

## 2010 Paper 5 Question 5

### Concurrent and Distributed Systems

For a transaction model based on objects and object operation time-stamps:

- (a) (i) Define how conflict may be specified in terms of object operation semantics.
- (ii) Give an example of conflicting operations.
- (iii) Give an example of non-conflicting operations that would be defined as conflicting under read–write semantics. [3 marks]
- (b) Define the necessary and sufficient condition for two transactions to be serialisable. Give an example of a non-serialisable execution of a pair of transactions. [3 marks]
- (c) Define the necessary and sufficient condition for *any* number of transactions to be serialisable. [1 mark]
- (d) Discuss how the following methods of providing concurrency control in database systems enforce the properties defined above.
- (i) Strict two-phase locking. [4 marks]
- (ii) Strict timestamp ordering. [4 marks]
- (iii) Optimistic concurrency control. [5 marks]