

## 2007 Paper 4 Question 1

### Concurrent Systems and Applications

- (a) What is meant by a *serializable* order for two or more transactions? [2 marks]
- (b) Explain how *timestamp ordering* (TSO) enforces isolation. [5 marks]
- (c) Draw and explain a history graph for two transactions whose invocations of a set of conflicting operations are serializable but which are rejected by TSO. [5 marks]
- (d) Considering Optimistic Concurrency Control (OCC):
- (i) State the properties of a transaction's set of shadow copies that must be verified at commit time. [2 marks]
  - (ii) Carefully explain the algorithm used by a single-threaded commit-time validator. [4 marks]
- (e) Consider a system in which the transactions cause updates to objects which are not all located on a single server but which are distributed widely around the Internet. What factors would influence your choice of using TSO or OCC to enforce isolation? [2 marks]