Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

M.Sc. in Advanced Computer Science

Grid Computing and eScience

Date: Tuesday 1st June 2010
Time: 14.00 – 16.00

Please answer Question 1 from Section A and TWO Questions from Section B

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text
Section A

1. Compulsory

a) Describe briefly the following terms and describe also how they are used in the problem of user authentication across security boundaries: private and public key-pair, X.509 certificate, Certificate Authority. (4 marks)

b) What do the following terms denote in the Unicore workflow description terminology: Abstract Action, Action Task, Action Group, Abstract Job Object? (4 marks)

c) Give a definition for a Service Oriented Architecture (SOA). What role does messaging play in an SOA? Give a definition for an Object-Oriented Architecture (OOA). Describe one difference in the way that an SOA and an OOA handle internal state. (4 marks)

d) Define what is meant by the two terms Virtual Machine and Service Hosting Environment. Which one is used by the Open Grid Services Architecture and which one by Cloud Computing? For each of these give a reason for your answer. (4 marks)

e) Briefly describe the role of each of the following components in the Unicore architecture and indicate how they would be used to access a machine in a High Performance Computing Centre; Client, Gateway, Network Job Supervisor (NJS), Target System Interface (TSI). (4 marks)
2.  
   a) What does the term Transitive Trust mean in the context of running computational workflows across administrative domains? What are the differences between the Grid Security Infrastructure (GSI) model of Globus and the Unicore Protocol Layer with respect to transitive trust? Name one advantage and one disadvantage of the proxy certificates used in GSI. How could such functionality be reproduced in Unicore by using the roles of Consigner and Endorser? (6 marks)

   b) A user prepares a job that involves sending an Abstract Job Object (AJO) created by a Job Preparation Agent on their desktop machine to a Usite called Manchester. The AJO is to run on two separate Vsites at Manchester called A and B. Describe how the Unicore Protocol Layer would ensure that this was consigned securely across the open internet between the client and Manchester and how the AJO would be incarnated at A and B. Use a diagram to illustrate your answer and to identify the Unicore components involved. (6 marks)

   c) What does the term Incarnation refer to in the Unicore architecture? Which components interact to incarnate an AJO? How does the concept of incarnation generalise to the concept of Resource Requester and Resource Provider spaces? Draw an analogy between the process of Incarnation in Unicore and the three stages of compilation, linking and execution in higher level programming languages. Give two reasons why Java has not become the universal language for programming distributed systems such as a Computational Grid. (8 marks)
3. a) Define what is meant by the term “computational steering”. Describe the problem for computational steering when running on a computer or cluster controlled by a batch queuing system. How does the RealityGrid steering methodology deal with this problem? What is the difference between file-based and Web Service based steering in RealityGrid? (4 marks)

b) Draw a diagram to show how the RealityGrid Steering Web Service enables computations to be steered via SOAP messages using visualization of the computation to guide the steering. Show clearly the roles of the Steering Client, the Steering Service, the Registry and the communication between the computational component and the visualization component. (4 marks)

c) What is the role of Web Service Description Language (WSDL) in terms of the Web Services Architecture? What is a WSDL portType? Explain clearly the difference between Remote Procedure Call (RPC) and Document Based methods of invoking Web Services by considering how a service that updates a Counter would be invoked in each style. (4 marks)

d) With reference to the diagram below explain how a client acting on behalf of a user would access a Web Service providing up-to-date information about the weather. What would the Service Provider need to publish? What would the consequence be if the computer running the discovery agency crashed before the service requestor had located the service? What would the consequence be if the crash occurred after the service provider had been located? (4 marks)

**Service Oriented Architecture**

![Diagram of Service Oriented Architecture]

- **Discovery Agency**
  - **Find**
  - **Publish**

- **Service Requester**
- **Service Provider**
- **Service Description**

- **Interact**

- **HTTP GET** operation is described as “idempotent”, what does this term mean? What benefits could an idempotent operation have in a system based on an unreliable network? (4 marks)
4. a) Give a definition of a Virtual Organisation and using your definition show how this applies to a particular realisation of a Virtual Organisation.

   (2 marks)

b) Give two aspects of computational “power” on a computational Grid that makes it a different quantity to electrical power on an electricity Grid. Outline two critical functions that must exist in a Grid in order to ensure that computational “power” can be traded and briefly outline a service that could provide each function.

   (4 marks)

c) Here are three types of computation that could be run on a Grid:

   i) An application to analyse the signals from a radio telescope to search for patterns indicating signals from extraterrestrial civilizations.

   ii) A workflow that integrates information from different bioinformatics databases and notifies the user when the data in any of the databases changes so that the workflow can be re-enacted.

   iii) An engineering calculation involving gas flow in a turbine that computes the solid mechanics and fluid dynamics on different machines then sends the result to a visualization supercomputer so that the engineers can observe the behaviour of the simulation and can steer it as it is running.

   For each of these cases discuss the software engineering problems involved in creating a Grid to solve the problem in terms of three issues: security, degree of concurrency and synchronicity, complexity of messaging between services or components.

   (9 marks)

d) Give brief (one or two lines) definitions of the following terms used in Web Services:

   i) WS-Security

   ii) WSDL

   iii) SOAP

   iv) OGSA

   v) WSRF

   (5 marks)

END OF EXAMINATION