Galway Mayo Institute of Technology, Dublin Rd Campus

Final Year Exam Solutions

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45620 Distributed Systems
Bachelor of Science in Computing in Software Development
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Contents

Chapter 1

Semester 7 Year 4 Distributed Systems

This is a LaTeX document holding The answers/questions from 2015 exam papers to 2020 for the module 45620 – Distributed Systems. This .pdf acts as a study aid for any student preparing for the 2hr written paper session during Winter or Summer(Repeat).Happy reading :)

- Black is Examiners Question

- Blue is my sample answer

1.0.1 Distributed Systems - Exam paper 2019-20 Semester 7

1. Question 1 (25 marks)

    - Explain what is meant by heterogeneity in distributed systems, giving examples of ways in which distributed systems can be heterogeneous. (15) marks

        - heterogeneity is one of the two key attributes of Distributed Systems (1.Resource Sharing 2.heterogeneity) heterogeneity in simple terms describes the variety and difference in systems. Describes the Variety and difference in modern computing obstacles such as Networks , Hardware and Operating Systems.

    - What is the role of middleware in a distributed system? (5 marks)

        - The role of middleware is to make application development easier, by providing common programming abstractions, by masking the heterogeneity and the distribution of the underlying hardware and operating systems, and by hiding low-level programming details

    - Explain what is meant by distribution transparency in a distributed system, giving examples of types of transparency. (5 marks)

        - In a distributed systems there are some features of the system which are hidden from the users this is called transparency. The end users are not aware of certain mechanisms which do not appear on the distributed applications because transparency confines it in the layer below the one user interacts with. There are several types of transparencies which are available to be implemented on distributed systems such as access transparency, location transparency, concurrency transparency, replication transparency, failure transparency, scaling transparency etc.

2. **Question 2 (25 marks)**

   - Explain what is meant by Data Serialisation, and discuss why it is necessary for distributed systems. (5 marks)

      - my answer

   - Discuss the relative merits of the following types of Serialisation formats, and give a specific example of each type: – Text-Based – Semi-Compiled – Binary (15 marks).

      - my answer

   - Write a Protocol Buffer message definition for a Person message, with fields name (string), id (integer), and email (string). Either proto2 or proto3 syntax is acceptable. (5 marks)

      - my answer

3. **Question 3 (25 marks)**

   - Processes can communicate with each other by passing messages in different ways. Explain what is meant by the following types of inter-process messaging: – Persistent – Transient – Synchronous – Asynchronous (10 marks)

      - my answer

   - Describe the functioning of the Remote Procedure Call (RPC) model for inter-process communication, using diagrams as necessary, and the gRPC framework as a specific example. (15 marks)

      - my answer

4. **Question 4 (25 marks)**

   - Discuss the ways in which the REST architectural style for web services differs from traditional web services based on SOAP and XML-RPC. Your answer should include a description of REST's reliance on web protocols. (15 marks)

      - my answer

   - Explain what the OpenAPI specification is, and discuss the role of OpenAPI/Swaggger in developing RESTful web services. (10 marks)

      - my answer

5. **Question 5 (25 marks)**

   - Replication and Partitioning are fundamental techniques employed in the design and implementation of distributed data stores. Explain what is meant by these two terms, and discuss why they are useful. (10 marks)

      - my answer

   - Describe the MapReduce programming model for distributed batch processing of large datasets. (10 marks)

      - my answer

   - Give an example of how MapReduce could be used to determine the frequency with which different URLs are accessed based on logs of web page requests. (5 marks)

      - my answer

Chapter 2

Semester 7 Year 4 Distributed Systems

- Black is Examiners Question

- Blue is my sample question

2.0.1 Distributed Systems - Exam paper 2018-19 Semester 7

1. Question 1 (25 marks)

    - Explain the importance of the following terms as they apply to distributed systems: Heterogeneity , Transparency , Scalability , Middleware , Inter-Process Communication (13 marks)

        - my answer

    - Compare and contrast each of the following Inter-Process Communication models, identifying the key differences between them. Your answer should provide an example of each model. Use diagrams where appropriate. Remote Procedure Call Model , Object-Oriented Model , Service-Based Model (12 marks)

        - my answer

2. Question 2 (25 marks)

    - "Marshalling frameworks based on highly structured Unicode formats have largely supplanted serialisation and binary data transfer formats." You are required to provide a critique of this statement. Your answer should compare Unicode and lower-level marshalling formats in terms of heterogeneity, extensibility and efficiency. (10 marks)

        - my answer

    - "XML schema definitions in combination with data binding frameworks can greatly simplify Inter-Process Communication in heterogeneous distributed systems". Provide a critique of this statement. Discuss the data modelling process, the concept of data binding, an externalisation framework and a utility for automatically generating the code for class definitions from a .xsd your answer.(10 marks)

        - my answer

    - Explain using pseudocode (or Java code), how an object may be transferred from one process to another using a Unicode format. Your answer should include the operations performed by the client and the server.(5 marks)

- my answer

3. Question 3 (25 marks)

- Describe the function of the following components of the RMI architecture, using diagrams where appropriate: Remote Objects , RMI URLs and the RMI Registry (13 marks)

  - my answer

- Explain the procedure that is followed when creating a custom interface which specifies how a client process may interact with a Remote object. (3 marks) Write out the Java code for a Remote interface which provides the functionality described below. (10 marks)

  You have been tasked with creating a RMI Database Service for student records. You may assume that a serializable class definition Student.java is available. The methods in the interface should make use of this serializable class definition where possible.
  The Database Service will have the following remotely accessible methods:
  getStudent – this method retrieves a single student record from the database. It takes an integer (student id) as an argument. getAllStudents – this method retrieves all student records from the database.
  addStudent – this method adds a new student to the database. deleteStudent – this method removes a single student record from the database.
  It takes an integer (student id) as an argument.

  - my answer

- Explain how a pass by reference may be simulated using the RMI framework. Use examples of Java code and/or pseudocode to support your answer. (6 marks)

  - my answer

4. Question 4 (25 marks)

- Explain the mapping between HTTP methods and CRUD operations in RESTful architectures. (5 marks)

  - my answer

- Assume that a RESTful service which allows CRUD operations on a student resource is available at the following URL: http://www.examplesite.com/students

  Explain how a HTTP request may be made to this service to retrieve the details of a student called Jane in XML format. Use a diagram of the client-server interaction along with the text of a sample HTTP request and HTTP response to aid your explanation.(10 marks)

  - my answer

- Explain how annotations may be used in the JAX-RS/Jersey framework to facilitate deployment of a Java Object as a RESTful web resource. Use a sample annotated Java class with one method to support your answer. Your code sample should demonstrate the use of annotations specifying the HTTP method type handled, resource path, path parameters and MIME response type.(10 marks)

- my answer

5. Question 5 (25 marks)

- Compare the following partitioning strategies for distributed databases: Range Partitioning , Hash Partitioning , List Partitioning (9 marks)

  - my answer

- State Brewer's CAP theorem and explain the meaning of each of the three systematic requirements to which it relates. (9 marks)

  - my answer

- Explain the purpose of WSDL in the context of distributed systems, giving examples. List and describe the four key aspects of a service which is described by WSDL. (7 marks)

  - my answer

Chapter 3

Semester 7 Year 4 Distributed Systems

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3.0.1   Distributed Systems - Exam paper 2017-18 Semester 7

1. Question 1 (25 marks)

   - Briefly outline the key differences between distributed computing models and monolithic computing models.(3 marks)

     - my answer

   - Explain, using diagrams and examples, the following terms as they apply to distributed systems:
     Heterogeneity
     Transparency
     Scalability
     Concurrency
     (5 marks)

     - my answer

   - Explain what is meant by the term Inter-Process Communication. (10 marks)

     Explain how each of the following Inter-Process Communication models work, and identify the key differences between them. Use diagrams where appropriate.

     Remote Procedure Call Model

     Object-Oriented Model

     - my answer

2. Question 2 (25 marks)

   - Explain what is meant by the term Externalisation in the context of Distributed Systems. (10 marks)

Compare the following Externalisation formats, giving an example of each:

Binary
Semi-compiled
Unicode

- my answer

- Explain how an XML schema document may be used as a Data Definition Language to create a platform and language neutral mechanism for data exchange. Refer to the use of data binding, the JAXB framework and the XJC utility in your answer (10 marks).

  - my answer

- Explain using pseudocode (or Java code), how an object may be transferred from one process to another using a Unicode format. Your answer should include the operations performed by the client and the server.(5 marks)

  - my answer

3. Question 3 (25 marks)

   - Describe the function of the following components of the RMI architecture, using diagrams where appropriate:(9 marks)

     Remote Objects and the Remote Interface

     RMI URLs and the RMI Registry

     Stubs and Skeletons

     - my answer

   - Explain the procedure that is followed when creating a custom interface which specifies how a client process may interact with a Remote object. (10 marks)

     You have been tasked with creating a RMI File Service. The File Service will have the following remotely accessible methods:

     downloadFile() – this method retrieves a file from the File Service. It takes a file name as an argument, and will return the file requested as an array of bytes

     uploadFile() – this method uploads a file to the File Service. It takes the file name and a byte array containing the file contents as arguments, and has a void return type.

     listFiles() – this method does not take any arguments, and returns a list of all the files which are available to download from the File Service.

     Write out the Java code for a Remote FileService interface which provides the functionality described above.

     - my answer

- Briefly describe how Java RMI can be used to provide an object façade/gateway to a suite of server-side objects. Your answer should include a brief discussion of the rationale for applying such an approach, and a diagram if required.(6 marks)

    - my answer

4. Question 4 (25 marks)

    - Explain the meaning of the term SOAP, and how it is relevant to Distributed Systems. Make reference to the SOAP Specification, Requests, Responses, and SOAP messages in your answer. Use diagrams where appropriate. (9 marks)
        - my answer
    - What is the function of WSDL in the context of distributed systems? List and describe the four key aspects of a service which is described by WSDL.(8 marks)
        - my answer
    - State the principles of RESTful application development. (8 marks)
        - my answer

5. Question 5 (25 marks)

    - State Brewer's CAP theorem, and explain the meaning of each of the three systematic requirements to which it relates. (8 marks)
        - my answer
    - Compare the following partitioning strategies for distributed databases:(6 marks)

        Range Partitioning
        Hash Partitioning
        List Partitioning

        - my answer
    - Compare the process of distributing a database across multiple nodes for the following database types. Use diagrams where appropriate(11 marks)

        Relational
        Key-value store

        - my answer

Chapter 4

Semester 7 Year 4 Distributed Systems

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- Blue is my sample question

4.0.1 Distributed Systems - Exam paper 2016-17 Semester 7

1. Question 1 (25 marks)

   - Using diagrams and examples where appropriate, explain the following terms as they apply to distributed systems:(9)

     Heterogeneity
     Scalability
     Transparency

     - my answer
   - "A façade can be used to shield a client from the complexity of a distributed system and promote loose coupling between service requestors and providers."

     Discuss this statement. Your answer should address how session and message façades can be used to aggregate services and increase the scalability of a distributed system.(16 marks)

     - my answer

2. Question 2 (25 marks)

   - "Marshalling frameworks based on highly structured unicode formats have largely supplanted serialisation and binary data transfer formats."

     You are required to provide a critique of this statement. Your answer should compare XML, JSON and lower-level marshalling formats in terms of heterogeneity, extensibility and efficiency.(15marks)

     - my answer

- Describe, using examples, the main roles and their function in both XML and RESTful Service Oriented Architectures (SOA) .(6 marks)
    - my answer
- Explain any advantages that a SOA may have over lower-level procedural and method-oriented remote communication models.(4 marks)
    - my answer

3. Question 3 (25 marks)

- "C.J. Date's rules for distributed databases define a set of objectives that must be satisfied by a fully Distributed Database System (DDBS)."

  Discuss the degree to which relational, wide-column and graph database models can be considered to be fully DDBS using the criteria specified by C.J. Date.(15 marks)
    - my answer
- Explain how a distributed tuple store can exploit a hash-ring to promote both high availability and scalability. Include in your answer a diagram showing how a hash ring can be used to partition and locate database nodes.(10 marks)
    - my answer

4. Question 4 (25 marks)

- Describe, using UML and diagrams where relevant, the function of the following components of the RMI architecture: (9 marks)
  Remote Interfaces
  Remote and Dynamic Proxies
  Naming Services

    - my answer
- Discuss how RMI can be used to simulate a pass-by-reference. Your answer should be accompanied by a diagram illustrating the component parts involved in the process and code snippets showing the key interactions.(11 marks)
    - my answer
- Briefly, explain how the RMI architecture can be adapted to enable direct communication with a remote CORBA orb.(5 marks)
    - my answer

5. Question 5 (25 marks)

- Using a fully labelled diagram, describe the major components of an Object Request Broker (ORB) and their function in the CORBA architecture. (13 marks)
    - my answer
-) The following two Java interfaces abstract an PurchaseOrder and an LineItem respectively.

  package ie.gmit.sw;
  public interface LineItem
  String itemNumber ();

String name ();
int quantity ();
double price ();

package ie.gmit.sw;
public interface PurchaseOrder
String poNumber();
void add (LineItem i);
void remove (LineItem i) throws ItemNotFoundException;
int count ();
LineItem[] items ();

Translate the two Java interfaces into their CORBA Interface Definition Language (IDL) representation and show how the IDL module may be compiled and orchestrated into a set of server-side classes. (12 marks)

- my answer

Chapter 5

Semester 7 Year 4 Distributed Systems

- Black is Examiners Question

- Blue is my sample question

5.0.1 Distributed Systems - Exam paper 2015-16 Semester 7

1. Question 1 (25 marks)

   - Explain, using diagrams and examples, the following terms as they apply to distributed systems (15 marks) :
   Heterogeneity
     Transparency
     Openness

     - my answer

   - Discuss how message queues can be used to augment traditional client-server communication with both synchronous and asynchronous capabilities. Illustrate your answer with UML diagrams where appropriate.(10 marks)

     - my answer

2. Question 2 (25 marks)

   - The following diagram depicts the system architecture for a web-based e-commerce application that allows users to purchase concert tickets online:
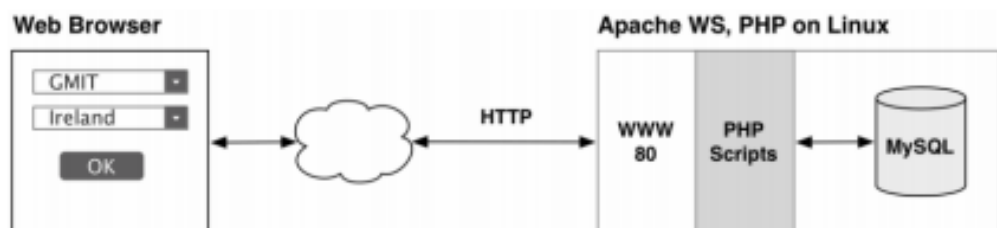
   While the system operates well for small to medium sized concerts, concerns have been raised about the scalability of the system, after users experienced a

major degradation in performance when making bookings for a recent 50,000-ticket Beyoncé concert at the Aviva Stadium.

You are required to provide a re-design of the system that will:

Allow the system to scale to support thousands of concurrent users

Enable the system to be extended to support the aggregation of additional functionality from separate heterogeneous remote services.

Allow the system to be remotely queried using different request protocols from different types of devices, including Windows and Linux workstations, Android tablets and IPhones.

Your answer should include a fully labelled diagram of the new system architecture along with a description of the roles of its constituent technologies and platforms(25marks)

- my answer

3. Question 3 (25 marks)

- "Marshalling is a salient and essential component of distributed systems, promoting both loose-coupling and support for heterogeneity."

Discuss this statement. Your answer should address the centrality of marshalling and the role of middleware in distributed computing. Where appropriate, include system diagrams, UML designs and code snippets in your answer.(25 marks)
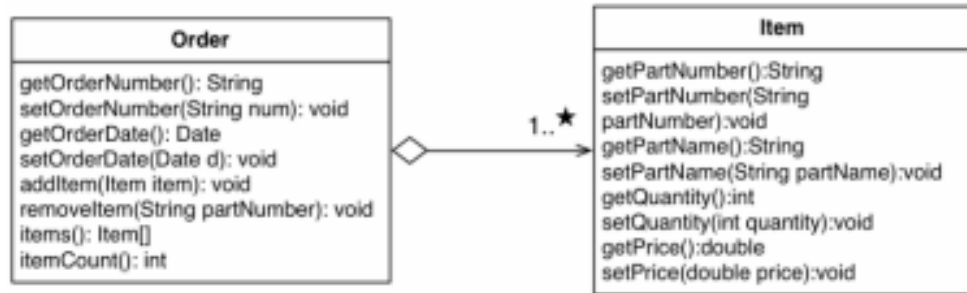
- my answer

4. Question 4 (25 marks)

- Describe the function of the following components of the RMI architecture:(10 marks)

The Remote Interface
The RMI Registry
Stubs and Skeletons

- my answer

- The following UML diagram depicts the composition relationship between an Order and a LineItem class. Both classes form part of an Order-Management system used by a local Galway company that specialises in the sale of novelty shirts and ties.

Explain, using code examples and diagrams where appropriate, how the above classes can be incorporated into the RMI architecture. You should apply the Open-Closed Principle in your answer, i.e. the Order and Item classes should not require modification. You may assume that both classes already implement the interface java.io.Serializable.(15 marks)

- my answer

5. Question 5 (25 marks)

   - Discuss, citing examples, the difference between homogeneous and heterogeneous distributed database systems. (8 marks)

     - my answer

   - Describe how the two-phase-commit protocol can be used to implement a distributed atomic transaction.(8 marks)

     - my answer

   - Discuss how a hash-ring can be used in a distributed hash table as a mechanism for promoting with both high availability and scalability. Include in your answer a diagram showing how a hash ring is used to partition and locate database nodes(9 marks)

     - my answer

6. Question 6 (25 marks)

   - Using a fully labelled diagram, describe the main components of a CORBA orb. Include in your answer a description of the services provided by the CORBA object adapter.(12 marks)

     - my answer

   - The following figure describes two Java interfaces that abstract a student and a class respectively:

```
public interface Student{
        public void setStudentName(String name,  int id);
        public String getStudentName(int id);
        public int getStudentId(String name);
        public boolean deleteStudent(int id);
}


import java.util.Vector;
public interface Class{
        public boolean addClass(String className,  int courseCode,  String lecturer);

        // returns a list of student objects
        public Vector getStudents(String className);
}
```

Show how Interface Definition Language (IDL) can be used to represent these interfaces in a CORBA architecture.

- my answer

- Briefly describe the mechanism through which a CORBA orb can communicate directly with a J2EE container.(5 Marks)

  - my answer

Chapter 6

References

6.0.1 References

All answers were sourced from notes via www.learnonline.gmit.ie