

Computer Engineering 171

Homework 2: Object-Oriented Programming

Due: May 4th at 9:00 am

In this assignment, you will use C++ and Smalltalk, two object-oriented languages discussed in class. Use the Linux machines in the Engineering Computing Center for this assignment. The Smalltalk interpreter is `gst` (you will need to execute “`setup smalltalk`” first) and the C++ compiler is `g++`.

1 Binary Search Trees

On Camino you will find an implementation in C++ of a binary search tree. Translate this program to Smalltalk, keeping the same class and operation names. Equivalent code for the function `main` in C++ is provided for you as `main.st`. Call the file with your class definitions `Tree.st` and submit it using Camino. You can run both files through the interpreter using `gst Tree.st main.st`.

Goal: To learn about classes as a mechanism for information hiding.

2 The 8-Queens Problem

In chess, a queen can move any number of squares horizontally, vertically, or diagonally. The **8-queens problem** is the problem of trying to place eight queens on an empty chessboard in such a way that no queen can attack any other queen. This problem is intriguing because there is no efficient algorithm known for solving the general problem. Rather, the straightforward algorithm of trying all possible placements is most often used in practice, with the only optimization being that each queen must be placed in a separate row and column:

1. Starting with the first row, try to place a queen in the current column.
2. If you can safely place a queen in that column, move on to the next column.
3. If you are unable to safely place a queen in that column, go back to the previous column, and move that queen down to the next row where it can safely be placed. Move on to the next column.

On Camino you will find my solution to the 8-Queens Problem in the file `Queens.cpp`. My solution provides the following generalizations:

1. Solves the n -Queens Problem rather than the 8-Queens Problem. The chessboard is of size $n \times n$ rather than of size 8×8 , and n queens are to be placed on the board.
2. Computes and displays the **total** number of solutions possible. Rather than finding one solution and exiting, my program will find all possible solutions and write the total number of possible solutions to standard output.
3. Solves the n -**Pieces** Problem rather than the n -Queens Problem. Given any kind of chess piece, not just a queen, my program displays the total number of solutions possible for placing n of those pieces on the board such that no piece can attack any other piece.

You will need to write a file called `Queens.h` that contains the class and function definitions for each chess piece. Write a base chess piece class with which my algorithm works. The base class should provide at least the following methods:

- `int row() const`: returns the row number of this piece
- `int column() const`: returns the column number of this piece
- `void place(int row, int col)`: places this piece on the board given a row number and a column number
- `bool menaces(const Piece *p)`: given another piece, returns true if this piece can attack the given piece, and false otherwise

Now write classes for each of the following chess pieces:

- rooks: A rook can move any number of squares horizontally or vertically, but cannot move diagonally.
- bishop: A bishop can move any number of squares diagonally, but cannot move horizontally or vertically.
- knight: A knight can move two spaces in either a horizontal or vertical direction and an additional space in the other direction.
- queens: A queen can move any number of squares horizontally, vertically, or diagonally. Thus, it can move as either a rook or a bishop.
- amazon: An amazon can move either as a queen or as a knight.

Use virtual multiple inheritance in your solution. Prove that your solution is correct by filling in the missing values in the table at the top of `Queens.h`. Submit `Queens.h` using Camino.

Goal: To generalize a problem using object-oriented techniques.

Hints: Write and test each piece in the order listed.

3 Coding Guidelines

- C++ requires explicit memory deallocation, whereas Smalltalk uses garbage collection.
- C++ does not automatically initialize instance variables to a default value, whereas Smalltalk initializes all variables to `nil`.
- By convention, Smalltalk classes understand the `new` message, which is inherited and parameterless, and use mutators on the object to initialize their state. Classes can also be written to have custom “constructors,” but mutators are typically still needed to modify the state of the created instance.
- Since all the functions required for the 8-Queens problem are rather small, they can easily be written in the header file. You are only allowed to submit the header file and not the source file. The source file provided on Camino will be used to test your header file.
- In order for the position of a piece to be kept hidden and only available to subclasses, it should be declared as `protected`. Also, decide which functions need be polymorphic, and which have no need to be polymorphic and overridden in subclasses.