

Ollscoil na hÉireann
The National University of Ireland

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Fourth Science: Computer Science

CS4504 Advanced Software Engineering

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Answer four questions (all questions carry equal marks)

160 marks

180 minutes

1.

- (a) The reason software projects succeed is more about people than technology. Discuss, with reasons, how much you agree or disagree with this statement. (4 marks)
- (b) An information system is being developed for a hospital that will support all aspects of patient care including dealing with patient records and patients' treatment schedule. You are the software project manager for this project. (In the following questions, please relate your answers explicitly to this particular project.)
- i. Give two reasons in favour of, and two reasons against, the use of an Agile process for this project. (4 marks)
 - ii. Given four general stages of the project: Requirements and Analysis; Architecture and Design; Coding; Software verification and validation, state, with reason(s), and in decreasing order which stages should be allocated most effort for this project. (6 marks)
 - iii. State, with reasons, what are the two most important non-functional requirements for this system? (2 marks)
 - iv. State, with reasons, the single most important method of validation that should be done on this project. (2 marks)
 - v. State, with reasons, the single most important method of verification that should be done on this project. (2 marks)
- (c) Software engineering can assist in the development of a software system that satisfies customer requirements through the use of a software process or through the use of a formal (mathematical logic based) method.
- i. Describe briefly one example of each technique. (6 marks)
 - ii. State the main benefit and of each technique. (2 marks)
 - iii. For each technique, state, with reasons, an example of an application for which the technique would be suitable. (2 marks)
- (d) Meyer's Design by Contract paradigm is based on the Floyd-Hoare formal approach but has some differences. State what is similar, and state two differences. (5 marks)
- (e) A class represents a simple controller for a DVD player. This DVDPlayer class has attributes representing the state of the DVD player: stopped; playing; open; noDVD. Write down a suitable class invariant in the propositional calculus for this class. Specify, using a contract expressed in the propositional calculus, two operations (methods) for the class: playDVD() to start playing, and open() to open the DVD player. (5 marks)

2.

- (a) The USA FBI Virtual Case File project and the UK e-University project are well-known examples of IT project failure. For **one** of these examples, describe two important underlying causes of the failure, and one software implementation issue contributing to the failure. (3 marks)
- (b) What is meant by model-driven software engineering, sometimes referred to as model-driven engineering (MDE), and state two important benefits and two limitations of its use in software development? (5 marks)
- (c) An on-line food shopping system is under development. This will allow customers to browse, order, buy, and cancel food items from a specialist food company. As well as basic ordering groceries, it may be possible to order ingredients for set menu meals. A UML-based software process following Larman's Agile UP (Unified Process) will be used in the development of this system. The following questions deal with activities of the Larman Agile UP.
- i. Give the full use case text for one important use case, and construct a simple domain (conceptual) model for this application. (5 marks)
 - ii. Draw an appropriate **system** sequence diagram for this application, and describe what role **system** sequence diagrams play in the Agile UP process. (5 marks)
 - iii. Draw an implementation interaction (sequence or collaboration) diagram for this system. Describe how the interaction diagram relates to the other stages of the Agile UP process. (6 marks)
 - iv. Discuss what data in this system should be persistent, and describe two methods of making the data persistent. (4 marks)
 - v. What criteria would you use when trying to decide which parts of this design should be implemented using software design patterns? (4 marks)
 - vi. Describe the Factory and Strategy software design patterns, state how they might be used in this system, and state the main benefit of each pattern for this application. (8 marks)

3.

- (a) N-version programming is often used in the development of safety-critical software, such as software for fly-by-wire control of an airplane. Describe this technique and discuss any limitations it may have. (4 marks)
- (b) A software controlled automatic insulin pump measures blood sugar, and delivers an appropriate insulin dose if necessary.
- What should be taken into account when classifying risk for this system? (2 marks)
 - Illustrate how the technique of hazard analysis using a fault-tree could be applied to this system. (4 marks)
 - Suggest two strategies for risk reduction for this application. (4 marks)
- (c) A program takes a candidate string (as might represent a DNA or RNA sequence) and a list of target strings, and returns a list of target strings which contain the candidate string as a substring along with the positions within the targets of the match.
- Without the source of the program, what method would you use to devise tests for the program, and give examples of the tests? (4 marks)
 - Given the source code for the program, what other tests would you add? (2 marks)
- (d) Discuss two difficulties with the testing of functional properties, and two difficulties associated with the testing of non-functional properties. (6 marks)
- (e) The term Six Sigma as used in software engineering, has two main interpretations (i.e. non-mathematical and mathematical). State these two interpretations and discuss how relevant these two interpretations are to software quality. (6 marks)
- (f) A flight reservation system is being designed that will include classes representing customers, flights, airlines, schedules, bookings, tickets, payments, and include methods supporting various functions including flight search, ticket booking, ticket purchase. Explain Larman's software design principles of Polymorphism, Pure Fabrication, Indirection and Protected Variation and, using this example application, illustrate the principles with two design suggestions for this system. (8 marks)

4.

- (a) Along with data and functionality, what other basic aspect of a software system might be considered in a general model of software architectures? (1 mark)
- (b) Discuss (with sketches if appropriate) how repository, distributed objects, and pipe-and-filter architectures differ with respect to location of data and functionality, and for each architecture name one non-functional property that may be better in that architecture than the others. (9 marks)
- (c) An information system is being designed to support all aspects of an on-line virtual university. The system will deal with all aspects including student registration, student examination, streaming of lectures on demand. Users may access the service from various devices, such as smart-phones, tablets, desktop computers. Please ensure that your answers to the following questions are relevant to this particular project.
- i. What is the most suitable distributed architecture model for **this** system? Describe how the architecture matches this application (with a diagram if appropriate), and justify your choice, stating three benefits and any limitations of the architecture. (8 marks)
 - ii. State the three most important non-functional requirements for **this** system. Discuss how the chosen architecture influences (or does not) these three non-functional properties. (6 marks)
 - iii. Describe two trade-offs (among the stated non-functional properties) that arise when trying to satisfy these non-functional requirements. (4 marks)
 - iv. Describe an alternative distributed architecture model that might be suitable for **this** system, and describe two advantages and two disadvantages with respect to the previous architecture. (6 marks)
- (d) State two differences between a service-oriented architecture and a conventional component-based architecture. (2 marks)
- (e) What are the useful characteristics of a web services architecture based on REST (REpresentational State Transfer) (RESTful web services)? (4 marks)

5.

- (a) Describe the two main options for scaling a non cloud-based architecture when faced with a large increase in number of users or transactions. (2 marks)
- (b) A cloud computing application uses storage on a public cloud (such as the Google App Engine) for source files and uses computational power on another public cloud (such as the Microsoft Azure Cloud) to process these files. Give an overview (with sketch if appropriate) of a solution which can perform processing of multiple files. How does your solution cope with different sizes and number of files to be processed? (6 marks)
- (c) Discuss, with appropriate examples, the challenges and solutions associated with managing data as encountered by large distributed applications (such as those of companies like Facebook, ebay and Amazon). (8 marks)
- (d) Brewer's CAP theorem refers to certain properties of a distributed system. State the CAP theorem, and explain how it relates to the architectural design decisions for large commercial online distributed applications. (4 marks)
- (e) The Apache Hadoop framework is important for companies such as Facebook, Yahoo, Twitter and Google. Describe the underlying computational model of Hadoop, and state two main benefits of this framework. (6 marks)
- (f) A software controller for a CD player must respond to signals: load; play; pause; eject and stop.
 - i. Develop a statechart that models precisely the controller system, adding any extra events, states and other information to the statechart as necessary. (8 marks)
 - ii. Indicate clearly in the statechart at least four features not found in conventional state machines. (2 marks)
 - iii. How do states of the software controller relate to the physical CD player, and what benefit and danger follow from that? (4 marks)