Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Pattern-based Software Development

Date: Thursday 16th May 2013
Time: 09:45 - 11:45

Answer ALL Questions in Section A
AND
Answer ALL Questions in Section B
Also answer ONE Question in Section C

This is a CLOSED book examination
The use of electronic calculators is NOT permitted
Section A
Answer All Questions

a) Explain what we mean by saying “Once an engineer, forever an engineer” in Object-Oriented Design and how this problem can be solved.

(4 marks)

b) It is claimed that the Object-Oriented approach combines three views into one complete object-oriented system. Explain what these views are and how they are represented in UML diagrams.

(3 marks)

c) Describe briefly different types of the IBM’s Patterns for e-business and their relationships.

(3 marks)

d) 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)

e) State the three operations involved in the Observer pattern and where each of them is implemented.

(3 marks)

f) Briefly explain the idea behind the Command pattern and give a specific example of where it might be used.

(3 marks)
Section B

Answer All Questions

**Question B1**

a) Explain the principle behind Aspect-Oriented Programming. Give two examples of an “aspect” in Object-Oriented design.

(2 marks)

b) Explain the principles of data abstraction, information hiding and encapsulation in Object-Oriented Programming, and how use of these concepts can help Object-Oriented software development.

(5 marks)

c) Explain the principle behind the MVC architecture and how its components interact.

(3 marks)

**Question B2**

You are designing an e-commerce system for a retail company. You want to apply some of the business application patterns you have learned from this course to help you to your design.

a) Design the shopping basket by using a UML class diagram. Your diagram should show: (1) the domain objects used to represent the shopping basket; (2) the relationships between these objects; (3) the multiplicities of these relationships; (4) essential attributes of these objects and essential operations performed by these objects.

(4 marks)

b) Explain the business application design patterns used in your design.

(2 marks)

c) Expand your design so that a customer can proceed to the checkout to make the payment. Explain the business application design patterns used in this extension.

(4 marks)
Section C

Answer ONE Question

Question C1

You are providing a Computer Assisted Design (CAD) system for Steelworks Ltd, a civil engineering company which specialises in large steel-framed buildings. Frames are constructed from steel bars by using a combination of nuts and bolts and welding. Larger frames are constructed from smaller frames and so on to complete the framework for a building. Other large structures (e.g. air conditioning systems, lifts) are likewise constructed from smaller ones.

a). Draw a UML class diagram which shows how the Composite design pattern could be applied to model structures as described above, showing the example structures mentioned. The diagram should indicate how the weight of a structure would be calculated.

(6 marks)

b). The company has a database of structural components it has in stock. In addition, it has read-only copies of databases from several suppliers which are regularly updated. A requirement for the CAD system is that, to improve responsiveness, all relevant database information is read into memory at startup time, so the database information needs to be represented as objects. For each database, there is a natural translation from the data format into an object structure. However, each resulting object structure is different from all the others. Also, the code that does the translation for each of the external suppliers is not available - they only provide the data, so we will need to write our own.

i). Suggest two ways in which we could structure the code to solve this problem, one of which makes use of the Adapter pattern and one which does not. Briefly explain what criterion you would use to decide which approach to take.

(3 marks)

ii). Draw a design class diagram showing the class structure required for the solution using the Adapter pattern. You should give names to associations where appropriate, but you need to show multiplicities, attributes, or operations.

(3 marks)

c). The company regularly orders shipments of structures from suppliers, where a shipment may involve several different container loads. A shipment can be in several different states, e.g. ordered, partially delivered (some containers have arrived but not others). Briefly suggest how two different design patterns could be used to help in the tracking of shipments.

(2 marks)
d). 

i). Briefly explain the principle behind the **Flyweight** pattern. (2 marks)

ii). Explain how Flyweight could be applied to the scenario described above, in a way that minimises the amount of storage required to represent small structural components both when they are being shipped and when they are parts of larger structures. (2 marks)

iii). How is the Flyweight pattern related to GRASP principles? (2 marks)
Question C2

The ABC exam software has a tool that allows students to draw diagrams which consist of boxes joined by connectors. 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. Naturally we use the Composite design pattern to represent these graph structures.

a). The Strategy, Visitor and Template Method patterns address different aspects of the same general problem. Briefly explain what that problem is, giving an example not shown on the course or on this exam paper.

(3 marks)

b) 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, so 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 in graph matching.

(3 marks)

c). Explain how the Visitor pattern could be used to help solve the graph-matching problem. 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 pattern could also be used to help structure the graph matching code.

(4 marks)

e). If we use the Strategy pattern, we may only need a single instance of each strategy. Show, in Java code, how this can be achieved, assuming that if we don’t need a particular strategy it is never created.

(4 marks)

f). What is the problem with the implementation shown in part e), and how can it be avoided?

(2 marks)

END OF EXAMINATION