Course Work 1

Module: CI6320 Advanced Data Modelling (ADM)
Module Leader: Mr. W A D B C Goonatillaka
Assignment Type: Individual
Submission Date: 2024.04.09

Student ID: E112691
Student Name: Ranuga Disansa Belpa Gamage
Student Email: e112691@esoft.academy

Part 1 - To Remain with the Assignment after Marking

Student ID: E11261	**Student Name: Belpa Gamage Ranuga Disansa**
Module Code: CI6320	**Module Name: Advanced Data Modelling**
Assignment number: 1	**ESoft Module Leader: Mr. W A D B C Goonatillaka**
Date set: 16th of March 2024	**Date due: 7th of April 2024**

Guidelines for the Submission of Coursework

1. Print this cover sheet and securely attach both pages to your assignment. You can help us ensure work is marked more quickly by submitting it at the specified location for your module. You are advised to keep a copy of every assignment.

2. Coursework deadlines are strictly enforced by the University.

3. You should not leave the handing in of work until the last minute. Once an assignment has been submitted it cannot be submitted again.

Academic Misconduct: **Plagiarism** and/or **collusion** constitute **academic misconduct** under the University's Academic Regulations. Examples of academic misconduct in coursework: making available your work to other students; presenting work produced in collaboration with other students as your own (unless an explicit assessment requirement); submitting work, taken from sources that are not properly referenced, as your own. By printing and submitting this coversheet with your coursework you are confirming that the work is your own.

ESoft Office Use Only: Date stamp: work received.

Part 2 – Student Feedback

Student ID:	**Student Name:**
Module Code:	**Module Name:**
Assignment number:	**ESoft Module Leader:**
Date set:	**Date due:**

Strengths (areas with well-developed answers)

Weaknesses (areas with room for improvement)

Additional Comments

ESoft Module Lecturer: **Provisional mark as %:**

ESoft Module Marker: **Date marked:**

Acknowledgement

I want to express my appreciation to those who have helped complete this report.
I have been able to complete this report because of the Academic advisor Mr. W A D B C Goonatillaka for their invaluable support, mentorship, and feedback and the faculty members of CI6320(Advanced Data Modelling).

Additionally, I would like to thank my family members for their unwilling encouragement and help throughout the report.

Thank you.

Table of Contents

Table of Figures

Part A

1. Introduction

1.1 What is data modelling?

A data model is a visual blueprint used to design databases or software systems depicting data entities and their relationships. It helps businesses order and organize their data effectively, making it easier to design or re-engineer databases that align with business and application requirements. A Datta model helps by creating a bridge between business and technical teams by incorporating real-world objects into a structure for a database. A data model is a critical first step after defining business requirements. (IBM, no date; Staff, 2023; G, 2018; DASCA, no date)

1.2 Importance of Data Models

- Documentation
- Ensure data integrity.
- Higher Quality
- Decision Making

2. Relational Data Model (RDM)

2.1 History

The relational data model was introduced by E.F. Codd at IBM in San Jose, where a new data representation framework called the relational data model was established. It suggested that all the data could be stored in a tabular structure, in turn leading to higher productivity in the early 1980s (Newcomb and Couch, 2010). It is taken into consideration as the landmark or the start of database systems. (Khan, no date)

2.2 Core Principles

The core principle of real data models is that data is organized in tables with columns and rows. Each table has rows, and each row is considered an instance of a relation. The columns are the attributes that are characteristics of the data. The model is built by implementing a computer presentation of mathematical theories of set theory and predicate logic. Relationships are used to store information about objects in a database. (Khan, no date.)

2.3 Characteristics

- Table-based structure.
- Atomic values
- Normalization
- SQL

3. Object-Oriented Data Model (OODM)

3.1 History

The object-oriented Datta model was created to define operations for designing schemas, creating databases, retrieving objects, and navigating, while also having additional object-oriented principles such as aggregation, generalization and particularization relationships (Zhao, 1988).

3.2 Core Principles

The object-oriented data model represents the real world as objects with problems, attributes, and relationships. OODM was created by combining relational data model concepts with object-oriented programming principles (GFG, 2021). This approach allows classes to be grouped into items with comparable qualities, vacillating the organization and management of data structures while allowing for a smooth transition from the design concept to implementation in object-oriented databases (Janecatalla, 2012; Alzahrani, 2016).

3.3 Characteristics

- Classes which are like blueprints can create objects which are instances of a class (GFG, 2021)
- Allows for features such as inheritance which allows subclasses to inherit attributes and methods from classes **(GFG 2021),** which is useful for code reuse.
- Operations are performed on the data that is encapsulated by the objects.

4. Object-Relational Data Model (ORDM)

4.1 History

With the limitations of both the relational and object-oriented data models, research in the 1990s led to the development of the object-oriented data model, which takes fundamental concepts from both the relational and object-oriented data model while addressing areas where improvement was sought. (Castro, 2020)

4.2 Core Principles

The Object-oriented model combines the important features of both the relational and object-oriented data models, and it has extracted important core principles such as Supporting objects, classes, and inheritance from the Object-oriented data model and data types and tables from the Relational Data Model (Castro, 2020; Auziņš, 2018).

4.3 Characteristics

- supports complex Data Types such as Arrays, Nested Tables, and user-defined types.
- Has object-oriented principles in combination with the features of the relational data model, in turn allowing for the creation of much more advanced objects with relational principles.
- Creates a data model which has the most important features to be able to model the real world while having the flexibility to represent complex relationships and structures.

5. Summary

5.1 Comparison Table

Feature	Object Oriented Data Model (OODM)	Relational Data Model (RDM)	Object Relational Data Model (ORDM)
Data Representation	Objects with attributes and methods	Tables with rows and columns	Tables with rows, columns, and some OO concepts (inheritance, complex data types)
Relationships	Inheritance, Aggregation, and Association	Foreign Keys	Foreign Keys and some OO concepts (inheritance)
Performance	Potentially faster due to no joins	It can be efficient for specific queries	It can be efficient for specific queries but may be slower for complex relationships
Advantages	Code reuse (inheritance) and Semantic modelling easier to model complex relationships	flexible and efficient for certain queries Secure and Scalable	Combines benefits of OO and Relational models. Supports complex data types: Inheritance
Disadvantages	no strong mathematical foundation Difficulty with persistence for complex structures	can be complex to design for large data sets not ideal for complex querying	can be complex to manage; may not be as performant as pure OO for complex relationships

5.2 Critical Discussion on Which Model to Use in real-world application scenarios.

When selecting a data model for a real-world application it heavily relies on the specific requirements, constraints and characteristics of the specific application. Relational Data models are extremely useful in scenarios where data integrity and consistency are important, for example, in a banking system. Object-oriented models (OODM) have extremely rare use cases because they are useful in complex data modelling scenarios such as the natural representation of entities with a lot of behaviours and relationships which are found in multimedia or gaming applications. Object-relational data models (ORDM) are a balance between flexibility and data integrity, making them useful in hybrid scenarios such as social media platforms and e-commerce systems. The choice between the different data models requires careful evaluation of the advantages and disadvantages while considering factors such as complexity, development and requirements.

Part B

The code used throughout Part B can be found in the following link: https://drive.google.com/drive/folders/1zVbInetUpIGh5gMlRNV28RNZWdoHLFf?usp=sharing

1. Setting Up the Development Environment

To set up the development environment to execute the following given programs: First, make sure that Oracle Database and Developer are installed on the development machine. Then configure the connection with the Oracle database, and then it would be possible to replicate the following programs. The following attached figure shows the Oracle database version that was used in development.

```
SQL> SELECT * FROM v$version;

BANNER
----------------------------------------------------------------
Oracle Database 10g Express Edition Release 10.2.0.1.0 - Product
PL/SQL Release 10.2.0.1.0 - Production
CORE    10.2.0.1.0      Production
TNS for 32-bit Windows: Version 10.2.0.1.0 - Production
NLSRTL Version 10.2.0.1.0 - Production
```

Figure 1Oracle Database Version

2. Publication

2.1 Type Creation

```
SQL> CREATE OR REPLACE TYPE Publication AS OBJECT (
  2      title VARCHAR2(255),
  3      publication_date DATE,
  4      publication_type VARCHAR2(20),
  5      -- Define member function to display basic information
  6      MEMBER FUNCTION displayBasicInfo RETURN VARCHAR2
  7  );
  8  /

Type created.
```

Figure 2Creating / Replacing Type Publication Execution

In this given SQL script creates or replaces a User Defined Type (UDT) called ‘Publication’. This type has 3 attributes which are: ‘title’ with VARCHAR (255) datatype, ‘publication_date’ with DATE datatype and ‘publication_type’ with VARCHAR2(2) datatype, and finally this defines a function called `displayBasicInfo()` which is expected to of type `VARCHAR2`.

```sql
-- Define Publication as an object type
CREATE OR REPLACE TYPE Publication AS OBJECT (
    title VARCHAR2(255),
    publication_date DATE,
    publication_type VARCHAR2(20),
    -- Define member function to display basic information
    MEMBER FUNCTION displayBasicInfo RETURN VARCHAR2
);
```

Figure 3Creating / Replacing Type Publication SQL

2.2 Body Creation

```
SQL> -- Define body for Publication type
SQL> CREATE OR REPLACE TYPE BODY Publication AS
  2      -- Implementation of the displayBasicInfo function
  3      MEMBER FUNCTION displayBasicInfo RETURN VARCHAR2 IS
  4      BEGIN
  5          RETURN 'Title: ' || title || ', Publication Date: ' || TO_CHAR(publication_date, 'DD-MON-YYYY') || ', Type:
 ' || publication_type;
  6      END displayBasicInfo;
  7  END;
  8  /

Type body created.
```

Figure 4Creating / Replacing Publication Type Body Execution

This block of SQL code defines the body type for the type `Publication`. It has the following components:

1. `CREATE OR REPLACE TYPE BODY Publication AS`: This statement either creates or replaces the Body for the Type Publication
2. `MEMBER FUNCTION displayBasicInfo RETURN VARCHAR2 IS`: This statement creates a member function called `displayBasicInfo()` which returns the data type of `VARCHAR2`.
3. `BEGIN`: This marks the start of the function implementation
4. `RETURN 'Title: ' || title || ', Publication Date: ' || TO_CHAR(publication_date, 'DD-MON-YYYY') || ', Type: ' || publication_type;`: This SQL statement returns a concatenated string with details such as title, publication_date and publication_type
5. `END displayBasicInfo;`: Marks the end of the displayBasicInfo function definition.

```
1 -- Define body for Publication type
2 CREATE OR REPLACE TYPE BODY Publication AS
3     -- Implementation of the displayBasicInfo function
4     MEMBER FUNCTION displayBasicInfo RETURN VARCHAR2 IS
5     BEGIN
6         RETURN 'Title: ' || title || ', Publication Date: ' || TO_CHAR(publication_date, 'DD-MON-YYYY') || ', Type: ' || publication_type;
7     END displayBasicInfo;
8 END;
9
```

Figure 5Creating / Replacing Publication Body SQL

2.3 Table Creation

```
SQL> CREATE TABLE Publications (
  2      publication_id NUMBER PRIMARY KEY,
  3      title VARCHAR2(255),
  4      publication_date DATE,
  5      publication_type VARCHAR2(20),
  6      -- Ensure publication_type is either 'Book' or 'Journal'
  7      CONSTRAINT chk_pub_type CHECK (publication_type IN ('Book', 'Journal'))
  8  );

Table created.
```

Figure 6Creating Publications Table Execution

The given SQL script creates a table named `Publications` with four columns: `publication_id`, `title`, `publication_date` and `publication_type`. This table contains a constraint named `chk_pub_type` that ensures that the column will only contain the values `Book` or `Journal`.

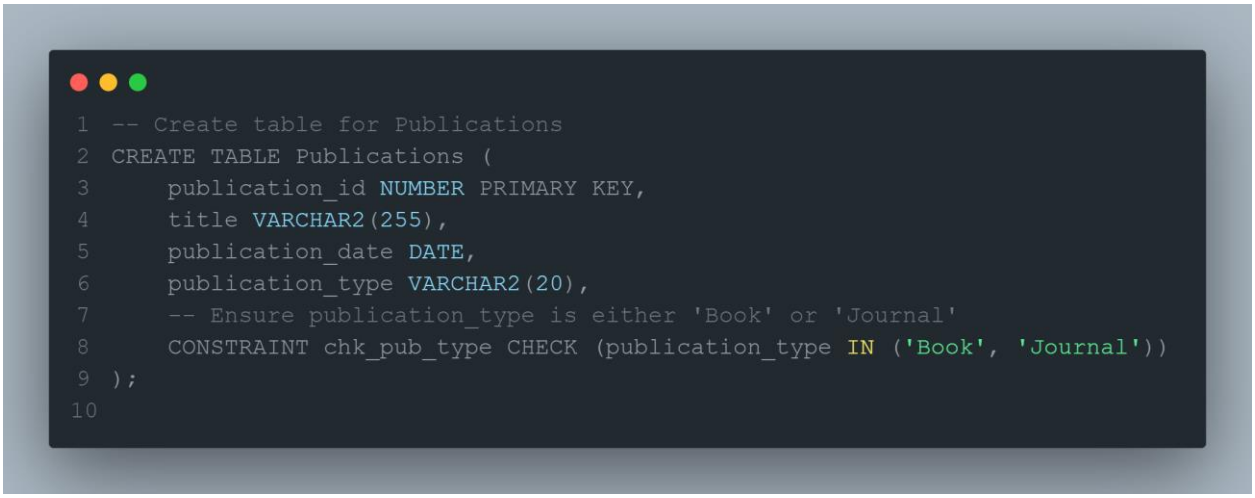


Figure 7Creating Publications Table SQL

2.4 Data Insertion

```
SQL> INSERT INTO Publications VALUES (1, 'The Great Gatsby', TO_DATE('2023-05-10', 'YYYY-MM-DD'), 'Book');

1 row created.

SQL> INSERT INTO Publications VALUES (2, 'National Geographic', TO_DATE('2023-04-15', 'YYYY-MM-DD'), 'Journal');

1 row created.

SQL> INSERT INTO Publications VALUES (3, 'Harry Potter and the Philosopher''s Stone', TO_DATE('2023-06-20', 'YYYY-MM-DD'
), 'Book');

1 row created.
```

Figure 8Inserting Data into the Publications Table Execution

These 3 statements enter 3 records into the Publications Table, where each INSERT INTO inserts one row of data. Each value corresponds to a column in the table, and there are 4 columns, so each insertion has 4 values corresponding to each column. The TO_DATE function is used to convert strings into the DATE data type/structure.

```sql
-- Inserting data for the publication titled 'The Great Gatsby' into the Publications table
INSERT INTO Publications VALUES (
    1, -- publication_id
    'The Great Gatsby', -- title
    TO_DATE('2023-05-10', 'YYYY-MM-DD'), -- publication_date
    'Book' -- publication_type
);

-- Inserting data for the publication titled 'National Geographic' into the Publications table
INSERT INTO Publications VALUES (
    2, -- publication_id
    'National Geographic', -- title
    TO_DATE('2023-04-15', 'YYYY-MM-DD'), -- publication_date
    'Journal' -- publication_type
);

-- Inserting data for the publication titled 'Harry Potter and the Philosopher''s Stone' into the Publications table
INSERT INTO Publications VALUES (
    3, -- publication_id
    'Harry Potter and the Philosopher''s Stone', -- title
    TO_DATE('2023-06-20', 'YYYY-MM-DD'), -- publication_date
    'Book' -- publication_type
);

```

Figure 9Inserting into the Publications Table SQL

2.5 Data Retrieval

```
SQL> SELECT p.title, Publication(p.title, p.publication_date, p.publication_type).displayBasicInfo() AS basic_info
  2  FROM Publications p;

TITLE
--------------------------------------------------------------------------------
BASIC_INFO
--------------------------------------------------------------------------------
The Great Gatsby
Title: The Great Gatsby, Publication Date: 10-MAY-2023, Type: Book

National Geographic
Title: National Geographic, Publication Date: 15-APR-2023, Type: Journal

Harry Potter and the Philosopher's Stone
Title: Harry Potter and the Philosopher's Stone, Publication Date: 20-JUN-2023,
Type: Book

TITLE
--------------------------------------------------------------------------------
BASIC_INFO
--------------------------------------------------------------------------------
```

Figure 10RRetrievingData from Publications Table Execution

This query selects data from the Publications table and for each row, it retrieves its title column and uses the other attributes to create an instance of the `Publication` type and then calls the `displayBasicInfo` method on the `Publication` instance and the returned information is aliased as `basic_info`, finally the title alongside the string from the `displayBasicInfo()`.

```sql
-- Query to retrieve basic information for each publication using the displayBasicInfo method
SELECT p.title, Publication(p.title, p.publication_date, p.publication_type).displayBasicInfo() AS basic_info
FROM Publications p;
```

Figure 11RRetrievingData from Publications Table SQL

3. Book

Before Executing any of the following SQL scripts the following SQL code must be executed to ensure that any errors won't be raised.

```sql
-- Allowing the "Publication" type to be extended
ALTER TYPE Publication NOT FINAL;
```

Figure 12Alternating the Type Publications to be extended.

3.1 Type Creation

```
SQL> CREATE TYPE Book UNDER Publication (
  2      author VARCHAR2(255), -- Attribute for the author of the book
  3      ISBN VARCHAR2(13), -- Attribute for the International Standard Book Number
  4      MEMBER FUNCTION displayFullInfo RETURN VARCHAR2 -- Member function to display full information of the book
  5  );
  6  /

Type created.
```

Figure 13Creating Type Book Execution

This code segment creates a subtype `Book` on top of the `Publication` supertype, it introduces more attributes such as `author` with VARCHAR2(255) datatype, `ISBN` with VARCHAR2(13) datatype; and the subtype introduces a new member function called `displayFullInfo()` which returns the data type `VARCHAR2`.

```sql
-- Defining a subtype "Book" under the "Publication" type
CREATE TYPE Book UNDER Publication (
    author VARCHAR2(255), -- Attribute for the author of the book
    ISBN VARCHAR2(13), -- Attribute for the International Standard Book Number
    MEMBER FUNCTION displayFullInfo RETURN VARCHAR2 -- Member function to display full information of the book
);

```

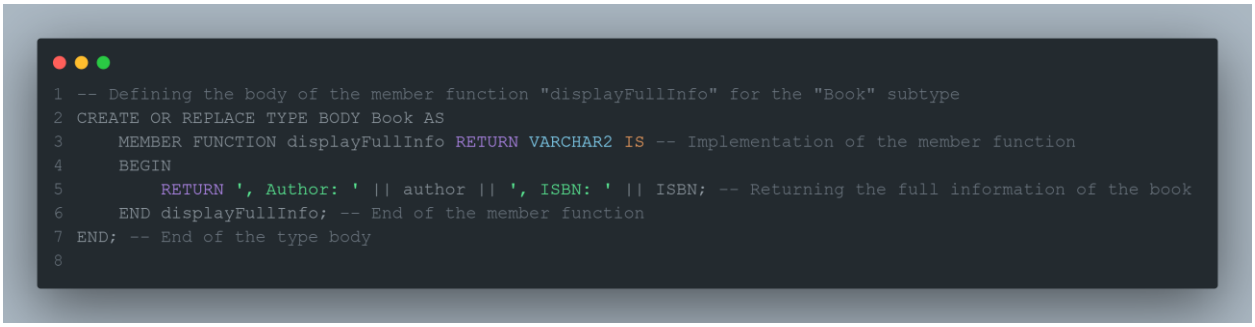
Figure 14Creating Type Book SQL

3.2 Body Creation

```
SQL> CREATE OR REPLACE TYPE BODY Book AS
  2      MEMBER FUNCTION displayFullInfo RETURN VARCHAR2 IS -- Implementation of the member function
  3      BEGIN
  4          RETURN ', Author: ' || author || ', ISBN: ' || ISBN; -- Returning the full information of the book
  5      END displayFullInfo; -- End of the member function
  6  END; -- End of the type body
  7
  8  /

Type body created.
```

Figure 15Creating / Replacing Body Type Execution

This code implements the `displayFullInfo` member function belonging to the `Book` subtype. The function is implemented so that a concatenated string with the details of all the attributes of the Book instance is returned.



```sql
-- Defining the body of the member function "displayFullInfo" for the "Book" subtype
CREATE OR REPLACE TYPE BODY Book AS
    MEMBER FUNCTION displayFullInfo RETURN VARCHAR2 IS -- Implementation of the member function
    BEGIN
        RETURN ', Author: ' || author || ', ISBN: ' || ISBN; -- Returning the full information of the book
    END displayFullInfo; -- End of the member function
END; -- End of the type body

```

Figure 16Creating / Replacing Body Type SQL

3.3 Table Creation

```
SQL> CREATE TABLE Books (
  2      ISBN VARCHAR2(13) PRIMARY KEY,
  3      publication_id NUMBER UNIQUE,
  4      author VARCHAR2(255),
  5      CONSTRAINT fk_books_publications FOREIGN KEY (publication_id) REFERENCES Publications(publication_id) ON DELETE CASCADE
  6  );

Table created.
```

Figure 17Create Table Books Execution

This SQL code creates the table `Books`, which is used to store information regarding books. The table has 3 attributes and 1 constraint, The attributes are: ISBN with VARCHAR2(13) datatype, publication_id with NUMBER datatype and author with VARCHAR2(255) datatype. The constraint in the Books table is that the `publication_id` but be referenced in Publications(publication_id) in turn creating a foreign key constraint.

```sql
CREATE TABLE Books (
    ISBN VARCHAR2(13) PRIMARY KEY,
    publication_id NUMBER UNIQUE,
    author VARCHAR2(255),
    CONSTRAINT fk_books_publications FOREIGN KEY (publication_id) REFERENCES Publications(publication_id) ON DELETE CASCADE
);

```

Figure 18Create Table Books SQL

3.4 Data Insertion

```
SQL> -- Add test data to the Books table
SQL> INSERT INTO Books (ISBN, publication_id, author)
  2  VALUES ('1234567890123', 1, 'J.K. Rowling');

1 row created.

SQL>
SQL> INSERT INTO Books (ISBN, publication_id, author)
  2  VALUES ('9876543210987', 2, 'George R. R. Martin');

1 row created.

SQL>
SQL> INSERT INTO Books (ISBN, publication_id, author)
  2  VALUES ('5555555555555', 3, 'Stephen King');

1 row created.
```

Figure 19Inserting into the Books Table Execution

These 3 statements enter 3 records into the Books Table, where each INSERT INTO inserts one row of data. Each value corresponds to a column in the table, and there are 3 columns, so each insertion has 3 values corresponding to each column. Due to the constraint, all the `publication_id`'s are already in the `Publications` table.

```sql
-- Add test data to the Books table
INSERT INTO Books (ISBN, publication_id, author)
VALUES ('1234567890123', 1, 'J.K. Rowling');

INSERT INTO Books (ISBN, publication_id, author)
VALUES ('9876543210987', 2, 'George R. R. Martin');

INSERT INTO Books (ISBN, publication_id, author)
VALUES ('5555555555555', 3, 'Stephen King');
```

Figure 20IInsuringinto the Books Table SQL

4. Journal

Before Executing any of the following SQL scripts the following SQL code must be executed to ensure that any errors won't be raised.

```sql
-- Allowing the "Publication" type to be extended
ALTER TYPE Publication NOT FINAL;
```

Figure 21 Alternating the Type of Publications to be extended

4.1 Type Creation

```
SQL> CREATE TYPE Journal UNDER Publication (
  2      volume NUMBER,
  3      issue NUMBER,
  4      MEMBER FUNCTION displayFullInfo RETURN VARCHAR2
  5  );
  6  /

Type created.
```

Figure 22Creating Type Journal Execution

This SQL statement creates a new object type, which is a subtype of the Publication supertype. It has 2 attributes and a member function called `displayFullInfo()` which returns the type of VARCHAR2.

```sql
CREATE TYPE Journal UNDER Publication (
    volume NUMBER,
    issue NUMBER,
    MEMBER FUNCTION displayFullInfo RETURN VARCHAR2
);
```

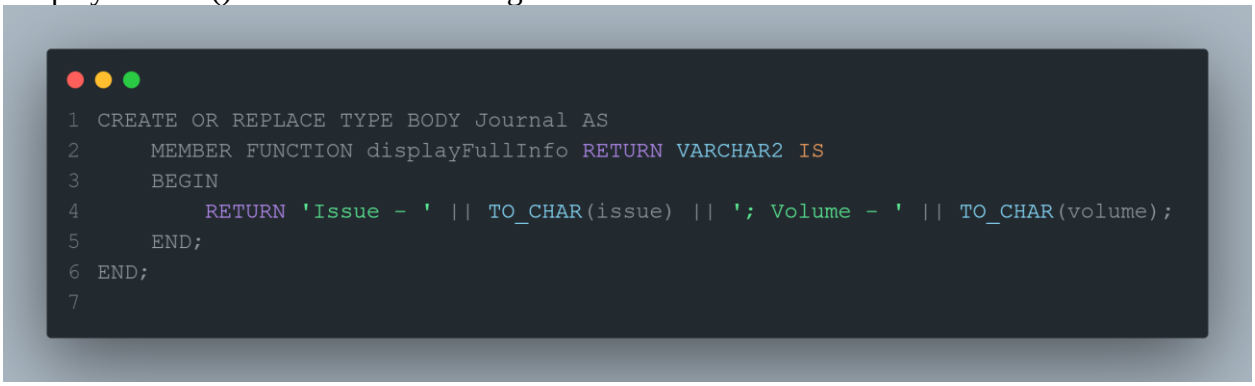
Figure 23Creating Type Journal SQL

4.2 Body Creation

```
SQL> CREATE OR REPLACE TYPE BODY Journal AS
  2      MEMBER FUNCTION displayFullInfo RETURN VARCHAR2 IS
  3      BEGIN
  4          RETURN 'Issue - ' || TO_CHAR(issue) || '; Volume - ' || TO_CHAR(volume);
  5      END;
  6  END;
  7  /

Type body created.
```

Figure 24Creating / Replacing Journal Type Body Execution

This code creates or replaces the body of the type `Journal` by implementing the function `displayFullInfo()` and it returns a string that contains all the attributes.



```
CREATE OR REPLACE TYPE BODY Journal AS
    MEMBER FUNCTION displayFullInfo RETURN VARCHAR2 IS
    BEGIN
        RETURN 'Issue - ' || TO_CHAR(issue) || '; Volume - ' || TO_CHAR(volume);
    END;
END;
```

Figure 25Creating / Replacing Journal Type Body SQL

4.3 Table Creation

```
SQL> CREATE TABLE Journals (
  2      publication_id NUMBER PRIMARY KEY,
  3      volume NUMBER,
  4      issue NUMBER,
  5      CONSTRAINT fk_journals_publications FOREIGN KEY (publication_id) REFERENCES Publications(publication_id) ON DEL
ETE CASCADE
  6  );

Table created.
```

Figure 26Creating Journals Table Execution

This SQL Code creates the table `Journals`, which is used to store information regarding Journals. The table has 3 attributes and 1 constraint, the attributes are volume with NUMBER datatype, publication_id with NUMBER datatype (which is the primary key) and issue with NUMBER datatype. The constraint in the Journals table is that the `publication_id` references in Publications(publication_id) in turn create a foreign key constraint.

```sql
CREATE TABLE Journals (
    publication_id NUMBER PRIMARY KEY,
    volume NUMBER,
    issue NUMBER,
    CONSTRAINT fk_journals_publications FOREIGN KEY (publication_id) REFERENCES Publications(publication_id) ON DELETE CASCADE
);

```

Figure 27Creating / Replacing Journal Table SQL

4.4 Data Insertion

```
SQL> -- Insert test data into the Journals table
SQL> INSERT INTO Journals (publication_id, volume, issue)
  2  VALUES (1, 10, 1);

1 row created.

SQL>
SQL> INSERT INTO Journals (publication_id, volume, issue)
  2  VALUES (2, 11, 2);

1 row created.

SQL>
SQL> INSERT INTO Journals (publication_id, volume, issue)
  2  VALUES (3, 12, 3);

1 row created.
```

Figure 28Inserting Data into the Journals Table Execution

These 3 statements enter 3 records into the Journals Table, where each INSERT INTO inserts one row of data. Each value corresponds to a column in the table, and there are 3 columns, so each insertion has 3 values corresponding to each column. Due to the constraint, all the `publication_id`'s are already in the `Publications` table.

5. Member

5.1 Type Creation

```
SQL> CREATE TYPE Member AS OBJECT (
  2      member_id NUMBER,
  3      name VARCHAR2(255),
  4      contact_info VARCHAR2(255),
  5      MEMBER FUNCTION displayInfo RETURN VARCHAR2
  6  );
  7  /

Type created.
```

Figure 29Creating Type Member Execution

This SQL statement creates a new object type Member, it has 3 attributes (member_id, name, contact_info) and a member function called `displayFullInfo()` which returns the type of VARCHAR2.

```
1 CREATE TYPE Member AS OBJECT (
2     member_id NUMBER,
3     name VARCHAR2(255),
4     contact_info VARCHAR2(255),
5     MEMBER FUNCTION displayInfo RETURN VARCHAR2
6 );
7
```

Figure 30Creating Type Member SQL

5.2 Body Creation

```
SQL> CREATE OR REPLACE TYPE BODY Member AS
  2      MEMBER FUNCTION displayInfo RETURN VARCHAR2 IS
  3      BEGIN
  4          RETURN 'Member ID: ' || TO_CHAR(member_id) || ', Name: ' || name || ', Contact Info: ' || contact_info;
  5      END;
  6  END;
  7  /

Type body created.
```

Figure 31Creating / Replacing Member Type Body Execution

This code creates or replaces the body of the type `Member` by implementing the function `displayFullInfo()` and it returns a string that contains all the attributes.

```sql
CREATE OR REPLACE TYPE BODY Member AS
    MEMBER FUNCTION displayInfo RETURN VARCHAR2 IS
    BEGIN
        RETURN 'Member ID: ' || TO_CHAR(member_id) || ', Name: ' || name || ', Contact Info: ' || contact_info;
    END;
END;
```

Figure 32Creating / Replacing Member Type Body SQL

5.3 Table Creation

```
SQL> CREATE TABLE Members (
  2      member_id NUMBER PRIMARY KEY,
  3      name VARCHAR2(255),
  4      contact_info VARCHAR2(255)
  5  );

Table created.
```

Figure 33Creating Members Table Execution

This SQL Code creates the table `Members`, which is used to store information regarding Members. The table has 3 attributes, the attributes are member_id with NUMBER datatype (which is the primary key), a name with VARCHAR2(255) datatype and contact_info with VARCHAR(255) datatype.

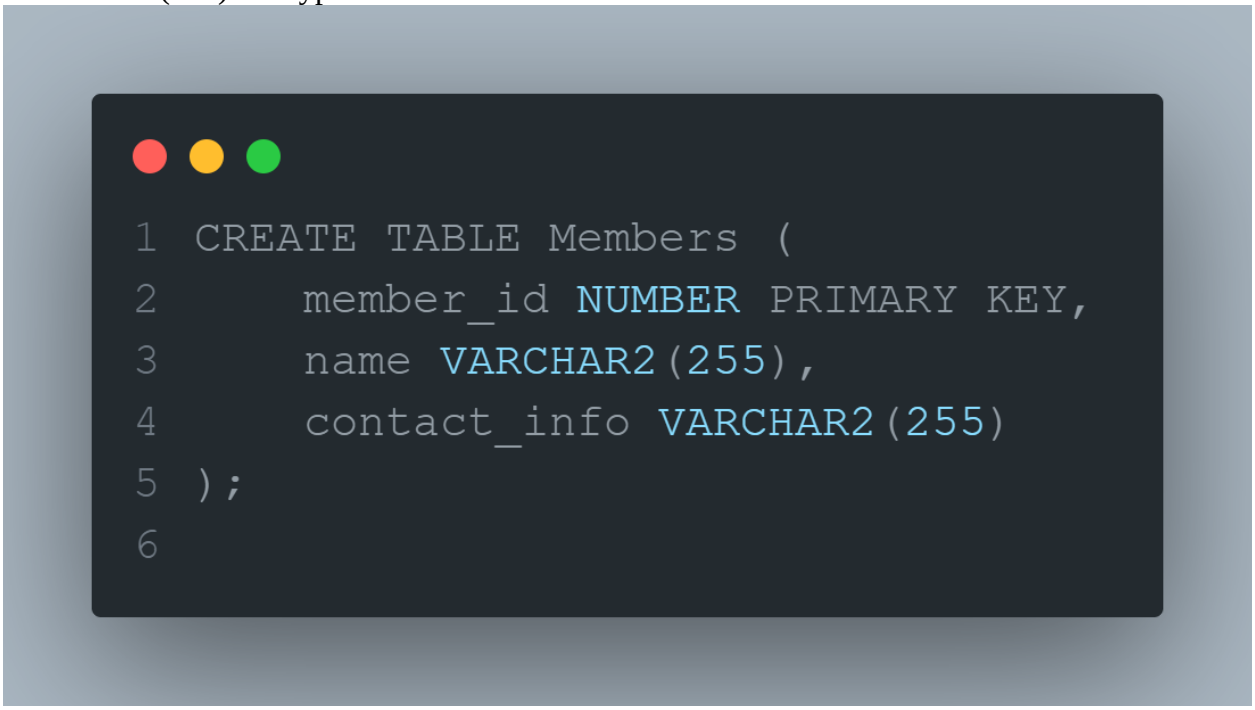


Figure 34Creating Members Table SQL

5.4 Data Insertion

```
SQL> INSERT INTO Members (member_id, name, contact_info)
  2  VALUES (1, 'John Doe', 'john.doe@example.com');

1 row created.

SQL>
SQL> INSERT INTO Members (member_id, name, contact_info)
  2  VALUES (2, 'Jane Smith', 'jane.smith@example.com');

1 row created.

SQL>
SQL> INSERT INTO Members (member_id, name, contact_info)
  2  VALUES (3, 'Michael Johnson', 'michael.johnson@example.com');

1 row created.
```

Figure 35Inserting Data into the Member's Table Execution

These 3 statements enter 3 records into the Members Table, where each INSERT INTO inserts one row of data. Each value corresponds to a column in the Table, and there are 3 columns, so each insertion has 3 values corresponding to each column.

Figure 36Inserting Data into the Members Table SQL

6. Loans

To execute the following SQL code it is required that the above SQL code has already been executed.

6.1 Table Creation

```
SQL> CREATE TABLE Loans (
  2      member_id NUMBER,
  3      publication_id NUMBER,
  4      loan_date DATE,
  5      return_date DATE,
  6      PRIMARY KEY (member_id, publication_id),
  7      CONSTRAINT fk_loans_members FOREIGN KEY (member_id) REFERENCES Members(member_id),
  8      CONSTRAINT fk_loans_publications FOREIGN KEY (publication_id) REFERENCES Publications(publication_id)
  9  );

Table created.
```

Figure 37Creating Table Loans Execution

This SQL statement creates a new object type Loans, it has 4 attributes: member_id, publication_id (which both are primary keys), loan_date, and return_date. There are 2 constraints in the table, 1 which make sure that the member_id exists in the Members (member_id) attribute, and another to make sure that the `publication_id` exists in the Publications(publication_id).

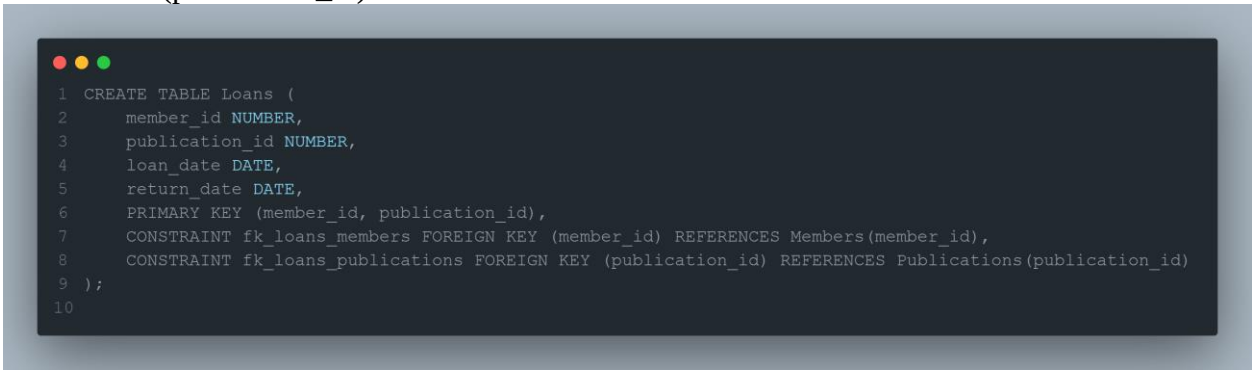


Figure 38Creating Table Loans SQL

6.2 Data Insertion

```
SQL> -- Inserting data for loan of 'The Great Gatsby' to John Doe
SQL> INSERT INTO Loans (member_id, publication_id, loan_date, return_date)
  2  VALUES (1, 1, TO_DATE('2023-07-01', 'YYYY-MM-DD'), TO_DATE('2023-07-08', 'YYYY-MM-DD'));

1 row created.

SQL>
SQL> -- Inserting data for loan of 'National Geographic' to Jane Smith
SQL> INSERT INTO Loans (member_id, publication_id, loan_date, return_date)
  2  VALUES (2, 2, TO_DATE('2023-07-03', 'YYYY-MM-DD'), TO_DATE('2023-07-10', 'YYYY-MM-DD'));

1 row created.

SQL>
SQL> -- Inserting data for loan of 'Harry Potter and the Philosopher''s Stone' to Michael Johnson
SQL> INSERT INTO Loans (member_id, publication_id, loan_date, return_date)
  2  VALUES (3, 3, TO_DATE('2023-07-05', 'YYYY-MM-DD'), TO_DATE('2023-07-12', 'YYYY-MM-DD'));

1 row created.
```

Figure 39Inserting Data into the Loans Table Execution

These 3 statements enter 3 records into the Loans Table, where each INSERT INTO inserts one row of data. Each value corresponds to a column in the Table, and there are 4 columns, so each insertion has 4 values corresponding to each column.

```
1  -- Inserting data for loan of 'The Great Gatsby' to John Doe
2  INSERT INTO Loans (member_id, publication_id, loan_date, return_date)
3  VALUES (1, 1, TO_DATE('2023-07-01', 'YYYY-MM-DD'), TO_DATE('2023-07-08', 'YYYY-MM-DD'));
4
5  -- Inserting data for loan of 'National Geographic' to Jane Smith
6  INSERT INTO Loans (member_id, publication_id, loan_date, return_date)
7  VALUES (2, 2, TO_DATE('2023-07-03', 'YYYY-MM-DD'), TO_DATE('2023-07-10', 'YYYY-MM-DD'));
8
9  -- Inserting data for loan of 'Harry Potter and the Philosopher''s Stone' to Michael Johnson
10 INSERT INTO Loans (member_id, publication_id, loan_date, return_date)
11 VALUES (3, 3, TO_DATE('2023-07-05', 'YYYY-MM-DD'), TO_DATE('2023-07-12', 'YYYY-MM-DD'));
12
```

Figure 40Inserting Data into the Loans Table SQL

7. Additional Features

7.1 Additional Attributes for Publications

```
SQL> ALTER TABLE Publications
  2  ADD (
  3      categories VARCHAR2(255),
  4      genres VARCHAR2(255),
  5      keywords VARCHAR2(255)
  6  );

Table altered.
```

Figure 41Altering Publications Table Execution

The given SQL segment alters the table Publications to include 3 new columns/attributes: categories, genres, and keywords and all of them are of type VARCHAR2 with maximum characters of 255.

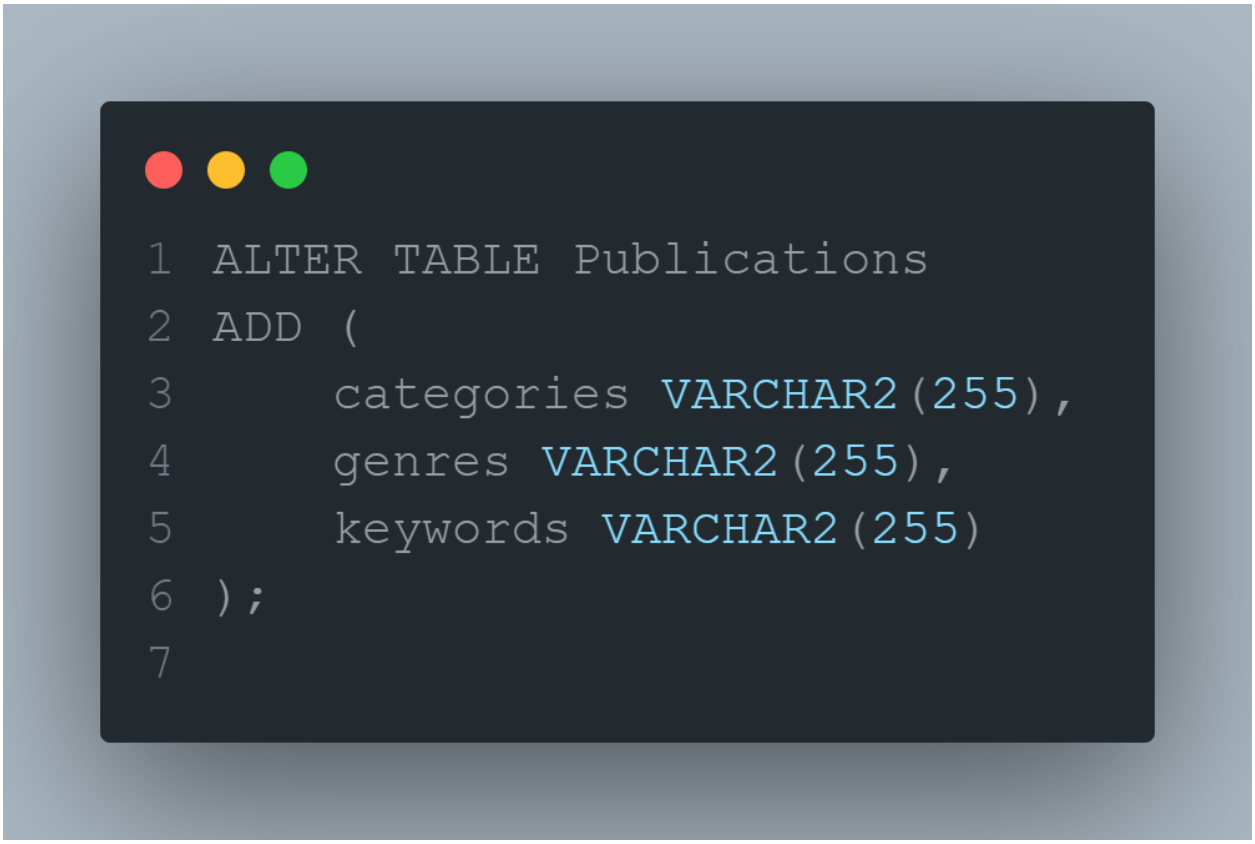


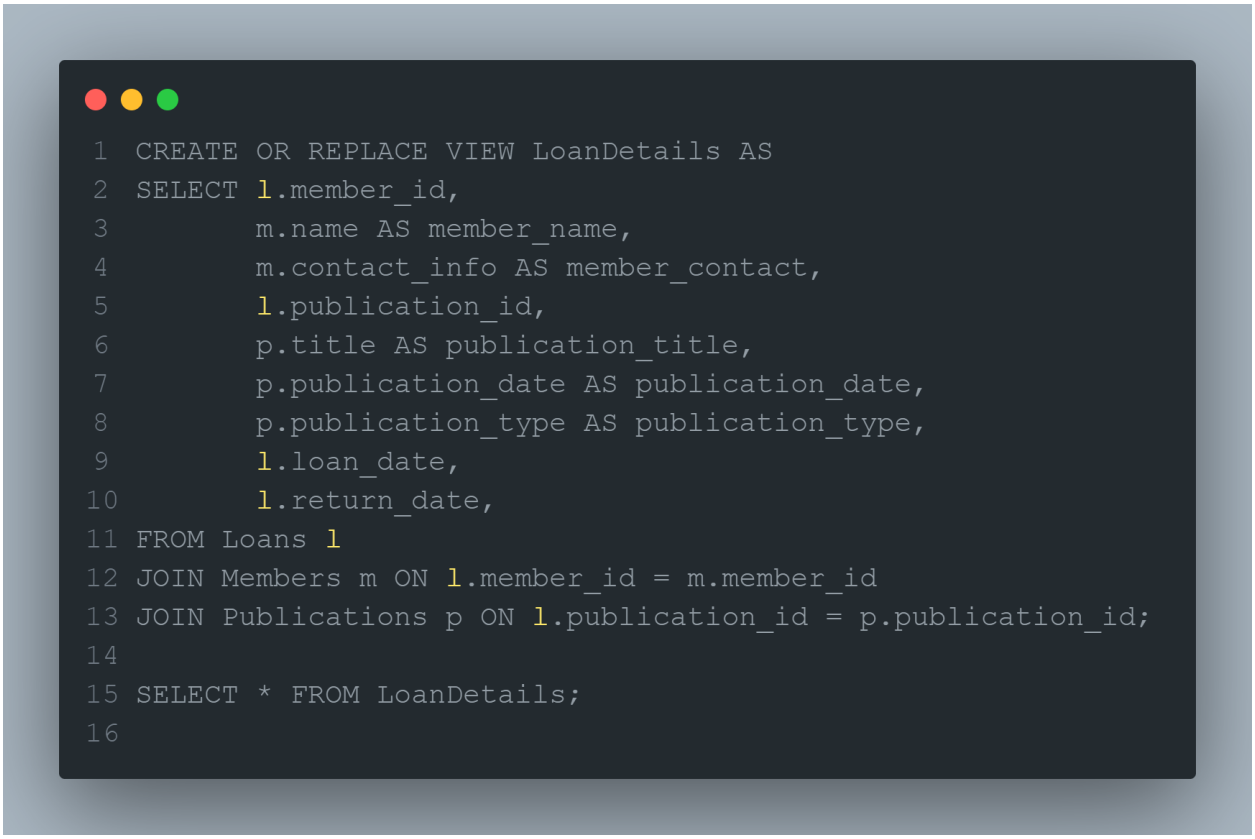
Figure 42Altering Publications Table SQL

7.2 Loan Details Viewer

```
SQL> CREATE OR REPLACE VIEW LoanDetails AS
  2  SELECT l.member_id,
  3         m.name AS member_name,
  4         m.contact_info AS member_contact,
  5         l.publication_id,
  6         p.title AS publication_title,
  7         p.publication_date AS publication_date,
  8         p.publication_type AS publication_type,
  9         l.loan_date,
 10         l.return_date
 11  FROM Loans l
 12  JOIN Members m ON l.member_id = m.member_id
 13  JOIN Publications p ON l.publication_id = p.publication_id;

View created.

SQL> SELECT * FROM LoanDetails;

 MEMBER_ID
----------
MEMBER_NAME
--------------------------------------------------------------------------------
MEMBER_CONTACT
--------------------------------------------------------------------------------
PUBLICATION_ID
--------------
PUBLICATION_TITLE
--------------------------------------------------------------------------------
PUBLICATI PUBLICATION_TYPE     LOAN_DATE RETURN_DA
--------- -------------------- --------- ---------
         1

 MEMBER_ID
----------
MEMBER_NAME
--------------------------------------------------------------------------------
MEMBER_CONTACT
--------------------------------------------------------------------------------
PUBLICATION_ID
--------------
PUBLICATION_TITLE
--------------------------------------------------------------------------------
PUBLICATI PUBLICATION_TYPE     LOAN_DATE RETURN_DA
--------- -------------------- --------- ---------
John Doe

 MEMBER_ID
----------
MEMBER_NAME
```

Figure 43Loan Details Viewer Execution

This code creates a view named LoanDetails which collects data from Tables: Loans, Members and Publications and displays details such as member and publication details, and loan dates in turn making it easier to analyse related information.



```sql
CREATE OR REPLACE VIEW LoanDetails AS
SELECT l.member_id,
       m.name AS member_name,
       m.contact_info AS member_contact,
       l.publication_id,
       p.title AS publication_title,
       p.publication_date AS publication_date,
       p.publication_type AS publication_type,
       l.loan_date,
       l.return_date,
FROM Loans l
JOIN Members m ON l.member_id = m.member_id
JOIN Publications p ON l.publication_id = p.publication_id;

SELECT * FROM LoanDetails;

```

Figure 44Loan Details Viewer SQL

Conclusion

Throughout this coursework, advanced data modelling concepts such as RDM, OODM, and ORDM have been critically analyzed. In the practical aspect, a Library management system was developed using Oracle SQL, allowing the theoretical knowledge to be implemented in a real-world scenario. Overall the coursework has provided incredible knowledge in both theoretical and practical aspects of Advanced Data Modelling.

References

Ameya (2024) 'What is relational Database with Real-Life examples,' RedSwitches, 31 January. https://www.redswitches.com/blog/what-is-relational-database/.

GfG (2021) Basic object-oriented data model. https://www.geeksforgeeks.org/basic-object-oriented-data-model/.

Object-Oriented Data Model and its Application | Free essay example (2022). https://studycorgi.com/object-oriented-data-model-and-its-application/.

Bhagwat, S. (2022) *What is Object Oriented Model in DBMS? - Scaler Topics*. https://www.scaler.com/topics/object-oriented-model-in-dbms/.

Dancuk, M. (2023) What is an Object-Oriented Database. https://phoenixnap.com/kb/object-oriented-database.

Object-relational data model (no date). https://www.tutorialspoint.com/Object-relational-Data-Model.

Auziņš, A. *et al.* (2018) 'Object-relational database structure model and structure optimisation,' *Applied Computer Systems (Online)*, 23(1), pp. 28–36. https://doi.org/10.2478/acss-2018-0004.

Jordan, M. (2023) *What is Database Scalability? Definition & FAQs | ScyllaDB*. https://www.scylladb.com/glossary/database-scalability/#:~:text=Are%20relational%20databases%20scalable%3F,a%20vertical%20approach%20to%20scaling.

Murphy, E. (2022) 'Flexible Relational Data,' *induro*, 13 May. https://induro.io/blog/2022/05/flexible_relational_data/#:~:text=When%20relationships%20are%20predictable%20and,flexible%20to%20accurately%20represent%20it.

Ot, A. (2023) *Relational Data Model 101: Key components & benefits*. https://www.datamation.com/big-data/relational-data-model/#:~:text=Relational%20data%20models%20also%20aid,data%20sets%20in%20various%20applications.

Pahi, N. (2013) *The relational model and normalization*. https://blog.oureducation.in/relational-model-normalization/.

What is data modelling? | IBM (no date b). https://www.ibm.com/topics/data-modeling.

What is a Data Model? (no date b). https://cedar.princeton.edu/understanding-data/what-data-model.

Staff, C. (2023b) *What is a data model?* https://www.coursera.org/articles/data-model.

G, M. (2018b) *Why Data Modelling is Important*. https://www.linkedin.com/pulse/why-data-modelling-important-munish-goswami/.

What is Data Modeling and Why Do You Need It? (no date b). https://www.dasca.org/world-of-big-data/article/what-is-data-modeling-and-why-do-you-need-it.

Vivek, J. (2024b) *Data modelling: benefits, types, importance & steps involved*. https://www.zucisystems.com/blog/what-is-data-modeling-and-why-is-it-important/.

Team, P.B. (no date b) *What is data modelling?* https://powerbi.microsoft.com/en-my/what-is-data-modeling/.

Watt, A. (2014b) *Chapter 7 The Relational Data model*. https://opentextbc.ca/dbdesign01/chapter/chapter-7-the-relational-data-model/#:~:text=The%20relational%20data%20model%20was%20modern%20commercial%20database%20management%20systems.

Newcomb, P.H. and Couch, R. (2010b) 'Veterans Health Administration's VISTA MUMPS modernization pilot,' in *Elsevier eBooks*, pp. 301–345. https://doi.org/10.1016/b978-0-12-374913-0.00012-3.

Khan, S. (no date b) *Brief history of the relational model*. https://www.scribd.com/document/94827565/Brief-History-of-the-Relational-Model.

Peterson, R. (2024b) *Relational Data model in DBMS | Database Concepts & example*. https://www.guru99.com/relational-data-model-dbms.html.
GfG (2024b) *Relational model in DBMS*. https://www.geeksforgeeks.org/relational-model-in-dbms/.
T, N. (2021b) *Relational Data model*. https://binaryterms.com/relational-data-model.html.