Assignment 7: Inheritance and polymorphism

ETH Zurich

handout: Monday, 10 November 2014
Due: Wednesday, 19 November 2014

Goals

- Understand polymorphism and dynamic binding.
- Practice inheritance.
- Continue the design and implementation of the board game.

1 Polymorphism and dynamic binding

Review polymorphic attachment and dynamic binding (Touch of Class, sections 16.2 and 16.3).

Below you can see a class diagram and code of three classes from the video game “Blades of Glory”.

```
class HERO
  WARRIOR
  HEALER
```

Well 2 © Randall Munroe (http://xkcd.com/568/)
deferred class

HERO

feature -- Initialization

make (s: STRING)
    -- Create a hero with name ‘s’.
    require
        s /= Void
    do
        name := s
        level := 1
        health := 100
    end

feature -- Access

name: STRING

level: INTEGER

health: INTEGER

feature -- Basic operations

do_action (other: HERO)
    -- Perform main action on ‘other’.
    require
        alive: health > 0
    deferred
end

level_up
    -- Increase level.
    do
        level := level + 1
        set_health (100)
    end

feature {HERO} -- Setters

set_health (h: INTEGER)
    -- Set ‘health’ to ‘h’.
    require
        0 <= h and h <= 100
    do
        health := h
        if health = 0 then
            print (name + ” is dead.%N”)
        end
    end

invariant

name /= Void
0 <= health and health <= 100
level > 0
end

class
   WARRIOR

inherit
   HERO
   rename
   do_action as attack
   redefine
   level_up
end

create
   make

feature -- Basic operations
   attack (other: HERO)
      -- Attack ‘other’.
      local
      damage: INTEGER
      do
         damage := (5 * level).min (other.health)
         other.set_health(other.health – damage)
         print (name + ” attacks ” + other.name + ”. Does ” + damage.out + ” damage%N”)
      end

   level_up
      do
         Precursor
         print (name + ” is now a level ” + level.out + ” warrior%N”)
      end
end

class
   HEALER

inherit
   HERO
   rename
   do_action as heal
   redefine
   make,
   level_up
end

create
   make

feature -- Initialization
**make** (s: STRING)
   -- Create a healer with name 's'.
   do
      Precursor (s)
      mana := 100
   end

**feature** -- Access
mana: INTEGER

**feature** -- Basic operations
heal (other: HERO)
   -- Heal 'other'.
   local
      h: INTEGER
   do
      if mana >= 10 then
         h := (10 * level).min (100 - other.health)
         other.set_health(other.health + h)
         mana := mana - 10
         print (name + ” heals ” + other.name + ” by ” + h.out + ” points%N”)
      end
   end

level_up
   do
      Precursor
      mana := 100
      print (name + ” is now a level ” + level.out + ” healer%N”)
   end
end

---

Given the following variable declarations:

hero: HERO
warrior: WARRIOR
healer: HEALER

indicate, for each of the code fragments below, whether it compiles. If the code fragment does not compile, explain why this is the case. If the code fragment compiles, specify the text that is printed to the screen when the code fragment is executed. This is a pen-and-paper task; you are not supposed to use EiffelStudio.

**Example:**

**create** warrior
warrior.level_up

This code does not compile, because default creation is not available for class **WARRIOR**.
Task 1

create warrior.make ("Thor")
warrior.level_up

Task 2

create hero.make ("Althea")
hero.level_up

Task 3

create warrior.make ("Thor")
create healer.make ("Althea")
warrior.do_action (healer)

Task 4

create {HEALER} warrior.make ("Diana")
warrior.level_up

Task 5

create {WARRIOR} hero.make ("Thor")
hero.do_action (hero)
create {HEALER} hero.make ("Althea")
hero.do_action (hero)

Task 6

create {WARRIOR} hero.make ("Thor")
warror := hero
create {WARRIOR} hero.attack (hero)

To hand in
Hand in your answers for the code fragments above.

2 Ghosts in Zurich

Ghosts are taking over Zurich! In this task you will implement a special kind of mobile object: a GHOST. Ghosts in Traffic have the following behavior: they choose a station of the city and then fly around it in circles.

To do

1. Download http://se.inf.ethz.ch/courses/2014b_fall/eprog/assignments/07/traffic.zip, unzip it, copy the dir assignment_7 into directory traffic/examples and open assignment_7.ecf from within EiffelStudio.

2. Create a new class GHOST and make it inherit from MOBILE. The latter has three deferred features: position, speed and move_distance, which you have to implement before you can successfully compile your class. For the first two features you have a choice of making them into either an attribute or a function. The third one should be implemented as a procedure that calculates where the ghost ends up when it moves from the current
position by \(d\) meters. You can assume that all ghosts always move at the same speed (e.g. 10 meters per second).

You'll probably also want to add new features to GHOST, for example to store the station that it is flying around and the distance it keeps from the station (the radius of its circular trajectory). Additionally you'll need a creation procedure that takes the station and the radius as arguments.

**Hint:** It’s convenient to represent the ghost position at any point in time as a sum of two vectors, one of them constant and the other one changing as the ghost moves, like on this picture:

3. In the class GHOST_INVASION implement a feature \texttt{add.ghost (s: STATION; r: REAL,64)} that creates a ghost flying around a station \(s\) at a distance \(r\) and adds it to Zurich (using the feature \texttt{add_custom_mobile}). Don’t forget to update the map in order to create the view for the new ghost. After that, modify the view so that the ghost is depicted as an icon instead of the default black dot; you can use “ghost.png” from the “images” directory for the icon. The expression \(\text{Zurich}\_\text{map}.\text{custom}\_\text{mobile}\_\text{view}(\text{ghost})\) gives you access to the view of the object \texttt{ghost}.

Test the \texttt{add.ghost} feature by calling it from \texttt{invade} with arguments of your choice. Double-click on the map to pause the ghosts’ movement, or to start it again.

4. Modify the feature \texttt{invade} so that it generates 10 ghosts flying around random stations of Zurich at a random distance between 10 and 100 meters (you don’t have to check that all stations are different). To access stations by integer index, create a cursor that iterates through the stations and call the command \texttt{go_to} on that cursor.

**To hand in**

Hand in classes \texttt{GHOST} and \texttt{GHOST_INVASION}.

### 3 Code review

Code review is a widely applied software engineering practice, in which source code produced by a software developer is examined by his or her peers. The purpose of a code review is to find design, programming, and style errors, improving the overall software quality and the developers’ skills.

In this task you will conduct a review of the Board game (part 2) implementation, written by one of your peers. You will receive the code to review from your assistant by the end of Wednesday, November 5.

**To do**

Examine the code carefully, evaluating the following aspects:
1. Choice of abstractions (the set of classes, the set of responsibilities of each class)
2. Architecture (relationship between classes, such as inheritance and client-supplier)
3. Contracts
4. Implementation techniques (choice of data structures and algorithms)
5. Coding style and names
6. Comments and documentation (including header comments and note clauses for classes)

For each category listed above, write down related issues you found in the code, if any. If the same issue occurs multiple times (for example, a header comment is missing in all features) you only have to mention it once.

To hand in
Your review.

4 Board game: Part 3

In this task you will extend the implementation of the board game. You will find an updated problem description below.

The board game comes with a board, divided into 40 squares, a pair of six-sided dice, and can accommodate 2 to 6 players. It works as follows:

- All players start from the first square.
- One at a time, players take a turn: roll the dice and advance their respective tokens on the board.
- A round consists of all players taking their turns once.
- Players have money. Each player starts with 7 CHF.
- The amount of money changes when a player lands on a special square:
  - Squares 5, 15, 25, 35 are bad investment squares: a player has to pay 5 CHF. If the player cannot afford it, he gives away all his money.
  - Squares 10, 20, 30, 40 are lottery win squares: a player gets 10 CHF.
- The winner is the player with the most money after the first player advances beyond the 40th square. Ties (multiple winners) are possible.

To do
Modify the implementation of the board game in such a way that it accommodates the changes in the problem description (money, special squares, new winning criterion). We recommend that you start from the master solution to the assignment 6: http://se.inf.ethz.ch/courses/2014b_fall/eprg/assignments/07/board_game.zip.
Hints

Are there entities in the problem domain that didn’t have enough properties and behavior to
deserve their own classes in the previous version of the game, but that gained some properties
or behavior in the current version? You might want to introduce new classes for such entities.

Bad investment and lottery win squares are special cases of squares, which differ in a way
they affect players. To model this you can introduce class SQUARE and then use inheritance
and feature redefinition to implement the behavior of special squares. You can store squares
of all kinds in a single polymorphic container (e.g. V ARRAY [SQUARE]) and let dynamic
binding take care of which special behavior applies for each square.

To hand in

Hand in the code of your classes.

5 MOOC: Single Inheritance

To do

1. Access the main MOOC course web page at http://se.ethz.ch/mooc/programming.

2. Listen to lecture number 9 “Single Inheritance” and take the corresponding quiz.

Your goal is to provide all correct answers to the quiz. You can take the quiz as many times as
you want. If you succeed, you will be awarded a badge.