COMPUTER SCIENCE TRIPOS Part IB – 2021 – Paper 4

5 Further Java (arb33)

Clients of an online service execute code remotely at runtime by sending and receiving serialised Java objects to and from a server. Clients use the following classes:

```
public class NewClass implements Serializable {
    private String name;
    private byte[] bytecode;
}
public class Result implements Serializable {}
public class Params implements Serializable {}
abstract public class Function<R extends Result, P extends Params>
    implements Serializable {
    abstract public R run(P args);
}
class Invoke implements Serializable {
    private Function function;
    private Params args;
}
```

Clients send the bytecode of new classes using NewClass and an instance of Invoke to request the server execute a specified function. The server responds to such a request by executing the run method in the Function object and serialising and returning the result back to the client. You may assume the above classes have appropriate constructors as well as getter and setter methods.

- (a) Define subclasses of Params, Result and Function (called Squared) to compute x^2 where x is of type double. [3 marks]
- (b) Implement a client which executes Squared. Your solution should accept an argument x from the user, remotely execute the code and print out the result. You may assume a static method byte[] getClassBytes(Class c). [5 marks]
- (c) An Invoke object can contain incompatible Function and Params references.
 Provide an example and describe how to refactor your client to include a compile-time compatibility check. Can the server also check? [5 marks]
- (d) Describe the security challanges in the server implementation. How might these be addressed? [3 marks]
- (e) Describe how you could improve runtime error handling by the server as well as reporting such errors to the client. [4 marks]