Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Software Design using Patterns

Date: Wednesday 16th January 2013
Time: 14:00 - 16:00

Please answer Question 1 and two other Questions

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]
Question 1
This question is COMPULSORY

a) State four reasons why design patterns are important in object-oriented software development. (4 marks)

b) The exam software has a tool which allows students to draw diagrams which consist of boxes joined by connectors. A box has content (inside it) and up to four labels around it. A connector always joins two boxes and has up to six labels attached to it. Since diagrams have a graph structure, we refer to them within the project as graphs. We can also take a complete graph and enclose it within a box, which is called a graph box.

Draw a design class diagram which captures the information above and makes use of the Composite design pattern to deal with graph boxes. You should assume that there is only one Box class and one Connector class, and the differences between particular boxes and particular connectors are represented by properties of these classes which you do not need to model. (6 marks)

c) Since diagrams have a graph structure, we can compare them by graph matching which potentially gives us the ability to do some semi-automatic marking. This turns out to be very complex. No single graph matching algorithm will do the job, we need several algorithms, each of which may be complex.

Briefly explain how the Strategy design pattern can be used to help manage the complexity involved. (3 marks)

d) Briefly explain how the Composite pattern can be used in conjunction with the Strategy pattern in this situation. Hint: this is a different use of Composite from that in part b. (3 marks)

e) State four different GRASP principles which are applied in both the Composite and Strategy patterns. (4 marks)
Question 2

a) “The Unified Process requires the construction of many artefacts, many of which are Ceremony. Therefore the notion of the Agile UP is a contradiction in terms”. Give a concise criticism of the above statement, making sure you make two distinct, relevant points. (2 marks)

b) Explain the role of users and other stakeholders in the UP. (2 marks)

c) List four distinct groups of users/stakeholders of the exam software other than students, and in each case state two important concerns that they will have (i.e. 8 different concerns in total). (8 marks)

d) State the four key principles of the Agile Manifesto (exact wording is not required, a paraphrase will do and they can be in any order), and for each one suggest a way it could be applied a project using the UP. (2 marks for each). (8 marks)
Question 3

You have been hired to implement software for a Safety and Security system for a large building. Currently the building has many safety and security devices, but very primitive facilities for monitoring them - essentially one large panel of lights for security and another, in a completely different place, for fire safety.

a) You are interviewing the Head of Safety and Security for the building to find out more about what's required. Suggest five questions it would be sensible to ask to start off.

(5 marks)

b) He gives you the following information:

"We have 30 floors with around 30 devices on each so around 1000 total. The majority of these are smoke detectors but there are door alarms and a number of other kinds, maybe 10 in total. The fire safety devices are of high standard - they have to be - but we would like to improve security, in particular we would like to make more use of CCTV.

We do want to monitor both fire safety and security together, but we want that monitoring to be distributed over the building in a flexible way. What we want is a monitoring station on every third floor, but only to have them all manned at busy periods. So at other times (e.g. overnight or at weekends or if we're just short of security staff) we would use fewer monitoring stations. There are also times when we may want more than one monitoring station to monitor a particular group of devices - if we're making a decision about whether to evacuate the building, for instance. Hence the challenge for you guys is to enable the monitoring stations to "see" different groups of devices at particular times."

i) List the important domain classes implied by this description.

(4 marks)

ii) Draw a domain class diagram which shows the relationships between these classes.

(5 marks)
Question 3 (continued)

c) You identify that the project has three main aspects: the user interface for the monitoring stations; the protocol which implements the relationship between devices and monitoring stations, and management functions which summarise the activity which takes place over a given time period. In what (if any) order would you tackle these aspects, and why?

(3 marks)

d) A device being triggered can be considered as an event, just like a button being pressed in a Java UI. This suggests a way of providing the flexibility required in associating devices with monitoring stations. Explain what this is.

(3 marks)
Question 4

a) Explain with an example the relationship between the GRASP principles of **High Cohesion** and **Low Coupling**, and the practice of Refactoring.  
(4 marks)

b) Briefly explain what the two types of coupling are, and for each give a specific example of how it can be kept low in the exam software. Use a different example for each. 
(4 marks)

c) Suppose you have exam software which was originally designed for English language testing and was adapted to become general purpose. One function of this software is to generate results. Initially, you have a ResultGenerator class which generates results in the format required by the English Language Centre. Later, you discover a requirement to provide results to the University central administration, but in a different format, so you add code to the ResultGenerator class to do this. Then, you discover that different schools within the University also require results, and also have different formats. The ResultGenerator class is becoming large and uncohesive.

Draw a skeleton design class diagram which shows how **Polymorphism** can be used to improve cohesion in this situation. You should assume that the results are always in the form of a spreadsheet, and that only the details of the information on the spreadsheet differ.  
(3 marks)

d) What is the effect of this use of Polymorphism on coupling? You should consider both kinds of coupling mentioned in part c.  
(2 marks)

e) How does your design support the principle of **Protected Variations**?  
(2 marks)

f) Briefly explain what a **Factory** is and how it could be used in the design given in your answer to part c.  
(3 marks).

g) Now suppose that the assumption stated above, that the results are always in the form of a spreadsheet, does not hold true; results can be in many different forms, such as XML or relational database tables. Draw a skeleton design class diagram which shows how your design in part d can be enhanced to deal with this situation.  
(2 marks)
Question 5

a) Explain why design patterns are a tool for communication. Your answer should state who is doing the communicating and should use the Observer pattern as an example. (4 marks)

b) The Strategy, Visitor and Template Method patterns address different aspects of the same general problem. Briefly explain what that problem is. (2 marks)

c) Explain how the Visitor pattern could be used to help solve the graph matching problem discussed in question 1. Your answer should state whether the situation described is one where use of Visitor could be considered appropriate. (4 marks)

d) Explain how the Template Method class could also be used to help structure the graph matching code. (4 marks)

e) Briefly explain the idea of a Proxy. (2 marks)

f) Suppose we want to construct a large number of variants of a multiple choice test, so that each student sees a slightly different version. A test is constructed from a large pool of MCQs held on a remote server, a small subset of which (i.e. those relevant to the topic of the test) will be used in each test. Of that subset, each MCQ will be used in multiple variants of the test. So for example there might be 100,000 questions in the pool, of which we use 50 altogether, spread among 1,000 variants which each have 20 questions. Explain how the Proxy design pattern can be used in an efficient design to meet these requirements. Hint: there are two proxy tasks here - briefly discuss whether there should be one proxy or two. (4 marks)