

University of Massachusetts Lowell

91.301: Organization of Programming Languages
Spring 2007

Problem Set 7 **The Adventure Game**

Issued: Thursday, 22 March 2007

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Reading: Additional Notes for PS7 on Object-Oriented Programming

The programming assignment for this week explores two ideas: the simulation of a world in which objects are characterized by collections of state variables, and the use of *object-oriented programming* as a technique for modularizing worlds in which objects interact. These ideas are presented in the context of a simple simulation game like the ones available on many computers. Such games have provided an interesting waste of time for many computer lovers. In order not to waste too much of your own time, it is important to study the system and plan your work before starting to write any code.

This problem set begins by describing the overall structure of the simulation. The warm-up exercises in Part 2 will help you to master the ideas involved. Part 3 contains the assignment itself.

Use the Textual lanague (MZScheme, includes R5RS) in DrScheme for this assignment. See the implementation section for more on the files that you need to download).

Part 1: The SICP Adventure Game

The basic idea of simulation games is that the user plays a character in an imaginary world inhabited by other characters. The user plays the game by issuing commands to the computer that have the effect of moving the character about and performing acts in the imaginary world, such as picking up objects. The computer simulates the legal moves and rejects illegal ones. For example, it is illegal to move between places that are not connected (unless you have special powers). If a move is legal, the computer updates its model of the world and allows the next move to be considered.

Our game takes place in a strange, imaginary world called UMass Lowell, with imaginary places such as a computer lab, a robot lab, and a department office. In order to get going, we need to establish the structure of this imaginary world: the objects that exist and the ways in which they relate to each other.

Initially, there are three procedures for creating objects:

```
(make-thing name)
(make-place name)
(make-person name birthplace restlessness)
```

In addition, there are procedures that make people and things and procedures that install them in the simulated world. The reason that we need to be able to create people and things separately from installing them will be discussed in one of the exercises later. For now, we note the existence of the procedures

```
(make&install-thing name birthplace)
(make&install-person name birthplace restlessness)
```

Each time we make or make and install a person or a thing, we give it a name. People and things also are created at some initial place. In addition, a person has a restlessness factor that determines how often the person moves. For example, the procedure `make&install-person` may be used to create the two imaginary characters, `holly` and `kate`, and put them in their places, as it were.

```
(define computer-lab (make-place 'computer-lab))
(define robot-lab (make-place 'robot-lab))

(define holly (make&install-person 'holly robot-lab 3))
(define kate (make&install-person 'kate computer-lab 2))
```

All objects in the system are implemented as message-accepting procedures.

Once you load the system on your machine, you will be able to control `holly` and `kate` by sending them appropriate messages. As you enter each command, the computer reports what happens and where it is happening. For instance, imagine we had interconnected a few places so that the following scenario is feasible:

```
(ask holly 'look-around)
At robot-lab : holly says -- I see nothing
()

(ask (ask holly 'place) 'exits)
(south)

(ask holly 'go 'south)
holly moves from robot-lab to west-hall
#t

(ask holly 'go 'east)
holly moves from west-hall to elevator-lobby
#t

(ask holly 'go 'north)
holly moves from elevator-lobby to computer-lab
At computer-lab : holly says -- Hi kate
#t

(ask kate 'look-around)
At computer-lab : kate says -- I see holly
(holly)
```

In principle, you could run the system by issuing specific commands to each of the creatures in the world, but this defeats the intent of the game since that would give you explicit control over all the characters. Instead, we will structure our system so that any character can be manipulated automatically in some fashion by the computer. We do this by creating a list of all the characters to be moved by the computer and by simulating the passage of time by a special procedure, `clock`, that sends a `move` message to each creature in the list. A `move` message does not automatically imply that the creature receiving it will perform an action. Rather, like all of us, a creature hangs about idly until he or she (or it) gets bored enough to do something. To account for this, the third argument to `make-person` specifies the average number of clock intervals that the person will wait before doing something (the restlessness factor).

Before we trigger the clock to simulate a game, let's explore the properties of our world a bit more.

First, let's create a `sicp-textbook` and place it in the `computer-lab` (where `holly` and `kate` now are).

```
(define sicp-textbook (make&install-thing 'sicp-textbook computer-lab))
```

Next, we'll have `holly` look around. She sees the textbook and `kate`. The textbook looks useful, so we have `holly` take it and leave.

```
(ask holly 'look-around)
At computer-lab : holly says -- I see sicp-textbook kate
(sicp-textbook kate)

(ask holly 'take sicp-textbook)
At computer-lab : holly says -- I take sicp-textbook
#t

(ask holly 'go 'south)
holly moves from computer-lab to elevator-lobby
#t
```

kate had also noticed the manual; he follows holly and snatches the textbook away. Angrily, holly sulks off to the network-closet:

```
(ask kate 'go 'south)
kate moves from computer-lab to elevator-lobby
At elevator-lobby : kate says -- Hi holly
#t

(ask kate 'take sicp-textbook)
At elevator-lobby : holly says -- I lose sicp-textbook
At elevator-lobby : holly says -- Yaaaah! I am upset!
At elevator-lobby : kate says -- I take sicp-textbook
#t

(ask holly 'go 'west)
holly moves from elevator-lobby to west-hall
#t

(ask holly 'go 'south)
holly moves from west-hall to network-closet
#t
```

Unfortunately for holly, beneath the network closet is an inaccessible dungeon, inhabited by a troll named *grendel*. A troll is a kind of person; it can move around, take things, and so on. When a troll gets a *move* message from the clock, it acts just like an ordinary person—unless someone else is in the room. When *grendel* decides to act, it's game over for holly:

```
(ask grendel 'move)
grendel moves from dungeon to network-closet
At network-closet : grendel says -- Hi holly
#t
```

After a few more moves, *grendel* acts again:

```
(ask grendel 'move)
At network-closet : grendel says -- Growl.... I'm going to eat you, holly
At network-closet : holly says --
    Dulce et decorum est
    pro computatore mori!
holly moves from network-closet to heaven
At network-closet : grendel says -- Chomp chomp. holly tastes yummy!
*burp*
```

Implementation The simulator for the world is contained in two files, which are included at the end of the problem set. The first file, *game.ss*, contains the basic object system, procedures to create people, places, things and trolls, together with various other useful procedures. The second file, *world.ss*, contains code that initializes our particular imaginary world and installs *holly*, *kate*, and *grendel*.

You can find these files on the web site. Loading and executing the *world.ss* file will load in the *game.ss* file as well.

Part 2: Warm-up Exercises

Do these exercises before starting work on the computer. These exercises should be turned in with your assignment.

Exercise 1: Draw a simple inheritance diagram showing all the kinds of objects (classes) defined in the adventure game system (`game.ss`), the inheritance relations between them, and the methods defined for each class.

Exercise 2: Draw a simple map showing all the places created by evaluating `world.ss`, and how they interconnect. You will probably find this map useful in dealing with the rest of the problem set.

Exercise 3: Suppose we evaluate the following expressions:

```
(define pizza (make-thing 'pizza robot-lab))
(ask pizza 'set-owner holly)
```

At some point in the evaluation of the second expression, the expression

```
(set! owner new-owner)
```

will be evaluated in some environment. Draw an environment diagram, showing the full structure of `pizza` at the point where this expression is evaluated. Don't show the details of `holly` or `robot-lab`—just assume that `holly` and `robot-lab` are names defined in the global environment that point off to some objects that you draw as blobs.

Exercise 4: Suppose that, in addition to `pizza` in Exercise 3, we define

```
(define pepperoni-pizza (make-named-object 'pizza))
```

Are `pizza` and `pepperoni-pizza` the same object (*i.e.*, are they `eq?`)? If `holly` wanders to a place where they both are and looks around, what message will she print?

Exercises

Solutions to these exercises should also be turned in with your solutions to the warm-up exercises.

Exercise 5: We suggest that you do this exercise *before* you start coding the assignment, because it illustrates a bug that is easy to fall into when working with the adventure game.

Note how `install` is implemented as a method defined as part of both `mobile-object` and `person`. Notice that the `person` version puts the person on the clock list (this makes them “animated”) then invokes the `mobile-object` version on `self`, which makes the `birthplace` where `self` is being installed aware that `self` thinks it is in that place. That is, it makes the `self` and `birthplace` consistent in their belief of where `self` is. The relevant details of this situation are outlined in the code excerpts below:

```

(define (make-person name birthplace threshold)
  (let ((mobile-obj (make-mobile-object name birthplace))
        :))
  (lambda (message)
    (cond ...
      :
      ((eq? message 'install)
       (lambda (self)
         (add-to-clock-list self)
         ((get-method mobile-obj 'install) self) )) ; **
      :
      :))))

(define (make-mobile-object name place)
  (let ((named-obj (make-named-object name)))
    (lambda (message)
      (cond ...
        :
        ((eq? message 'install)
         (lambda (self)
           (ask place 'add-thing self)))
        :
        :))))

```

Louis Reasoner suggests that it would be simpler if we change the last line of the `make-person` version of the `install` method to read:

```
(ask mobile-obj 'install) )) ; **
```

Alyssa P. Hacker points out that this would be a bug. “If you did that,” she says, “then when you `make&install-person holly` and `holly` moves to a new place, she’ll thereafter be in two places at once! The new place will claim that `holly` is there, and `holly`’s place of birth will also claim that `holly` is there.”

What does Alyssa mean? Specifically, what goes wrong? You will likely need to draw an appropriate environment diagram to explain carefully.

Exercise 6: We do not expect you to have to make significant changes in the `game.ss` code, though you may do so if you want to.

You will also have a `world.ss` buffer. Since the simulation model works by data mutation, it is possible to get your SCHEME-simulated world into an inconsistent state while debugging. To help you avoid this problem, we suggest the following discipline: any procedures you change or define should be placed in your answer file; any new characters or objects you make and install should be added to `world.ss`. This way whenever you change some procedure you can make sure your world reflects these changes by simply re-evaluating the entire `world.ss` file. Finally, to save you from retyping the same scenarios repeatedly—for example, when debugging you may want to create a new character, move it to some interesting place, then ask it to act—we suggest you define little test “script” procedures at the end of `world.ss` which you can invoke to act out the scenarios when testing your code. See the comments in `world.ss` for details.

After loading the files, make `holly` and `kate` move around by repeatedly calling `clock` (with no arguments). (a) Which person is more restless? (b) How often do both of them move at the same time?

Exercise 7: A student is a special kind of person. Define a procedure `make-student` that creates a student object. It should inherit from `person`. A student has an instance variable `passed-op1` that indicates whether or not the student has taken and passed OPL. Initially, all students have not passed OPL. A student has a method `take-op1` that changes the state of `passed-op1` to `#t`. A student also has a method `cheat-on-problem-set`

that changes the state of `passed-op1` to `#f`. A student also has a method `passed-op1?` that evaluates to `#t` if the student has passed OPL and `#f` otherwise.

Exercise 8: Make and install a new character of a student type, yourself, with a high enough threshold (say, 100) so that you have “free will” and are not likely to be moved by the clock. Place yourself initially in the `computer-lab`. Also make and install a thing called `late-homework`, so that it starts in the `computer-lab`. Pick up the `late-homework`, find out where `holly` is, go there, and try to get `holly` to take the homework even though she is notoriously adamant in her stand against accepting late problem sets. Can you find a way to do this that does not leave *you* upset? Turn in a list of your definitions and actions. If you wish, you can intersperse your moves with calls to the clock to make things more interesting. (Watch out for `grendel!`)

Exercise 9: Define a procedure `make-advisor` that makes a special kind of person. It should inherit from a `person` but have an additional method: `(ask 'advise Person)` An advisor will enroll a student in OPL if the student and the advisor are in the same place and the student has not yet passed OPL. When enrolled, the student is sent to the OPL classroom (you can do this with `(ask person 'move-to OPL)`).

Note that you’ll need to create the OPL place in your world. It’s up to you whether or not to make this a place from which one can exit.

In addition, you should make the `clock-tick` method for an advisor automatically enroll any students who haven’t passed OPL in the place where the advisor is. If no students are in the current location, the advisor will act like a normal `person` that is, it should invoke the super class (`person`) `clock-tick` method. You may find the `other-people-at-place` procedure (defined in `game.ss`) useful. Create and install at least one advisor in your world in the `elevator-lobby`.

Exercise 10: Now you have the elements of a simple game that you play by interspersing your own moves with calls to the clock. Your goal is to leave the `computer-lab`, gain access to the `robot-lab`, and return, without being enrolled in OPL (start yourself off as not having passed OPL, as you’re still in the course now).

To make the game more interesting, you should also create some student(s) besides yourself and set up the student `act` method so that a student will try to move around campus, collecting interesting things that they find and occasionally leaving some of their possessions behind when they move on.

Turn in your new student `act` method and a demonstration that it works.

Exercise 11: Design a non-trivial extension to this simulated world. You can do what you want (so long as it is in good taste, of course). The extension can be as elaborate as you like, but don’t go overboard this is meant to be a problem set, not a term paper, after all.

Try to base your extended simulation around a theme. Possibilities include classes, labs, food, robots, etc. Use your imagination!

Whatever you choose to do, your simulation should include at least two new kinds of persons, places, or things, using inheritance. For example, you might implement a classroom as a new kind of place. Your new objects should have some special methods or special properties in relation to other objects. To continue the previous example, you might make new kinds of people called `lazy-students`, who go to sleep when they enter classrooms.

In answering this problem, you should turn in:

- One or two paragraphs explaining the “story” behind your simulation. Describe your new objects and their behaviors.

- An inheritance diagram showing your new classes.
- Listings of any new procedures you write, or old procedures that you modify.
- A transcript that shows your simulation in action.

An award will be given for the best adventure game. Games will be judged on both technical merit and creativity. Note that it's more impressive to implement a simple, elegant idea, than to just amass tons of new objects and places.