

**Calculator instructions:**

- You are **not** allowed to use any calculator in this examination.

**Dictionary instructions:**

- A basic English dictionary is available to use: raise your hand and ask an invigilator, if you need it.

**Examination Information**

- There are **4** pages to this examination.
- There are **2 hours** to complete the examination.
- Answer **all 3** questions.
- The number in brackets [ ] indicates the marks available for each question or part question.
- You are reminded of the need for clear presentation in your answers.
- The total number of marks for this examination paper is **60**.
- You are allowed to use annotated materials.

## Question 1

- (a) An enterprise needs highly controlled storage and access to their databases as well as the ability to manage the infrastructure for Web front ends and other applications. They have a large existing IT infrastructure and are continually expanding its capability. Which cloud computing model will satisfy all their current needs and enable them to reduce cost? Justify your answer.

[5 marks]

- (b) Explain how to develop a cloud application that uses publish-subscribe to communicate between entities developed in different languages. Producers should be written in C++ and consumers should be in Java. Distributed components communicate with one another using ActiveMQ.

[5 marks]

- (c) It is common that most servers in cloud data centres are underutilized. A large amount of hardware, space, power, and management cost of these servers is wasted. Discuss how server consolidation can improve the low utility ratio of hardware resources.

[5 marks]

- (d) Give an example of a scenario where live migration of Virtual Machines, contextualisation, and re-contextualisation are supported.

[5 marks]

**[Question 1 Total: 20 marks]**

## Question 2

- (a) From the perspective of setting up and operating as a major cloud-computing service provider, name one major type of capital expenditure involved, one major line of operating expenditure, and the primary source of revenue.

[3 marks]

- (b) A company called Flixnet specialising in video streaming is about to provide its service on the cloud. This requires re-engineering their core application, which makes use of thousands of files that get changed and modified on a daily basis. The validity and integrity of the files get checked before they are finally backed up. Both serverless computing and containers will enable the company to deploy its application. Considering the following factors, which solution should Flixnet adopt, serverless computing or containers?

- scalability
- cost
- maintenance
- time of deployment

[6 marks]

- (c) Cloud providers supply cloud services by signing Service Level Agreements (SLA) with end-users. Discuss the issues of under-provisioning and over-provisioning of resources by providers and their impact in the context of SLAs fulfilment.

[5 marks]

- (d) From the cloud provider perspective, a negative consequence of the service-based model is that it may quickly lead to a situation where it becomes difficult to manage the whole cloud system and keep Quality of Service (QoS) at an acceptable level. Discuss the challenges faced by current cloud self-managed solutions in relation to:

- Cloud heterogeneity
- Cloud automation
- Cloud evolution

[6 marks]

**[Question 2 Total: 20 marks]**

### Question 3

- (a) Consider a large MapReduce job with  $m$  mappers and  $r$  reducers.
- (i) If you run the word count MapReduce program introduced in the lecture, how many output files will you get at the end of the job?
  - (ii) How many key-value pairs will there be in each file? Assume  $k$  is the number of unique words in the input files.
  - (iii) How many distinct copy operations will there be in the sort/shuffle phase?
- [4 marks]
- (b) A compute intensive application is being deployed on a virtualised cloud infrastructure providing resizable compute capacity. Explain how energy efficiency can be supported at the following cloud architectural layers: application, middleware, resource and network.
- [5 marks]
- (c) You have been asked to design a cloud security solution. The cloud as a multi-user distributed environment brings unique security challenges, dependent on the level at which the user operates: application, virtual or physical. For each level propose one security requirement and one associated threat.
- [6 marks]
- (d) Atmospheric pollution and congested roads depreciate the quality of life, resulting in lost time for drivers and wasted fuel. You have been contacted to lead a smart city project which aims at designing, deploying and validating in Leeds and its environment a platform composed of sensors, actuators, cameras and screens to offer useful information to citizens. Different parameters such as noise, temperature, luminosity, carbon monoxide and free parking slots can be monitored. Discuss how to deploy your solution and include any information that you feel is relevant to back it up.

[5 marks]

**[Question 3 Total: 20 marks]**

**[Grand Total: 60 marks]**