Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

M.Sc. in Advanced Computer Science

Grid Computing and eScience

Date: Tuesday 27th May 2008

Time: 09:45 – 11:45

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
1. **Compulsory**

   a) Explain the terms Authentication, Authorisation and Accounting as they are applied to Grid computing and for each of them give one reason why they are essential for distributed resource sharing. What is the role of a Certificate Authority in Authentication? (4 marks)

   b) 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)

   c) Explain what is meant by a protocol and give a reason why protocols are essential in distributed computing. What protocol is used to communicate with Web Services and what is its essential role? Describe briefly the parts of a message in this protocol. (4 marks)

   d) Give a reason why standards are important in Grid Computing. What is Job Submission Description Language (JSDL) and why may it be described as a standard? Briefly name and describe one of the predecessors of JSDL. (4 marks)

   e) Briefly describe the role of each of these components in the Unicore architecture: Client, Gateway, Network Job Supervisor (NJS), Target System Interface (TSI). (4 marks)
Section B

**Answer TWO questions from this section**

2. a) What is a private key and a public key as used in the PKI security architecture? How are the keys used in signing a digital certificate and establishing the author of a message? What is the role of the digital certificate in Grid authentication? (4 marks)

b) What do the terms explicit and implicit trust relate to when applied to computing across administrative boundaries? Explain how the Unicore security model implements explicit trust. How does the proxy certificate model of the Grid Security Infrastructure deviate from an explicit trust model? (4 marks)

c) Draw a diagram to show how the Unicore Client and Gateway establish a Secure Sockets Layer connection and how the Client and the Gateway decide if they can trust one another. (4 marks)

d) Draw a diagram to show how the Unicore Gateway and NJS collaborate to authorize a user who has presented a Certificate signed with her public key to login to a particular account. You need to show explicitly how the Abstract Job Object (AJO) and the Unicore User Data Base are used in this process. (4 marks)

e) What do the terms Uspace, Xspace and Nspace mean in the Unicore abstraction of the Grid and in a client-server architecture say where each one would reside? What is third party transfer in the context of the server side of a client-server architecture? (4 marks)
3. a) What is the role of a resource broker in a computational Grid? How is a resource broker important in ensuring scalability in a Grid? Explain the difference between resource requestor space and resource provider space in terms of brokering for a user request to run a weather model on a grid of 1000x1000x50 for a 12 hour forecast. (4 marks)

b) The diagram above shows a hierarchical resource broker that might be used in a Grid that provides resources across a whole Virtual Organisation (VO) composed of a collection of U-sites each of which provides access to multiple resources. Explain the role of each of the components in boxes when they are being used to get offers from resources across the VO to perform a piece of work issued on behalf of a user. Remember to pay attention to security issues in addressing this question, in particular the security context of the VO and the Unicore U-site. (4 marks)

c) What is the role of a registry in a Service Oriented Architecture? In terms of the diagram above, indicate which component could be replaced by a single centralised registry. What would be the drawbacks of such a single centralized registry? How could such drawbacks be overcome? (4 marks)

d) What is a Web Service? What does it mean to say that Web Services are “stateless”? Give an example of showing how state could be important in Grid Computing. How does the Web Services Resource Framework (WSRF) represent the state of the resources that provide the Web Service? (4 marks)

(Question 3 continues on the following page)
A broker has access to four computers, A, B, C, D. The broker acts for a weather prediction model that has four parameters that determine its resource needs, X the number of meshpoints in the X direction, Y the number of meshpoints in the Y direction, Z the number of meshpoints in the Z direction and T the number of time-steps. Suppose Computer A has a performance rating of M Megaflops/second which allows it to process a model with X=10, Y=10, Z=1 and T=1 in 10 seconds. Computer B has twice the processing speed of Computer A. Computer C consists of 100 processors each equivalent to Computer A and Computer D consists of 10 processors each equivalent to Computer B. What job time offers would the broker receive for running a job with X=100, Y=100, Z=10 and T=100 from each of nodes A, B, C, D? Please show clearly how you obtained the answer for each of A, B, C and D, i.e. show the calculation explicitly. (4 marks)
4.  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) **Service Oriented Architecture**

![Diagram of Service Oriented Architecture]

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)
e) Describe any two of the principles of REpresentational State Transfer (REST) and outline their significance in a distributed computing infrastructure. The 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)