

**Ollscoil na hÉireann  
The National University of Ireland**

**Coláiste na hOllscoile, Corcaigh  
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Fourth Science: Computer Science

*CS4504 Advanced Software Engineering*

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*Answer four questions (all questions carry equal marks)*

Three hours

1.

- (a) A good software development process is essential for a successful software development project. Discuss, with reasons, how much you agree or disagree with this statement. (5 marks)
- (b) A smartphone healthcare app (application) is being developed that will use the motion sensors to monitor the physical exercise of an elderly user. The app will upload the results, summarizing the activity levels of the user, to a server where they can be viewed by a caregiver such as a geriatric consultant. You are the software project manager for this project. Please ensure your answers are relevant to this particular project.
- i. Outline a software development process for this project and give three reasons why it would be suitable for this project. (5 marks)
  - ii. State the two biggest risks that could lead to the overall project failing. (2 marks)
  - iii. Describe and justify the two most important non-functional tests for this system. (4 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) A software process (such as one based on UML) and a formal method, such as Floyd-Hoare logic, both offer assistance in development of a 'correct' software solution. Discuss how these two approaches differ in how they do this. (6 marks)
- (d) Give the meaning of the Hoare triple  $\{P\}C\{Q\}$  as used in program verification. (5 marks)
- (e) Meyer's Design by Contract paradigm is based on the Floyd-Hoare formal approach but has some differences. What are these differences? (4 marks)
- (f) A class represents a level-crossing barrier controller in a railway application. This barrier class has attributes representing the state of the barrier: stopped, goingup, goingdown, isup and isdown. Write down an invariant for this class in standard mathematical logic stating the most important invariant properties. Specify two operations (methods) for the class using contracts expressed in standard mathematical logic. (5 marks)

2.

- (a) 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)
- (b) In Larman's Agile UP (Unified Process) coupling and cohesion are described as *evaluation patterns* in software design. Explain what this means and discuss why coupling and cohesion are important in software design. (5 marks)
- (c) A software system is under development implementing an online motor insurance broker. The system will act as a portal for customers seeking and purchasing motor insurance. A UML-based software process following Larman's Agile UP (Unified Process) will be used in the development of this system.
- i. For the above system: give the full use case text for one important use case; construct a simple conceptual model for this application; draw an appropriate **system** sequence diagram; for one operation (method) identified in the previous stage, write down the Larman-style contract; draw an interaction (collaboration or sequence) diagram implementing this operation. (12 marks)
  - ii. Which (if any) of the above five activities corresponds to object-oriented analysis and which (if any) corresponds to object-oriented design? (2 marks)
  - iii. What role (function) do the **system** sequence diagrams play in the process? (3 marks)
  - iv. Discuss how the interaction diagram relates to previous stages of Larman's Agile UP process. (4 marks)
  - v. Describe how Larman's Controller software design pattern might be used in this system, and state the benefits of this pattern for this project. (4 marks)
  - vi. Discuss what data in this system should be persistent, and describe two methods of making the data persistent. (5 marks)

3.

- (a) A program takes a candidate string (as might represent an 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)
- (b) Given the source code for this program, what other tests would you add? (2 marks)
- (c) A project is developing software for on-board control of a new airplane. Describe, a technique for fault tolerance that might be used on this project. (2 marks)
- (d) Describe, giving two example techniques, what is meant by the factorization of software designs, and state when one might **not** do factorization of a software application. (4 marks)
- (e) The term Six Sigma as used in software engineering, has two main interpretations (i.e. non-mathematical and mathematical). Discuss how relevant these two interpretations are to software quality. (6 marks)
- (f) Discuss why component-based software development has not become as successful as component-based hardware development. (6 marks)
- (g) An application has been implemented by two companies using similar development processes, and each claims to satisfy the requirements. If you are the customer, discuss how you would evaluate which is the 'better' system, given only the executable binary for each system. (6 marks)
- (h) An online airline reservation system is being developed. This system will include classes representing customers, flights, airlines, schedules, bookings, tickets, payments, and include methods supporting various functions including flight search, ticket booking, ticket purchase. Describe, and illustrate with sketches, two general software design patterns (i.e. **not** the five basic patterns of Larman's Agile UP) that could be used in the design. (6 marks)
- (i) State the benefits of the two chosen design patterns for this application. (4 marks)

4.

- (a) How data and functionality are located differs among different architectural patterns (or styles). Show this with three example architectural patterns (styles), illustrating your answer with small sketches as appropriate. (6 marks)
- (b) What is the third main aspect (along with data, functionality) that needs to be considered when deciding on an architecture for a system? (2 marks)
- (c) Describe any differences between a service-oriented architecture and a conventional component-based architecture. (4 marks)
- (d) What are the useful characteristics of a web services architecture based on REST (REpresentational State Transfer) (RESTful web services)? (4 marks)

An on-line media streaming system is being designed. The system will store video and audio media, media catalogues and customer profiles, and will provide various functionality including streaming audio and video, trailer viewing, pay-per-minute billing, recommendations based on customer preferences and history. Users may access the service from various devices, such as smart-phones, internet-tvs, desktop computers. Please ensure that your answers to the following questions are relevant to this particular project.

- (e) 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)
- (f) State the three most important non-functional requirements for **this** system. Describe what should be done during development to ensure these requirements are satisfied. (6 marks)
- (g) Describe any trade-offs that arise when trying to satisfy these non-functional requirements. (4 marks)
- (h) 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)

5.

- (a) 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)
- (b) What is the difference between scaling-up and scaling-out as might occur when a company has to cope with increased users. (2 marks)
- (c) Certain properties of a distributed system are captured by Brewer's CAP conjecture (later proved as a theorem). State Brewer's CAP theorem, explain its significance and comment on how the CAP theorem influences companies such as Amazon in the design of their information systems. (6 marks)
- (d) Describe the MapReduce framework as used by companies like Google, and state its advantages and any limitation. (6 marks)
- (e) What are two most important software technical challenges faced by Cloud Computing service providers? (3 marks)
- (f) What are two most important technical advantages (i.e. other than financial) that Cloud Computing offers to users? (3 marks)
- (g) A software controller for a phone supports a User making calls to a remote party, Other. This is a simple phone that just makes calls (does not receive them) and has a set of hot-keys for dialing numbers. The software must respond to events from the user such as UserPickUp, UserHangUp etc., and events from the other party such as OtherPickUp OtherHangUp etc. Conditions it must react to include NetworkBusy NoAnswer etc. The controller must perform necessary actions and activities, such as play the dial tone. Construct a statechart to model precisely a software controller for this phone. Include in the statechart at least four features, such as hierarchical states, not found in conventional state machines, and indicate clearly these particular features. (12 marks)