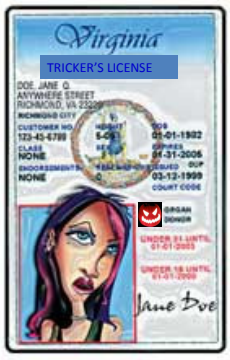
$R = H$ (secret + Z)

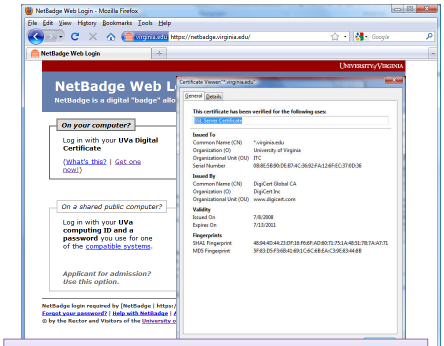
R, Z

Trickers Bureau

Valid!

Trick-or-Treating without Calling the Tricker's Bureau





You know what you need to survive tomorrow....we'll talk more about how this works on the web later.

Implementing Interpreters

Problem Set 7: posted today, due Monday 9 November.
- Understand the Charme interpreter (described in Chapter 11)
- Modify it to create a new language

Building a Language

Design the grammar

What strings are in the language?

Use BNF to describe all the strings in the language

Make up the evaluation rules

Describe what every string in the language means

Build an evaluator

Implement a procedure that takes a string in the language as input and an environment and outputs its value:

meval: *String* × *Environment* → *Value*

Is this an exaggeration?

It is no exaggeration to regard this as the most fundamental idea in programming:

The evaluator, which determines the meaning of expressions in the programming language, is just another program.

To appreciate this point is to change our images of ourselves as programmers. We come to see ourselves as designers of languages, rather than only users of languages designed by others.

Abelson and Sussman, *Structure and Interpretation of Computer Programs* (p. 360)

Building an Evaluator

To build an evaluator we need to:

- Figure out how to represent data in programs
  - What is a procedure, frame, environment, etc.
- Implement the evaluation rules
  - For each evaluation rule, define a procedure that follows the behavior of that rule.

Next: we'll look at a high-level how the application rule is implemented
Next week and Chapter 11: detailed walk-through of the interpreter

```
def meval(expr, env):
    if isPrimitive(expr):
        return evalPrimitive(expr)
    elif isIf(expr):
        return evalIf(expr, env)
    elif isDefinition(expr):
        evalDefinition(expr, env)
    elif isName(expr):
        return evalName(expr, env)
    elif isLambda(expr):
        return evalLambda(expr, env)
    elif isApplication(expr):
        return evalApplication(expr, env)
    else:
        error ('Unknown expression type: ' + str(expr))
```

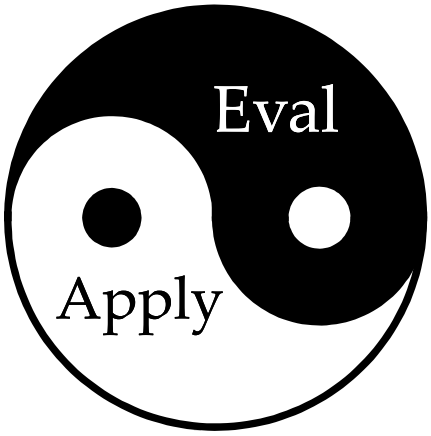
Core of the evaluator: **meval**

Stateful Application Rule

To apply a constructed procedure:

1. **Construct a new environment**, whose parent is the environment of the applied procedure.
2. **For each procedure parameter, create a place** in the frame of the new environment with the name of the parameter. Evaluate each operand expression in the environment of the application and initialize the value in each place to the value of the corresponding operand expression.
3. **Evaluate** the body of the procedure **in the newly created environment.** The resulting value is the value of the application.

Eval and Apply are defined in terms of each other.



evalApplication

To apply a constructed procedure:

1. **Construct a new environment**, whose parent is the environment of the applied procedure.
2. **For each procedure parameter, create a place** in the frame of the new environment with the name of the parameter. **Evaluate each operand expression in the environment of the application** and initialize the value in each place to the value of the corresponding operand expression.
3. **Evaluate** the body **the newly created** resulting value is t application.

```
def evalApplication(expr, env):
    subexprs = expr
    subexprvals = map (lambda sexpr: meval(sexpr, env), subexprs)
    return mapply(subexprvals[0], subexprvals[1:])
```

To apply a constructed procedure:

1. **Construct a new environment, whose parent is the environment of the applied procedure.**
2. **For each procedure parameter, create a place** in the frame of the new environment with the name of the parameter. Evaluate each operand expression in the environment of the application and initialize the value in each place to the value of the corresponding operand expression.
3. **Evaluate** the body of the procedure **in the newly c**
resulting va
application.

```
class Environment:
    def __init__(self, parent):
        self._parent = parent
        self._frame = {}
    def addVariable(self, name, value): ...
    def lookupVariable(self, name): ...
```

```
def mapply(proc, operands):
    if (isPrimitiveProcedure(proc)): ...
    elif isinstance(proc, Procedure):
        params = proc.getParams()
        newenv = Environment(proc.getEnvironment())
        ...
```

To apply a constructed procedure:

1. Construct a new environment, whose parent is the environment of the applied procedure.
2. **For each procedure parameter, create a place in the frame of the new environment with the name of the parameter.** Evaluate each operand expression in the environment of the application **and initialize the value in each place to the value of the corresponding operand expression.**
3. **Evaluate** the body of the procedure **in the newly created environ**
resulting value is the value
application.

```
def mapply(proc, operands):
    if (isPrimitiveProcedure(proc)): ...
    elif isinstance(proc, Procedure):
        params = proc.getParams()
        newenv = Environment(proc.getEnvironment())
        for i in range(0, len(params)):
            newenv.addVariable(params[i], operands[i])
        ...
```

To apply a constructed pro

1. Construct a new envir
parent is the environm
applied procedure.
2. For each procedure pa
a place in the frame of
environment with the
parameter. Evaluate each operand expression in the environment of the application and initialize the value in each place to the value of the corresponding operand expression.
3. **Evaluate the body of the procedure in the newly created environment. The resulting value is the value of the application.**

```
def mapply(proc, operands):
    if (isPrimitiveProcedure(proc)): ...
    elif isinstance(proc, Procedure):
        params = proc.getParams()
        newenv = Environment(proc.getEnvironment())
        for i in range(0, len(params)):
            newenv.addVariable(params[i], operands[i])
        return meval(proc.getBody(), newenv)
```

Charge

- Read Chapter 11
- PS7 posted today, due Monday, Nov 9

Remember to make "Trick-or-Treaters" to solve your challenge!