

## 2011 Paper 5 Question 9

### Concurrent and Distributed Systems

- (a) We have considered four types of middleware: remote procedure call, object-oriented middleware, message-oriented middleware, and event-based middleware.
- (i) Each middleware has a core action, such as a remote procedure call or a remote method invocation. This entails data transfer that is either unidirectional (out of or into the calling context) or bidirectional (in and out). State which is used by each of the **four** types of middleware. [4 marks]
  - (ii) Does each of these—uni- and bidirectional data transfer—have sufficient expressive power for programming? Explain your answer. [2 marks]
  - (iii) One of the characteristics of distributed systems is that they lack global time. Given your answers above, what effect might this have on middleware use? [4 marks]
- (b) (i) What are *causal* and *totally ordered* message delivery? [2 marks]
- (ii) Which does vector clocks provide? [1 mark]
  - (iii) The vector clock algorithm is a way of sharing state, ensuring that every process knows what it needs to about how far the others have progressed. Why is it critical that messages having vector timestamps are never lost? [2 marks]
- (c) (i) Storage services can be *stateful* or *stateless*. Give **one** advantage and **one** disadvantage of each. [2 marks]
- (ii) If you were designing a service to support film production, which would you use and why? [3 marks]