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**FACULTY OF ENGINEERING AND TECHNOLOGY**

**COMPUTER ENGINEERING**

**CEF 438: ADVANCED DATABASE AND ADMINISTRATION**

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**DATABASE MIGRATION ASSISTANT  
BY GROUP 8**

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## ABSTRACT

Database migration is a complex yet essential process for modern organizations that seek to transition their data infrastructure to more advanced and efficient systems. This project aims to develop a Database Migration Assistant, a tool designed to facilitate the migration of databases from various systems to Oracle DBMS, ensuring data integrity and consistency throughout the process.

The tool will encompass features for schema conversion, data extraction, transformation, and loading (ETL), and post-migration validation. By addressing the differences in data types, SQL dialects, and functionalities between MySQL and Oracle, the Database Migration Assistant will provide a reliable and efficient solution for organizations looking to transition their databases. The project will leverage Python and its libraries, alongside Oracle-specific tools, to create a user-friendly interface that simplifies complex migration tasks, ultimately minimizing downtime and reducing the risk of data loss.

The resulting Database Migration Assistant significantly benefits organizations by streamlining the migration process, eliminating the need for redesigning databases for new systems, and minimizing the risk of data loss during transit. Additionally, this framework is adaptable and can be used for migrations between various Database Management Systems, including Oracle, Microsoft SQL Server, and MySQL.

**Keywords:** Database, Migration, Architecture, Migration Strategy, Database Management System.

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## 1. INTRODUCTION

With advancement in technology and the continues increase in the volumes of data collected by various institutions and businesses, better and more efficient tools for the management of these data are essential. [1] As data volumes continue to grow, institutions begin to face significant challenges in handling the sheer volume, variety, and velocity of data. Existing database systems become inefficient due to their inability to cope with the complexity of modern data demands. [1] Missed opportunities for extracting value from data, compromised data quality, and the evolving regulatory landscape all contribute to their inefficiency. With these inefficiencies, the cost of maintenance increases and the performance is compromised as some of the existing database management systems may not be scalable. [2] Thus, the main drivers that make an institution to do database migration could be as a result of upgrading to the latest version of the database software to improve security and compliance, moving existing data to a new database to reduce cost, improve performance, and achieve scalability. Moving from an on-premises database to a cloud-based database for better scalability and lower costs. [3]

### 1.1. PROBLEM STATEMENT

In this project, we aim to develop a data migration assistant that will aid institutions in the migration process from other databases to the oracle database management system. [4] This tool will combat the key challenges faced during the migration system and ensure that there is data consistency and integrity, compatibility between the source and target systems, minimize the downtime during migration as well as ensure data confidentiality, integrity, and compliance with regulations. [1]

### 1.2. TERMINOLOGIES

- A. **Database migration:** A migration of data from source databases to target databases with the goal of turning down the source database systems after the migration completes. The entire dataset, or a subset, is migrated.
- B. **Homogeneous migration:** A migration from source databases to target databases where the source and target databases are of the same database management system from the same provider.

- C. **Heterogeneous migration:** A migration from source databases to target databases where the source and target databases are of different database management systems from different providers. [4]

## 2. LITERATURE REVIEW OF A DATABASE MIGRATION SERVICE

### 2.1. BASELINE STUDY

Baseline Study was to establish the challenges that may hinder the process of database migration during the execution of a database migration project when using existing tools. A qualitative research method was used in this study. Capturing as much qualitative data as possible regarding how the existing tools are used to migrate database between different database management systems. [3]

### 2.2. DATA COLLECTION METHODS

Before starting the database conversion project, it is crucial to understand both the source and target database management systems. This involves consultations with database migration experts and reviewing related research. Key considerations for understanding the source database include:

- ✓ **Database Size and Complexity:** Determine the scope of the migration project based on the database size and complexity, as this will impact the time and computing resources required.
- ✓ **Tool Capabilities:** For large databases with millions of rows, use tools that can load data in parallel.
- ✓ **Qualitative Data:** Gather information on how existing tools are used for migrations, such as from MS SQL to Oracle, and understand their schema conversion capabilities.

The project will use a systematic approach, including data-oriented (DOA), object-oriented (OOA), and service-oriented approaches (SOA). Microservices, which consist of small and autonomous services, will be utilized. Each database migration will be treated as a microservice, working cohesively to achieve the overall objective.

The goal is to ensure efficiency and effectiveness in migrating databases, including data, constraints, and structure, between different DBMSs (Oracle, MS SQL Server, MySQL). The development process involves data and constraint exchange between non-identical DBMSs and backing up databases in flexible formats like JSON. The design followed best practices by ETL tools for better development and performance, and also by making use of the method of parallel processing and pipelining to allow data to be partitioned are essential in designing especially when dealing with large volumes of data in ETL. [3]

### 2.3. DATABASE MITIGATION STRATEGY

The proposed framework for database migration includes two endpoints: source and target, which provide connection points to the respective DBMS. Each service within this architecture is self-contained, adhering to the microservice architecture consisting of small, autonomous services that interact to achieve a common goal.

This framework involves:

- ✓ **Components:** Source and target DBMS, data mapping, data extraction, transformation, loading processes, and validation.
- ✓ **Microservices:** Small and autonomous services that rely on a single capability within a bounded context, data mapping, data extraction, transformation, loading processes and validation
- ✓ **Data Transfer Process:** Transferring data from one database system to another.

The framework follows the database migration strategy guidelines to ensure successful migration. It provides a user interface for selecting the source and destination DBMS and supports migrations between MySQL, SQL Server, and Oracle. The system can efficiently migrate records and data details between different DBMSs in a short period.

[3]



## 2.4. SYSTEM IMPLEMENTATION

The design of database migration service was effectively implemented using the technologies elaborated in the research methodology and would operate using the following system features.

### **Java Spring tool Suite:**

Java spring Boot is an open-source Java-based framework It is designed to simplify the process of building and deploying production-ready applications with the Spring Framework

### **mysql:mysql-connector-java:8.0.22**

this java library was used to connect MySQL database management system from java.

### **Oracle JDBC (ojdbc8.ja):** this java library was used to connect Oracle database management system from java

### **Oracle JDBC (ojdbc8.ja):** this java library was used to connect Oracle database management system from java

### **SQL server (mssql-jdbc-8.2.0.jreVERSION.jar):** this java library was used to connect SQL server database management system from java.

### **MySQL DBMS:**

MySQL database management system was used to store database in MySQL format (.frm). MySQL database management system stores data in separate tables. The database structures are organized into physical files .The logical model, with objects such as databases, tables, views, rows, and columns.

### **MS SQL Server DBMS:** Microsoft SQL Server is a database management system developed by Microsoft. As a database management system, it is a software product whose primary function is to store and retrieve data as requested by other software applications.in our system the SQL server database management system was used to store database in SQL server format (.mdf).

### **Oracle Database Management System:** An Oracle database Management system is a collection of data treated as a unit. The purpose of a database is to store and retrieve related information. A database server is the key to solving the problems of information management. Oracle database management system was used to store database in Oracle database format (.dbf).

- ✚ **Data Type Dictionary:** A Datatype dictionary was used to map datatypes for different DBMS's, it defines a collection of names, definitions, and attributes about data elements that are being used or captured in between database management systems. [3]

Oracle data type	SQL Server data type	MySQL data type
BLOB	VARBINARY(MAX)	LONGBLOB
CHAR([1-2000])	CHAR([1-2000])	VARCHAR(MAX)
CLOB	VARCHAR(MAX)	VARCHAR(MAX)
DATE	DATETIME	DATETIME
FLOAT	FLOAT	FLOAT
INT	NUMERIC(p)	DECIMAL(p,s)

Figure 1: Data type Dictionary i

## 2.5. SYSTEM IMPLEMENTATION RESULT

### A. Sample Data from Oracle DBMS

SELECT* FROM EMPLOYEES			
	EMPLOYEE_NUMBER	FIRST_NAME	LAST_NAME
▶	2401	JANE	BANDA
	2402	MWANSA	CHANDA
	2403	MULENGA	KALILO
	2404	SILIO	KANGWA
	2405	JONES	DAKA
	2406	NAOMI	PHIRI
	2407	CHILESHE	KALUBA
	2408	MAIA	MTONGA
	2409	MATEYO	LUNGU
	2410	SERAH	TEMBO
	2411	HELLEN	MUTALE
	2412	RHODA	BANDA

Figure 2: Sample Data From Oracle DB ii

### B. Sample Data from MySQL



Result Grid     Filter Rows: <input type="text"/>   E			
	EMPLOYEE_NUMBER	FIRST_NAME	LAST_NAME
▶	2401	JANE	BANDA
	2402	MWANSA	CHANDA
	2403	MULENGA	KALILO
	2404	SILIO	KANGWA
	2405	JONES	DAKA
	2406	NAOMI	PHIRI
	2407	CHILESHE	KALUBA
	2408	MAIA	MTONGA
	2409	MATEYO	LUNGU
	2410	SERAH	TEMBO
	2411	HELLEN	MUTALE
	2412	RHODA	BANDA
	2413	LUCY	LUNGU

Figure 3: Sample data from MySQL DB iii

### C. Testing Scenarios and Results

	Testing scenarios	Expected results	Actual results
2	Mysql to json file	Json file	Mysql database was converted to jfon file
3	Sql to json file	Json file	Sql database was converted to json file
4	Oracle to json file	Json file	Oracle database was converted to json file

	Testing scenarios	Expected results	Actual results
2	Json file to mysql	Mysqldb	Json file was converted to mysqldb
3	Json file to sql sever	Sql server db	Json file was converted to sql server db
4	Json file to oracle	Oracle db	Json file was converted to oracle db

## 2.6. CONCLUSION

A migration framework based on microservices architecture was developed to manage the database migration process effectively and reduce associated risks. The study identified key challenges such as data inconsistency, poor management, and improper data mapping. The proposed framework addresses these issues, ensuring efficient and effective database migration. Implementing this framework is recommended to enhance productivity and efficiency in institutions using database management systems.

### 3. METHODOLOGY

Migrating a database from MySQL to Oracle can be a complex task, but it can be broken down into a series of manageable steps

#### 3.1. DESIGN SPECIFICATIONS

##### 3.1.1 UNIFIED MODELING LANGUAGE (UML) DIAGRAMS

Unified Modeling Language (UML) diagrams are a standardized way of visualizing the design of a system. They are used in software engineering to provide a clear and detailed representation of the system's architecture, components, and interactions. UML diagrams help developers and stakeholders understand, design, and document the structure and behavior of a system. By using various types of UML diagrams, such as class diagrams, sequence diagrams, and use case diagrams, teams can effectively communicate complex system designs and ensure all aspects of the system are considered during development.

##### 3.1.1.A. USE CASE DIAGRAM & TEXTUAL DESCRIPTION

This diagram provides a clear and structured overview of the interactions and functionalities involved in the data migration process. It illustrates how the Data Admin interacts with the system to select the source database, migrate data, and monitor the migration process, ensuring that all necessary steps are covered and optional behaviours are identified

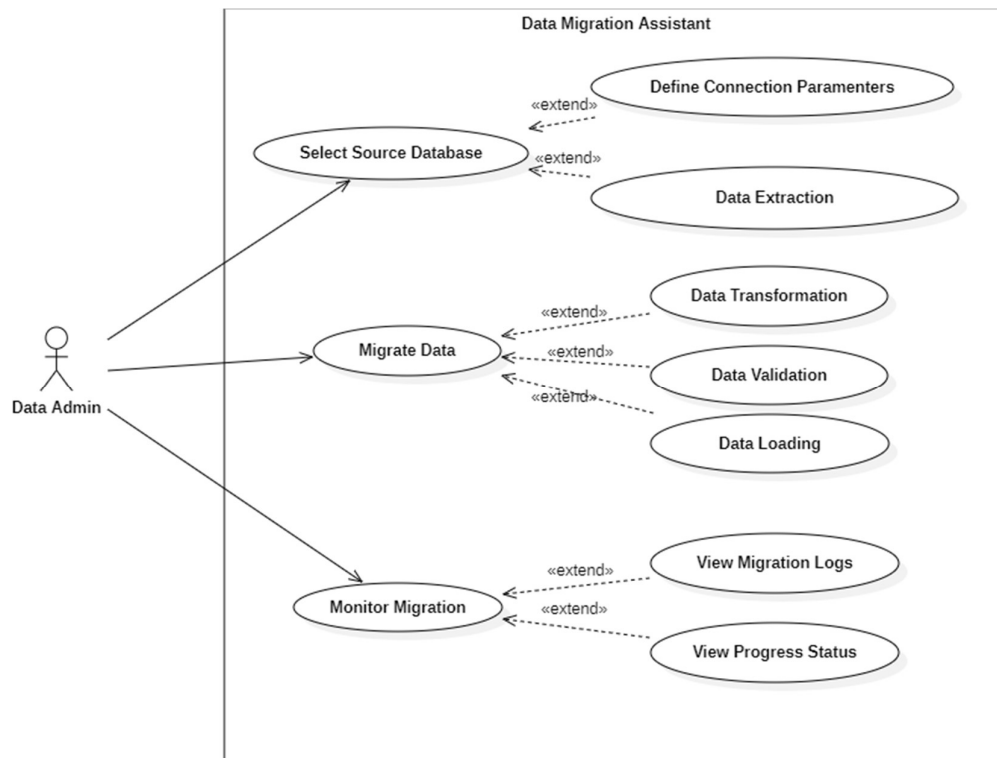


Figure 4: Use Case Diagram iv

## Use Case Diagram and Description

### Actor

- **Data Admin:** The primary user responsible for initiating and managing the data migration process.

### Use Cases

#### 1. Select Source Database

- **Description:** The Data Admin selects the source database from which data will be migrated. This use case includes the ability to define or modify connection parameters and specify data extraction details.
- **Extends:**

- **Define Connection Parameters:** Allows the Data Admin to set or modify the connection string and other necessary connection details for accessing the source database.
- **Data Extraction:** Extracts data from the source database.

## 2. Migrate Data

- **Description:** This central use case covers the actual migration of data from the source to the target database. It includes various sub-tasks necessary to transform, validate, and load the data to the target database.
- **Includes:**
  - **Data Transformation:** Converts the data into a format that is compatible with the target database.
  - **Data Validation:** Ensures the data meets all integrity criteria before it is loaded into the target database.
  - **Data Loading:** Handles the process of importing the validated and transformed data into the target database.

## 3. Monitor Migration

- **Description:** Allows the Data Admin to oversee and monitor the progress and status of the data migration process.
- **Extends:**
  - **View Migration Logs:** Provides the ability to review detailed logs of the migration process, which can be used for troubleshooting and verification purposes.
  - **View Progress Status:** Displays the current status and progress of the ongoing migration, giving the Data Admin insights into the process.

### 3.1.1.B. CLASS DIAGRAM

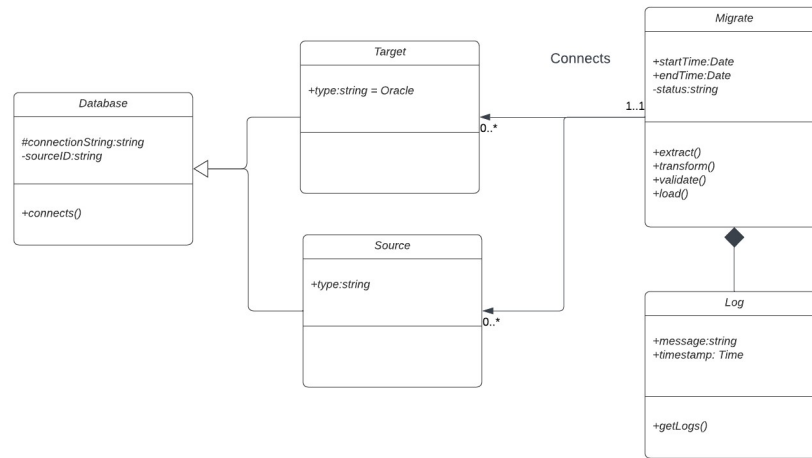


Figure 5: Class Diagram i

## Class Diagram Description

The class diagram for the Data Migration Assistant system provides a structural representation of the classes, attributes, methods, and relationships involved in the data migration process. Here is a detailed explanation of each component in the diagram:

### Classes and Attributes

#### 1. Database

##### ○ Attributes:

- `connectionString: string`: The connection string used to connect to the database.
- `sourceID: string`: The identifier for the source database.

##### ○ Methods:

- `connects()`: Establishes a connection to the database using the provided connection string.

#### 2. Source

- **Attributes:**

- type: string: Specifies the type of the source database (e.g., MySQL, PostgreSQL).

### 3. Target

- **Attributes:**

- type: string = Oracle: Specifies the type of the target database, defaulting to Oracle in this context.

### 4. Migrate

- **Attributes:**

- startTime: Date: The start time of the migration process.
- endTime: Date: The end time of the migration process.
- status: string: Indicates the current phase of the migration process (extracting, transforming, validating, or loading).

- **Methods:**

- extract(): Extracts data from the source database.
- transform(): Transforms the extracted data into a suitable format for the target database.
- validate(): Validates the transformed data to ensure correctness and integrity.
- load(): Loads the validated data into the target database.

### 5. Log

- **Attributes:**

- message: string: Contains detailed messages and information about the migration process.



- timestamp: Time: Records the time when the log entry was created.
- **Methods:**
  - getLogs(): Retrieves the logs for review and troubleshooting.

## **Relationships**

1. **Target, source and database (inheritance):** inherit their properties from the class database. Also, the migrate class conn
2. **Migrate to Log (composition):** this just indicates that a log is dependent on the migrate, so a log will be created if and only if there's a migration.

### 3.1.1.C. SEQUENCE DIAGRAM & DESCRIPTION

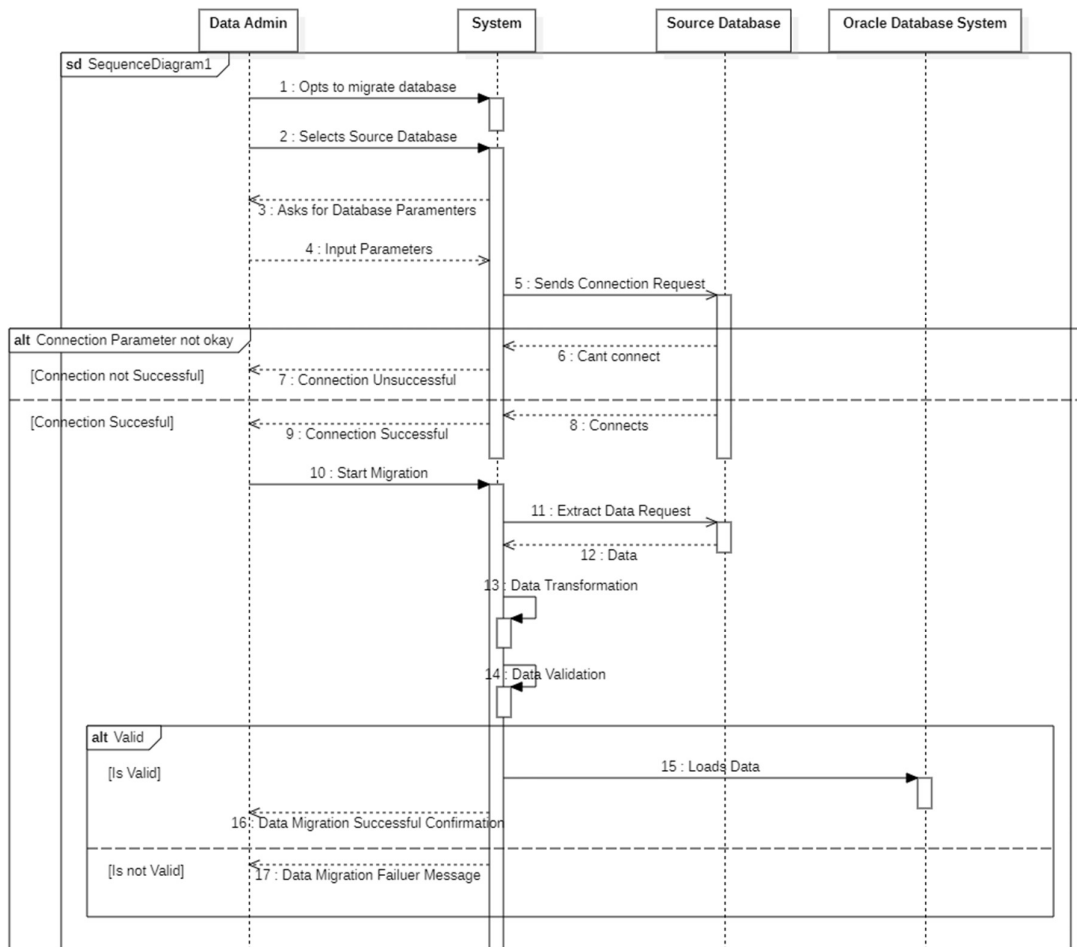


Figure 6: Sequence Diagram i

### Sequence Diagram Description

This section analyzes the sequence diagram for the initial stage of the data migration process, focusing on the process of migrating data from the source to the destination.

The sequence diagram depicts the following steps involved in connecting to the source database:

1. **Initiate Migration:** The data migration process is triggered by the DBA.
2. **Source Selection:** The DBA selects the source database from which data will be migrated.

3. **Parameter Request:** The system prompts the DBA to enter connection string and details for the source database. These typically include:
  - Username
  - Password
  - Hostname
  - Port Number etc.
4. **Parameter Input:** The DBA provides the requested connection parameters.
5. **Connection Request:** The system sends a connection request along with the provided parameters to the source database.

**Connection Outcome:**

- **Successful Connection:**
  - Upon receiving valid parameters, the system attempts to connect to the source database.
  - If successful, the system establishes a connection and confirms it to the DBA.
  - Following a successful connection, the data migration process can proceed to subsequent stages like data transformation, validation and loading.
  - If transformed data is valid, migration complete, else migration failure message.
- **Unsuccessful Connection:**
  - If the system encounters an error while connecting (e.g., invalid credentials, network issues), a connection failure message is displayed to the DBA or administrator.

### 3.1.1.D. ENTITY RELATIONSHIP (ER) DIAGRAM DESCRIPTION

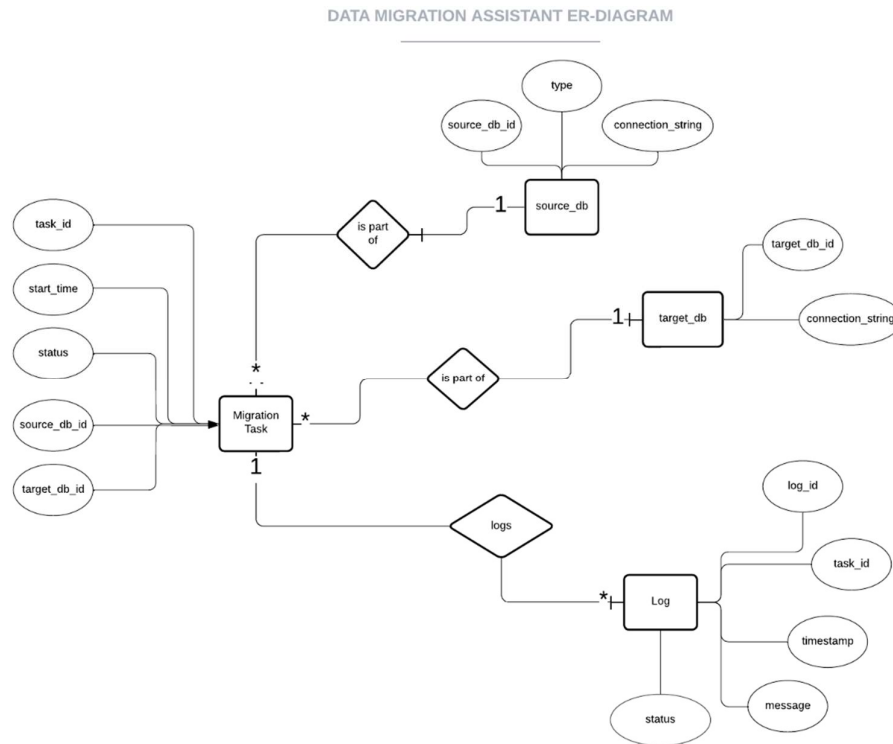


Figure 7: ER Diagram 1

An **entity** represents a real-world object, concept, or event that you want to store information about. An ERD is a visual representation of these entities and the relationships between them. This section outlines the entities, their attributes, and the relationships between them in the context of data migration from various databases to Oracle

#### Entities:

- **Source DB**
  - Attributes:
    - source\_db\_id (unique identifier)
    - connection\_string (connection details for the source database)
    - type (database type e.g. MySQL, postgres, SQL server etc.)
- **Target DB**

- Attributes:
  - target\_db\_id (unique identifier)
  - connection\_string (connection details for Oracle database)
- **MigrationTask**
  - Attributes:
    - task\_id (unique identifier)
    - start\_time (timestamp of task initiation)
    - status (current state of the task, e.g., pending, running, completed, failed)
- **Log**
  - Attributes:
    - log\_id (unique identifier)
    - timestamp (timestamp of log message creation)
    - status (indicates whether the migration is on the extraction, transform, validation, or loading)
    - message (content of the log message or full detail about current migration status)

## Relationships:

- **One-to-Many:**
  - A **Source DB** can participate in **Many** migration **Tasks**. (One source database can be used for multiple migrations)
  - A **Target DB** (Oracle in this case) can participate in **Many** migration **Tasks**. (Oracle can be the target for multiple migrations)

- A **Task** can have **Many** associated **Logs**. (One migration task can generate many log messages)

## 3.2. DATABASE MIGRATION PROCESS

### 3.2.1 Planning and Assessment

- **Assess the Database Structure:** Understand the structure of our source SQL database, including tables, relationships, indexes, and stored procedures.
- **Identify Differences:** Note differences between MySQL and Oracle in terms of data types, SQL dialects, and functionalities.

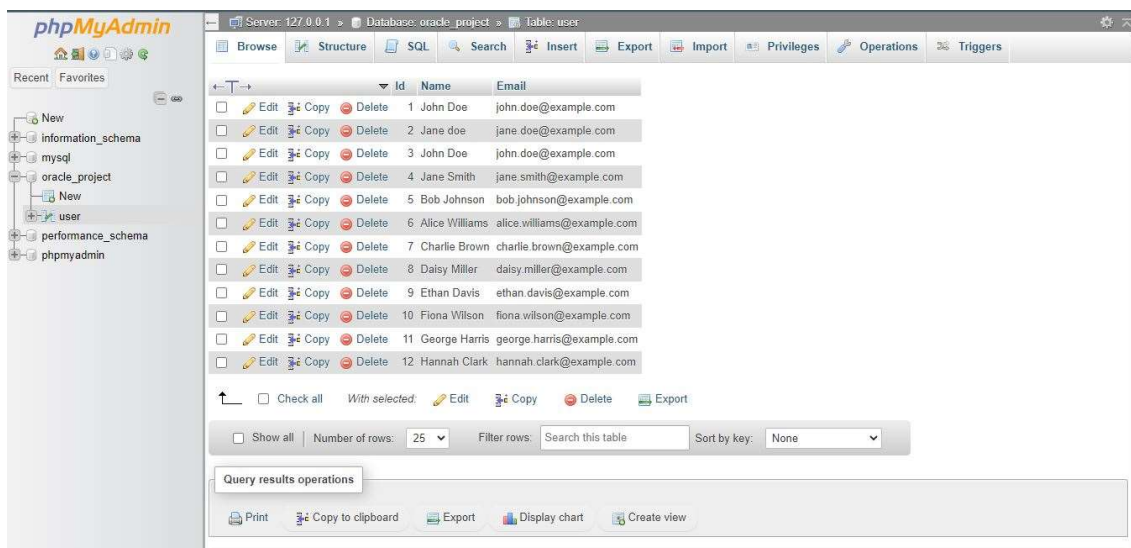


Figure 8: Source SQL Database on php i

### 3.2.2 Setting Up the Environment

- **Install Oracle Database:** Make sure you have an Oracle database instance set up and ready for data migration.
- **Prepare MySQL Database:** Ensure your MySQL database is running and accessible.

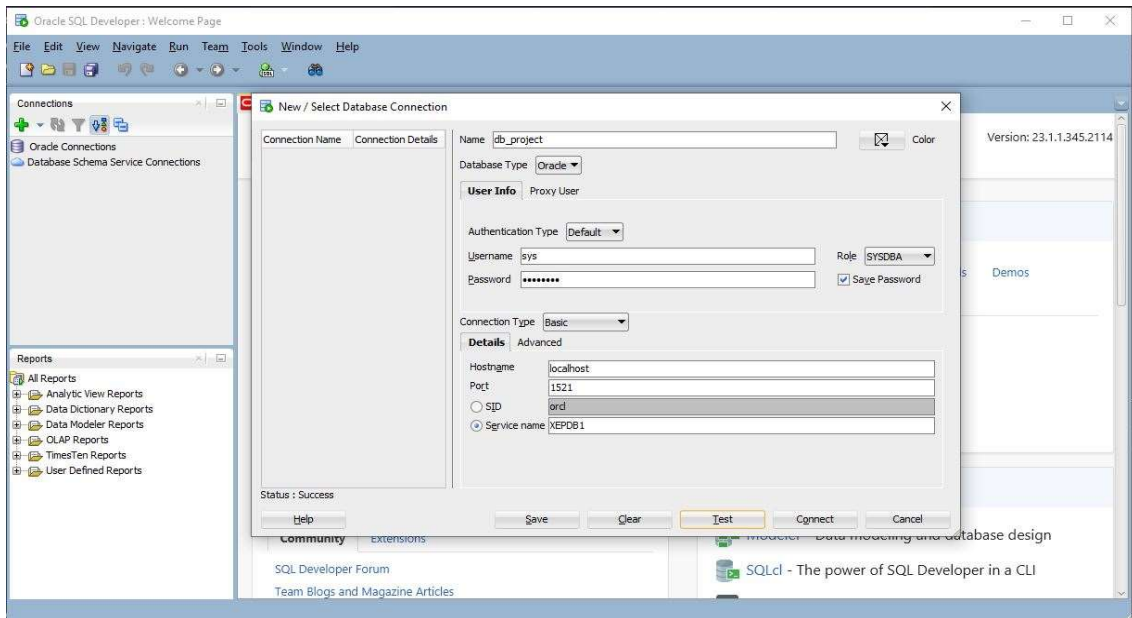


Figure 9: Database Configuration setting i

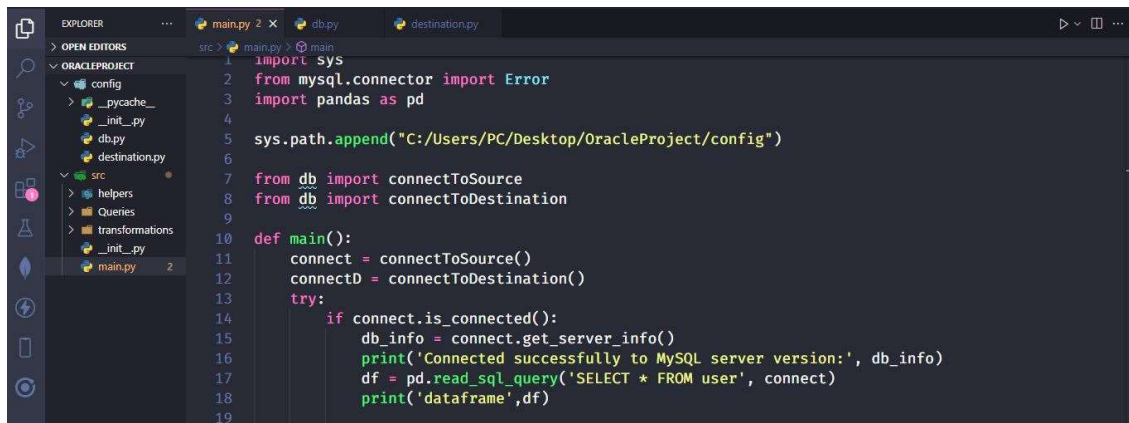


Figure 10: Connection setting to MySQL i

### 3.2.3 Schema Conversion

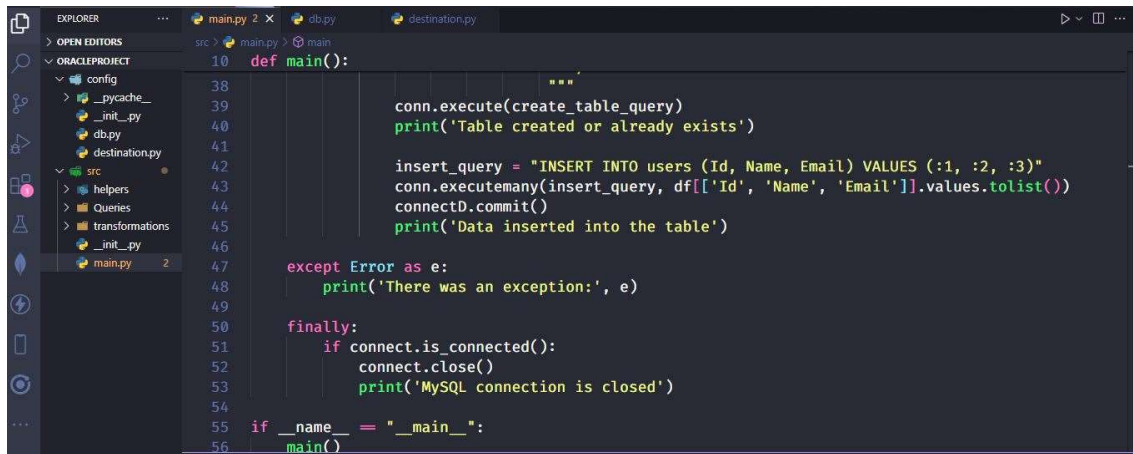
➤ **Convert Data Types:** Map MySQL data types to Oracle data types. For example:

- VARCHAR in MySQL can be VARCHAR2 in Oracle.
- TINYINT in MySQL can be NUMBER(3) in Oracle.

- **Convert Table Definitions:** Translate table definitions from MySQL to Oracle-compatible SQL.
- **Convert Indexes and Constraints:** Ensure all indexes, primary keys, and foreign keys are converted correctly.
- **Stored Procedures and Functions:** Rewrite MySQL stored procedures and functions in PL/SQL, Oracle's procedural language.

### 3.2.4 Data Migration

- **Extract Data:** Export data from MySQL tables. This can be done using tools like `mysqldump` or custom scripts.
- **Transform Data:** Transform data if necessary to match Oracle's data formats and constraints.
- **Load Data:** Import data into Oracle using tools like SQL\*Loader, Oracle Data Pump, or custom ETL (Extract, Transform, Load) scripts.



```

EXPLORER
  ORACLEPROJECT
    config
    __pycache__
    __init__.py
    db.py
    destination.py
    src
    helpers
    Queries
    transformations
    __init__.py
    main.py 2

main.py 2
10 def main():
38
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    """
    conn.execute(create_table_query)
    print('Table created or already exists')

    insert_query = "INSERT INTO users (Id, Name, Email) VALUES (:1, :2, :3)"
    conn.executemany(insert_query, df[['Id', 'Name', 'Email']].values.tolist())
    conn.commit()
    print('Data inserted into the table')

    except Error as e:
        print('There was an exception:', e)

    finally:
        if connect.is_connected():
            connect.close()
            print('MySQL connection is closed')

    if __name__ == "__main__":
        main()

```

Figure 11: Data Loading Script i

### 3.2.5 Testing

- **Data Integrity Check:** Verify that all data has been migrated correctly and that there are no discrepancies.



- **Application Testing:** Test your application with the Oracle database to ensure everything works as expected.
- **Performance Testing:** Conduct performance tests to compare the performance of the application using the Oracle database versus the MySQL database.

### 3.2.6 Optimization

- **Indexing:** Ensure that all necessary indexes are created to optimize query performance.
- **Query Optimization:** Review and optimize queries and stored procedures for Oracle.
- **Database Configuration:** Fine-tune Oracle database configuration settings for optimal performance.

### 3.2.7 Deployment

- **Backup:** Ensure you have a backup of both MySQL and Oracle databases before making any changes.
- **Switch Over:** Redirect your application from MySQL to Oracle.
- **Monitoring:** Monitor the new Oracle database for any issues and performance bottlenecks.

## 3.3. TOOLS AND TECHNOLOGIES

- ✓ **Oracle SQL Developer:** A tool provided by Oracle to help with the migration process.
- ✓ **ETL Tools:** Python scripts using libraries like `pandas` can be used for data extraction, transformation, and loading.
- ✓ **Database Migration Services:** Consider using cloud-based migration services if you are migrating to Oracle Cloud.

## 4. RESULTS

## 5. CONCLUSION

### 5.1. Obstacles Faced and Solutions Provided

#### A. Network Issues

1. **Obstacle:** Slow internet connection caused delays in downloading and importing necessary libraries for the project.
2. **Solution:** To mitigate this, libraries were downloaded during off-peak hours to maximize internet speed. Additionally, local mirrors of required libraries were used where possible to reduce dependency on external downloads.

#### B. Rescheduled Deadline

1. **Obstacle:** The project timeline was rescheduled to a closer date than initially planned.
2. **Solution:** To address this, the project scope was reassessed and critical tasks were prioritized. Agile methodologies were employed to manage the workflow effectively, ensuring that essential functionalities were tackled on first

#### C. Learning Curve of Python

1. **Obstacle:** As a beginner in Python programming, there was a steep learning curve to write effective scripts for database connection and migration.
2. **Solution:** Peer support and code reviews were also leveraged to accelerate the learning process and ensure code quality.

#### D. Security Concerns

1. **Obstacle:** The security of the migration process was challenging, especially in terms of data integrity and unauthorized access.

## E. Poor Data Filtering

1. **Obstacle:** Inadequate data filtering led to issues with data consistency and quality during the migration.

## 5.2. Potential Future Updates

- ✓ **Integration with Cloud Services:** Integrate the migration framework with popular cloud services to offer seamless and scalable migration options.
- ✓ **Real-Time Migration Monitoring:** Develop a real-time monitoring dashboard to track the migration process and quickly address any issues that arise.
- ✓ **User-Friendly Interface:** Enhance the user interface to make the migration tool more accessible and easier to use for non-technical users.
- ✓ **Machine Learning Algorithms:** Incorporate machine learning algorithms to predict and mitigate potential migration issues based on historical data.

## 5.3. Suggestions for Further Improvement

1. **Regular Training:** Conduct regular training sessions for the team on new technologies and best practices in database migration.
2. **Community Engagement:** Engage with the developer community to share experiences, gather feedback, and collaborate on improving the migration framework.
3. **Comprehensive Testing:** Implement comprehensive testing strategies, including unit tests, integration tests, and performance tests, to ensure the reliability and robustness of the migration tool.
4. **Automated Security Protocols:** Implement automated security checks and encryption protocols to ensure data security without manual intervention.
5. **Enhanced Data Filtering Tools:** Develop more sophisticated data filtering and validation tools to ensure data quality throughout the migration process.

## 5.4. Next Steps

1. **Release Beta Version:** Release a beta version of the migration tool to a selected group of users for feedback and further refinement.
2. **Plan for Full Deployment:** Develop a deployment plan for rolling out the migration tool to a wider audience, including support and maintenance strategies.

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