WATER BILL MANAGEMENT SYSTEM

A MINI PROJECT REPORT

SUBMITTED BY

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

ABSTRACT

- The management of water resources is paramount for sustainable development, necessitating effective systems for monitoring and billing. This abstract presents a comprehensive overview of a novel Water Bill Management System (WBMS) designed to streamline the process of water consumption monitoring, billing generation, and payment management. The WBMS integrates advanced technology with user-friendly interfaces to provide water utility companies, municipalities, and consumers with a robust platform for efficient water resource management. The system utilizes IoT (Internet of Things) sensors and smart metering devices to collect real-time data on water usage at individual consumer endpoints. This data is transmitted securely to a centralized database for processing.
- Through sophisticated data analytics and machine learning algorithms, the WBMS analyzes consumption patterns, detects anomalies, and predicts future demand, enabling water utility companies to optimize distribution strategies and resource allocation. Moreover, the system generates accurate and transparent bills based on actual usage, eliminating estimation errors and promoting fairness in billing practices.One of the key features of the WBMS is its user-centric design, which empowers consumers with access to their water consumption data through web and mobile applications.
- By providing real-time insights into usage patterns and personalized conservation tips, the system promotes water conservation and enhances consumer awareness.Additionally, the WBMS incorporates secure payment gateways and automated billing processes, simplifying the payment cycle for consumers and facilitating revenue collection for water utility companies. Integration with existing accounting systems and regulatory compliance mechanisms ensures seamless operations and adherence to industry standards.Furthermore, the WBMS offers scalability and customization options to accommodate varying needs and operational contexts, making it adaptable to both urban and rural environments.

WATER BILL MANAGEMENT SYSTEM

INTRODUCTION

- Water is a fundamental resource crucial for sustaining life, supporting economic activities, and fostering environmental health. As global populations grow and urbanization accelerates, the demand for water continues to rise, placing unprecedented pressure on existing water infrastructure and management systems. In this context, the effective management of water resources becomes imperative to ensure sustainability, equitable distribution, and efficient utilization.

- Traditional methods of water billing and management often suffer from inefficiencies, inaccuracies, and limited transparency. Manual meter reading, estimation-based billing, and fragmented data management systems contribute to billing errors, disputes, and revenue loss for water utility companies. By leveraging cutting-edge technology, data analytics, and user-centric design principles, the WBMS aims to enhance efficiency, transparency, and sustainability across the water utility sector. This introduction provides an overview of the key components, features, and benefits of the Water Bill Management System, highlighting its potential to transform the way water resources are managed and allocated.

- In the subsequent sections, we delve deeper into the architecture, functionality, and implications of the WBMS, exploring its role in promoting conservation, optimizing resource allocation, and fostering collaboration among stakeholders. Through a multidisciplinary approach that integrates technology, policy, and behavioral insights, the WBMS seeks to empower water utility companies, municipalities, and consumers to address the pressing challenges of water scarcity, climate change, and urbanization.

OBJECTIVES

- The objectives of the Water Bill Management System (WBMS) are multifaceted, aiming to address various challenges in water resource management while enhancing efficiency, transparency, and sustainability. Here are the primary objectives:

- 1. Accurate Billing: Ensure accurate and transparent billing based on actual water consumption, eliminating estimation errors and promoting fairness in billing practices.
- 2. Efficient Data Collection: Implement real-time data collection mechanisms using IoT sensors and smart metering devices to capture water usage data at individual consumer endpoints.
- 3. Data Analysis and Insights: Utilize advanced analytics and machine learning algorithms to analyze consumption patterns, detect anomalies, and generate actionable insights for water utility companies and consumers.
- 4. Resource Optimization: Optimize water distribution strategies and resource allocation based on data-driven insights, enabling water utility companies to meet demand effectively while minimizing waste and inefficiencies.
- 5. Promotion of Conservation: Empower consumers with access to their water consumption data and personalized conservation tips through user-friendly interfaces, fostering awareness and encouraging responsible water usage practices.

- 6. Streamlined Billing Processes: Automate billing processes, payment management, and revenue collection through secure payment gateways and integration with existing accounting systems, reducing administrative overhead and enhancing operational efficiency.
- 7. Scalability and Adaptability: Design the WBMS to be scalable and adaptable to varying needs and operational contexts, accommodating both urban and rural environments and facilitating future technological advancements.
- 8. Compliance and Regulatory Oversight: Ensure compliance with regulatory standards and industry best practices, incorporating features for regulatory reporting, auditing, and accountability.
- 9. Enhanced Customer Experience: Improve the overall customer experience by providing user-friendly interfaces, timely billing notifications, and responsive customer support services.
- 10. Long-Term Sustainability: Contribute to the long-term sustainability of water resources by promoting efficient usage, conservation practices, and equitable access to water for present and future generations.

MODULES

- The Water Bill Management System (WBMS) comprises several interconnected modules, each serving specific functions to ensure the efficient management of water resources and billing processes. Here are the key modules typically found in a WBMS:
- 1. User Management Module: This module handles user registration, authentication, and authorization. It allows water utility companies to manage user accounts, permissions, and access levels for different stakeholders, including administrators, staff members, and consumers.
- 2. Meter Data Collection Module: Responsible for collecting real-time data from IoT sensors and smart metering devices installed at consumer endpoints. It includes functionalities for data transmission, aggregation, and validation to ensure the accuracy and reliability of consumption data.
- 3. Data Analytics Module: Utilizes advanced analytics and machine learning algorithms to analyze consumption patterns, detect anomalies, and generate actionable insights. This module helps water utility companies identify trends, optimize distribution strategies, and predict future demand based on historical data.
- 4. Billing Generation Module: Generates accurate and transparent bills based on actual water consumption data collected from meters. It calculates charges, applies tariffs, and generates invoices for consumers, taking into account any applicable discounts, taxes, or penalties.
- 5. Payment Management Module: Handles payment processing, including billing notifications, payment gateways, and transaction tracking. It allows consumers to view their bills, make payments through various channels (e.g., online payments, bank transfers, or in-person payments), and receive confirmation of payment.

- 6. Customer Relationship Management (CRM) Module: Manages customer interactions and support services, including inquiries, complaints, and feedback. It tracks communication history, resolves issues, and maintains a database of customer profiles and preferences to improve customer satisfaction and retention.
- 7. Reporting and Analytics Module: Provides reporting tools and dashboards for monitoring key performance indicators (KPIs), financial metrics, and regulatory compliance. It enables water utility companies to generate customizable reports, conduct trend analysis, and facilitate decision-making at various levels of the organization.
- 8. Regulatory Compliance Module: Ensures compliance with regulatory standards and industry guidelines governing water billing, data privacy, and environmental conservation. It includes features for regulatory reporting, auditing, and documentation to demonstrate adherence to legal and ethical requirements.
- 9. Mobile and Web Interfaces: Offers user-friendly interfaces accessible via web browsers and mobile applications. It allows consumers to monitor their water consumption, view billing information, and access self-service features, while administrators can manage system settings, monitor performance, and generate reports.
- 10. Integration and Scalability Module: Facilitates integration with third-party systems, such as accounting software, GIS (Geographic Information System), or SCADA (Supervisory Control and Data Acquisition) systems. It ensures interoperability, scalability, and future-proofing of the WBMS to accommodate evolving technological and operational needs.

SOFTWARE DESCRIPTION

- In a Water Bill Management System (WBMS), databases play a crucial role in storing, managing, and retrieving various types of data related to water consumption, billing, customer information, and system configurations. Here's a breakdown of the software description in the context of databases within a WBMS:
- 1. Customer Database: This database stores information about consumers, including their contact details, billing addresses, consumption history, and account preferences. It facilitates user authentication, account management, and customer relationship management (CRM) functionalities.
- 2. Meter Data Database: Responsible for storing raw meter data collected from IoT sensors and smart metering devices installed at consumer endpoints. It includes fields such as meter readings, timestamps, consumption units, and device identifiers. This database enables real-time monitoring of water usage and data analytics for trend analysis.
- 3. Billing Database: Manages billing-related information, such as invoice details, payment history, billing cycles, and tariff structures. It calculates charges based on water consumption data and generates invoices for consumers. This database ensures accuracy, transparency, and compliance with billing regulations.
- 4. Payment Database: Stores transaction records, payment statuses, and payment methods used by consumers to settle their water bills. It tracks payments made through various channels, such as online payments, bank transfers, or in-person payments, and provides reconciliation capabilities for financial reporting.
- 5. Configuration Database: Contains system configurations, settings, and parameters governing the behavior and operation of the WBMS. It includes metadata related to tariff schedules, billing rules, user permissions, notification settings, and integration endpoints. This database allows administrators to customize and maintain the system according to organizational requirements.

LANGUAGES

Python is a versatile, high-level programming language known for its simplicity, readability, and ease of use. Python is a general-purpose programming language, meaning it is designed to be applicable in various domains and contexts. It is widely used in web development, data analysis, scientific computing, artificial intelligence, automation, and many other fields

.Python is an interpreted language, which means that code is executed line by line by an interpreter, without the need for compilation. This allows for rapid development and testing through interactive shell environments and scripting.

Python's syntax is simple and intuitive, making it easy for beginners to learn and understand. Its clean and readable code structure emphasizes readability and reduces the cost of program maintenance and collaboration.It abstracts low-level details, such as memory management and hardware dependencies, allowing developers to focus on solving problems rather than dealing with implementation intricacies. This makes Python suitable for rapid prototyping and development.It is dynamically typed, meaning variable types are determined at runtime, allowing for flexible and expressive coding. However, it is also strongly typed, enforcing strict type-checking to prevent common programming errors and promote code reliability.Python code is platform-independent, meaning it can run on various operating systems, including Windows, macOS, Linux, and Unix-like systems, without requiring modifications. This portability enables code reuse and deployment across different environments.

SQL (Structured Query Language) is a specialized programming language designed for managing, manipulating, and querying relational databases.SQL is a declarative language, meaning that users specify what data they want to retrieve or manipulate, rather than how to achieve it. Users describe desired operations using SQL commands, and the database management system (DBMS) handles the implementation details.It is an industry-standard language standardized by the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO). While different database vendors may implement additional features or dialects, SQL provides a common syntax and semantics across platforms.

Data Definition Language(DDL):SQL includes commands for defining and managing database schema objects, such as tables, views, indexes, and constraints. DDL commands allow users to create, alter, and drop database structures, specifying their structure, data types, and relationships.

Data Manipulation Language (DML):SQL provides commands for manipulating data stored in database tables. DML commands include SELECT for querying data, INSERT for adding new rows, UPDATE for modifying existing rows, and DELETE for removing rows. These commands allow users to perform CRUD (Create, Read, Update, Delete) operations on database records.

Data Control Language (DCL): SQL includes commands for managing database security and access privileges. DCL commands allow users to grant and revoke permissions on database objects, controlling who can perform specific operations on the data.

Transactional commands such as COMMIT, ROLLBACK, and SAVEPOINT ensure data consistency and integrity by preserving the atomicity, consistency, isolation, and durability (ACID) properties of transactions.

REQUIREMENT ANALYSIS

FUNCTIONAL REQUIREMENTS:

- Functional requirements for a Water Bill Management System (WBMS) outline the specific functionalities and capabilities that the system must possess to meet the needs of its users and stakeholders. Here's a breakdown of functional requirements for a WBMS:
- 1. User Management: - The system should allow administrators to register new users (consumers, staff members) and manage user accounts. - Users should be able to log in securely, authenticate their identities, and access appropriate functionalities based on their roles and permissions.
- 2. Meter Data Management: - The system should collect real-time data from IoT sensors and smart meters installed at consumer endpoints. - It should validate and store meter readings, timestamps, consumption units, and device identifiers securely in the database. - Users should be able to monitor and analyze consumption data to track usage patterns and identify anomalies.
- 3. Billing and Invoicing: - The system should generate accurate and transparent bills based on actual water consumption data. - It should calculate charges, apply tariff rates, and generate invoices for consumers within predefined billing cycles. - Consumers should receive timely notifications about their bills and payment due dates via email, SMS, or other communication channels.
- 4. Payment Processing: - The system should support various payment methods, including online payments, bank transfers, and in-person payments. - It should integrate with secure payment gateways to facilitate secure transactions and financial reconciliation. - Users should be able to view payment history, track payment statuses, and receive payment confirmations.
- 5. Customer Service and Support: - The system should provide customer support functionalities, such as inquiry management, complaint resolution, and feedback collection.

- 7. Regulatory Compliance: - The system should ensure compliance with regulatory standards and industry guidelines governing water billing, data privacy, and environmental conservation.   - It should incorporate features for regulatory reporting, auditing, and documentation to demonstrate adherence to legal and ethical requirements.   - Users should be able to configure compliance settings, monitor compliance status, and address any compliance issues proactively.
- 8. Integration and Scalability: - The system should integrate seamlessly with third-party systems, such as accounting software, GIS (Geographic Information System), or SCADA (Supervisory Control and Data Acquisition) systems.   - It should be scalable and adaptable to accommodate growing data volumes, user populations, and technological advancements.   - Users should have access to APIs (Application Programming Interfaces) or middleware for integrating custom applications and extending system functionalities as needed.

NON FUNCTIONAL REQUIREMENTS:

Non-functional requirements describe the qualities or attributes that characterize how the system should behave, rather than specific features or functionalities. Here's a breakdown of non-functional requirements for a Water Bill Management System (WBMS):

1.Performance: Response Time: The system should respond to user requests within a reasonable time frame, typically milliseconds for basic operations.

Throughput: The system should handle a high volume of concurrent users and transactions, ensuring smooth performance during peak usage periods.

Scalability: The system should be scalable, able to accommodate increasing data volumes, user populations, and computational loads without degradation in performance.

2. Reliability: - Availability: The system should be available and accessible to users at all times, with minimal downtime for maintenance or upgrades.   - Fault Tolerance: The system should be resilient to hardware failures, software errors, and network disruptions, ensuring continuity of service.

- 3. Security: Data Confidentiality: The system should protect sensitive data, such as consumer information and payment details, from unauthorized access or disclosure.
- Authentication and Authorization: The system should enforce strong authentication mechanisms to verify user identities and control access to system resources based on user roles and permissions.
- Data Encryption: The system should encrypt data transmission and storage to prevent interception or tampering by unauthorized parties.
- 4. Usability: User Interface Design: The system should have a user-friendly interface that is intuitive, visually appealing, and easy to navigate.
- Accessibility: The system should be accessible to users with disabilities, complying with accessibility standards and providing alternative means of interaction
- 5. Maintainability: Modularity: The system should be modular, with well-defined components and clear separation of concerns, facilitating maintenance, updates, and enhancements.
- Code Quality: The system code should adhere to coding standards, best practices, and design patterns, promoting readability, maintainability, and extensibility.
- 6. Interoperability: Integration Capabilities: The system should integrate seamlessly with third-party systems and external data sources, using standard protocols and APIs.
- Platform Compatibility: The system should be compatible with various operating systems, web browsers, and devices, ensuring interoperability across different environments.
- 7. Regulatory Compliance: Legal and Regulatory Requirements: The system should comply with applicable laws, regulations, and industry standards governing water billing, data privacy, and environmental protection.
- Auditability: The system should maintain audit logs and provide audit trails for tracking user actions, system activities, and data changes for compliance and accountability purposes.

HARDWARE AND SOFTWARE SPECIFICATIONS

- HARDWARE SPECIFICATION :

PROCESSOR : INTEL i3

MEMORY SIZE : 4GB

HDD : 256GB

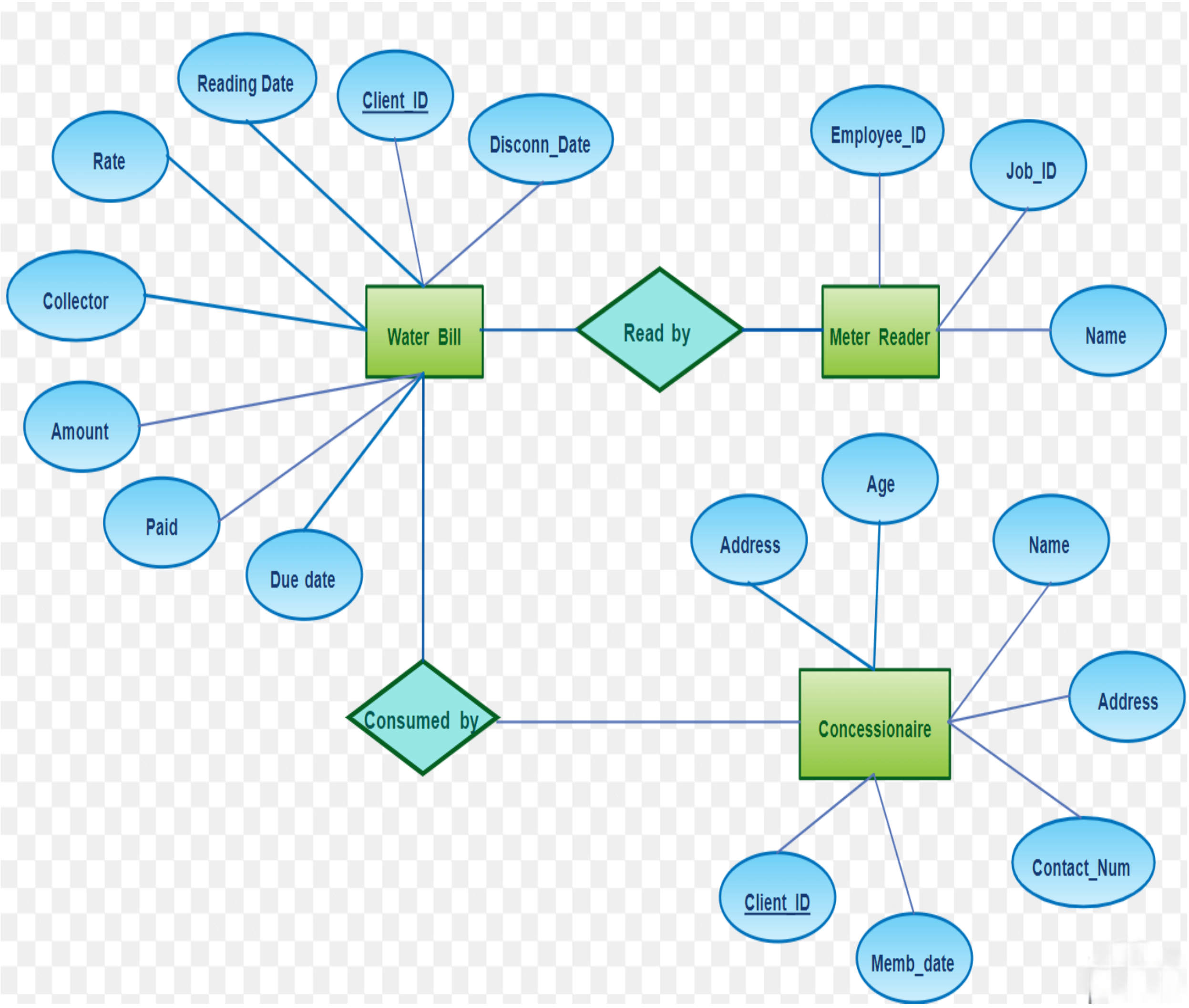
- SOFTWARE SPECIFICATION:

OPERATING SYSTEM : WINDOWS 11

GUI INTERFACE : PYTHON

BACKEND : MY SQL

ENTITY RELATIONSHIP DIAGRAM



NORMALIZATION

Normalization is the process of organizing data in a database to eliminate redundancy and dependency, ensuring data integrity and optimizing storage efficiency. Normalization is a process used in various fields, including databases, statistics, and data analysis, to organize and structure data in a way that reduces redundancy and dependency. The primary goal of normalization is to eliminate data anomalies such as insertion, deletion, and update anomalies, and to ensure that each piece of data is stored in only one place.

In the context of databases, normalization typically involves breaking down a large table into smaller, related tables and defining relationships between them. This is done through a series of normal forms, such as First Normal Form (1NF), Second Normal Form (2NF), Third Normal Form (3NF), and so on. Each normal form has specific criteria that must be met to ensure that the database is properly normalized.

Normalization helps improve database efficiency, reduces data redundancy, and ensures data integrity by minimizing the risk of inconsistencies and anomalies. However, it can also lead to more complex database designs and queries, so it's important to strike a balance between normalization and performance considerations. Let's discuss the normalization of the Water Bill Management System (WBMS) database into 1NF, 2NF, and 3NF:

FIRST NORMAL FORM:

- In 1NF, each column in a table must contain atomic (indivisible) values, and each row must be uniquely identifiable.   For the WBMS, the following steps might be taken to achieve 1NF: Break down multi-valued attributes into separate columns.Ensure each table has a primary key to uniquely identify each row.Eliminate repeating groups by creating separate tables for related entities.
- First Normal Form (1NF) is the initial step in the normalization process, vital for ensuring database integrity and efficiency. By adhering to 1NF principles, databases organize data into distinct columns, each containing atomic values, devoid of repeating groups or nested structures. This approach not only minimizes redundancy but also enhances data clarity and consistency. For instance, breaking down composite fields like addresses into separate components such as street, city, state, and zip code, ensures atomicity and eliminates the risk of data duplication. Moreover, 1NF establishes unique column names within tables, facilitating unambiguous data retrieval and maintenance. Overall, 1NF sets the groundwork for subsequent normalization steps, promoting data integrity, flexibility, and optimal performance within database systems.

ID	FIRST NAME	BILL
1	SANCH	1000
2	SAN	500
3	SAM	2000

SECOND NORMAL FORM:

- In 2NF, the table must be in 1NF, and each non-key column must be fully functionally dependent on the entire primary key.   - For the WBMS, if any non-key attribute depends on only part of the primary key, it should be moved to a separate table.
- Second Normal Form (2NF) builds upon the foundation laid by First Normal Form (1NF), further refining the database structure to eliminate partial dependencies and ensure data integrity. In 2NF, every non-key attribute is functionally dependent on the entire primary key, addressing scenarios where composite primary keys exist. By decomposing tables into smaller, more focused entities, 2NF reduces redundancy and enhances query efficiency. For instance, consider a table storing sales data with a composite primary key composed of order ID and product ID, and attributes like product name and price.
- In 2NF, product-related details would be stored in a separate table, with the product ID acting as a foreign key, thus avoiding partial dependencies and ensuring each attribute is fully dependent on the primary key. This normalization process not only streamlines database design but also improves data consistency and maintenance, laying the groundwork for higher normalization forms and robust database systems.

ID	FIRST NAME	ADDRESS	CONTACT
1	SANCH	ELLIOTS ST	123456
2	SAN	JACK ST	654321
3	SAM	EVERGREEN ST	987654

THIRD NORMAL FORM:

- In 3NF, the table must be in 2NF, and no non-key column should depend on another non-key column (transitive dependency). - For the WBMS, if any non-key attribute depends on another non-key attribute, it should be moved to a separate table.
- Third Normal Form (3NF) represents a further refinement in the database normalization process, aiming to eliminate transitive dependencies and achieve a higher level of data integrity. In 3NF, every non-key attribute is dependent only on the primary key and not on other non-key attributes. This ensures that data is stored in a manner that minimizes redundancy and facilitates efficient updates and maintenance. By breaking down tables into smaller, more cohesive units, 3NF enhances data consistency and query performance.
- In 3NF, such dependencies are resolved by separating the manager information into its own table, linking it to the employee table through a foreign key. This normalization step not only enhances database flexibility and scalability but also reduces the risk of anomalies and inconsistencies, thereby promoting a robust and reliable data management system.

ID	NAME	CONTACT	BILL
1	SANCH	123456	1000
2	SAN	654321	500
3	SAM	987654	2000

SOURCE CODE

```
import mysql.connector
from datetime import datetime
# Connect to MySQL
mydb = mysql.connector.connect(
  host="localhost",
  user="yourusername",
  password="yourpassword",
  database="water_bill_management"
)
mycursor = mydb.cursor()
# Create tables if not exist
def create_tables():
mycursor.execute("""
    CREATE TABLE IF NOT EXISTS customers (
      id INT AUTO_INCREMENT PRIMARY KEY,
      name VARCHAR(100) NOT NULL,
      address VARCHAR(255) NOT NULL,
      phone VARCHAR(15) NOT NULL
    )
  """)
  mycursor.execute("""
    CREATE TABLE IF NOT EXISTS water_usage (
```

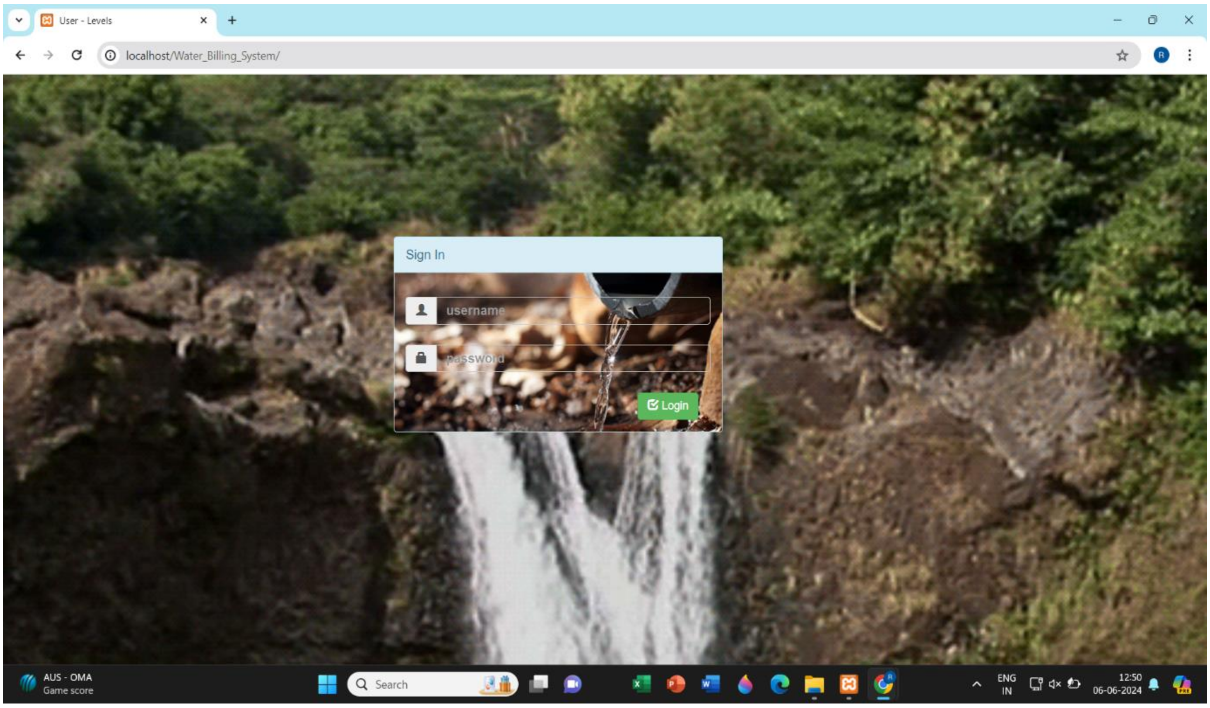
```
            id INT AUTO_INCREMENT PRIMARY KEY,
            customer_id INT,
            usage_date DATE,
            gallons_used FLOAT,
            FOREIGN KEY (customer_id) REFERENCES customers(id)
        )
    """)
mycursor.execute("""
        CREATE TABLE IF NOT EXISTS bills (
            id INT AUTO_INCREMENT PRIMARY KEY,
            customer_id INT,
            billing_month VARCHAR(10),
            total_gallons_used FLOAT,
            amount_due FLOAT,
            FOREIGN KEY (customer_id) REFERENCES customers(id)
        )
    """)
    mydb.commit()
create_tables()
# Function to add a new customer
def add_customer(name, address, phone):
    sql = "INSERT INTO customers (name, address, phone) VALUES (%s, %s,
%s)"
    val = (name, address, phone)
    mycursor.execute(sql, val)
    mydb.commit()
    print("Customer added successfully")
# Function to record water usage
```

```
def record_water_usage(customer_id, gallons_used):
    today = datetime.now().date()
    sql = "INSERT INTO water_usage (customer_id, usage_date, gallons_used)
VALUES (%s, %s, %s)"
    val = (customer_id, today, gallons_used)
    mycursor.execute(sql, val)
    mydb.commit()
    print("Water usage recorded successfully")
# Function to generate a bill
def generate_bill(customer_id, billing_month):
    sql = "SELECT SUM(gallons_used) FROM water_usage WHERE
customer_id = %s AND MONTH(usage_date) = %s"
    val = (customer_id, billing_month)
    mycursor.execute(sql, val)
    total_gallons_used = mycursor.fetchone()[0]
    amount_due = total_gallons_used * 0.01  # Assuming $0.01 per gallon
    sql = "INSERT INTO bills (customer_id, billing_month, total_gallons_used,
amount_due) VALUES (%s, %s, %s, %s)"
    val = (customer_id, billing_month, total_gallons_used, amount_due)
    mycursor.execute(sql, val)
    mydb.commit()
    print("Bill generated successfully")
# Function to view billing history for a customer
def view_billing_history(customer_id):
    sql = "SELECT * FROM bills WHERE customer_id = %s"
    val = (customer_id,)
    mycursor.execute(sql, val)
    result = mycursor.fetchall()
```

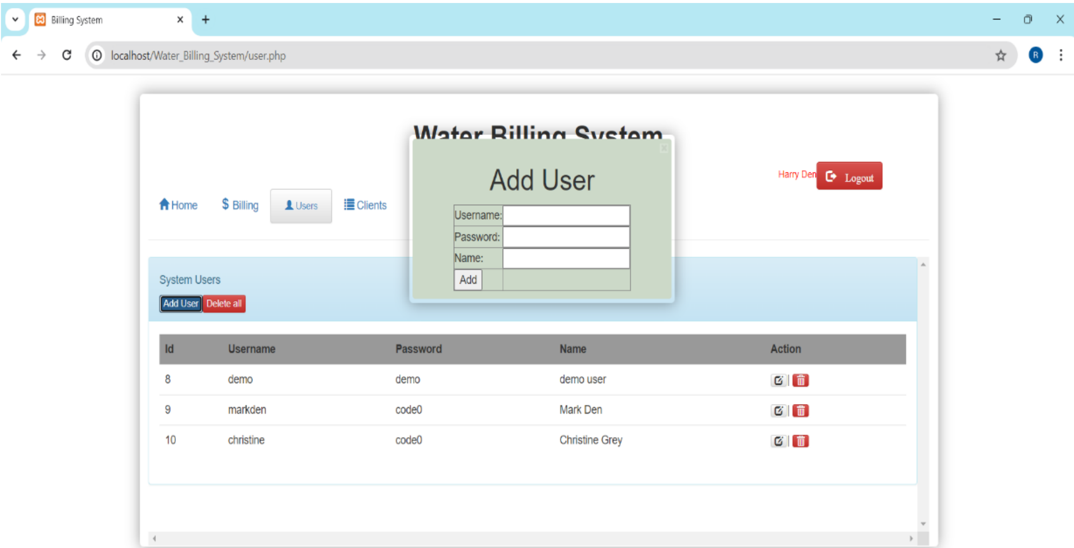
```
  for bill in result:
        print(bill)
# Example usage
add_customer("John Doe", "123 Main St", "555-1234")
record_water_usage(1, 100)
generate_bill(1, "2024-06")
view_billing_history(1)
# Close the database connection
mydb.close()
```

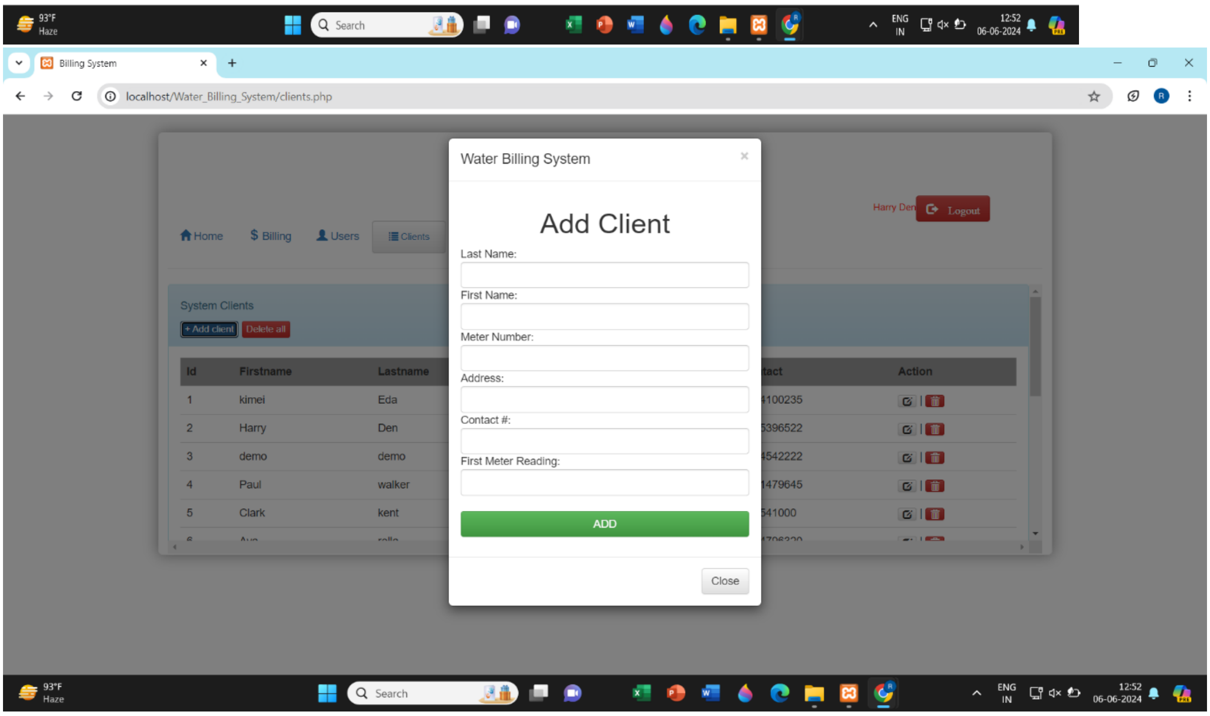
RESULT

- 1.User authentication and authorization:

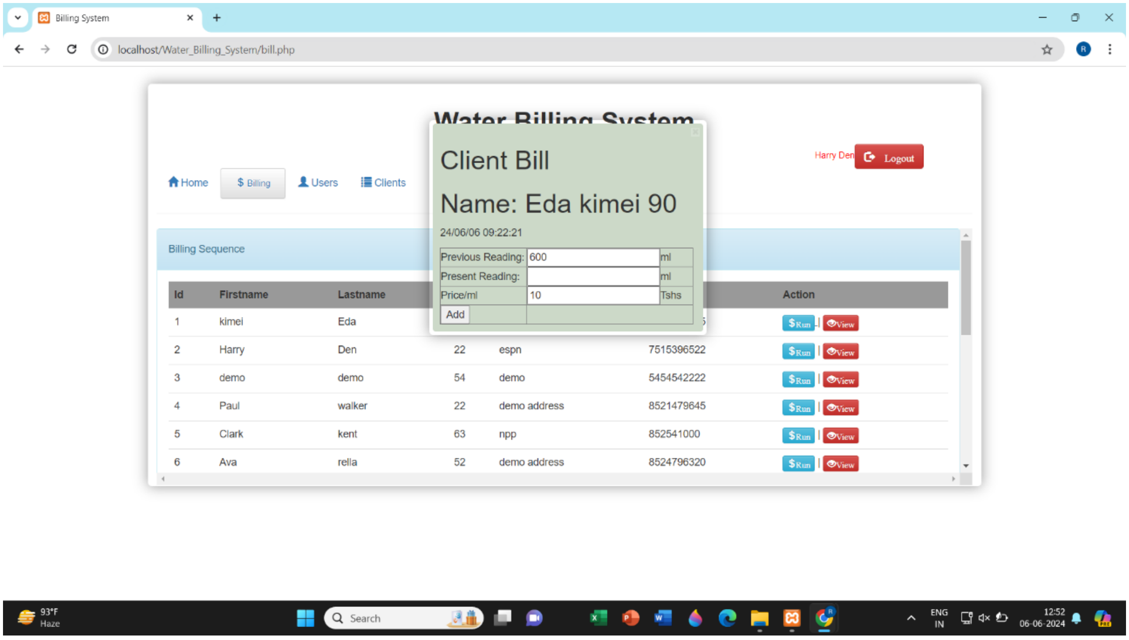


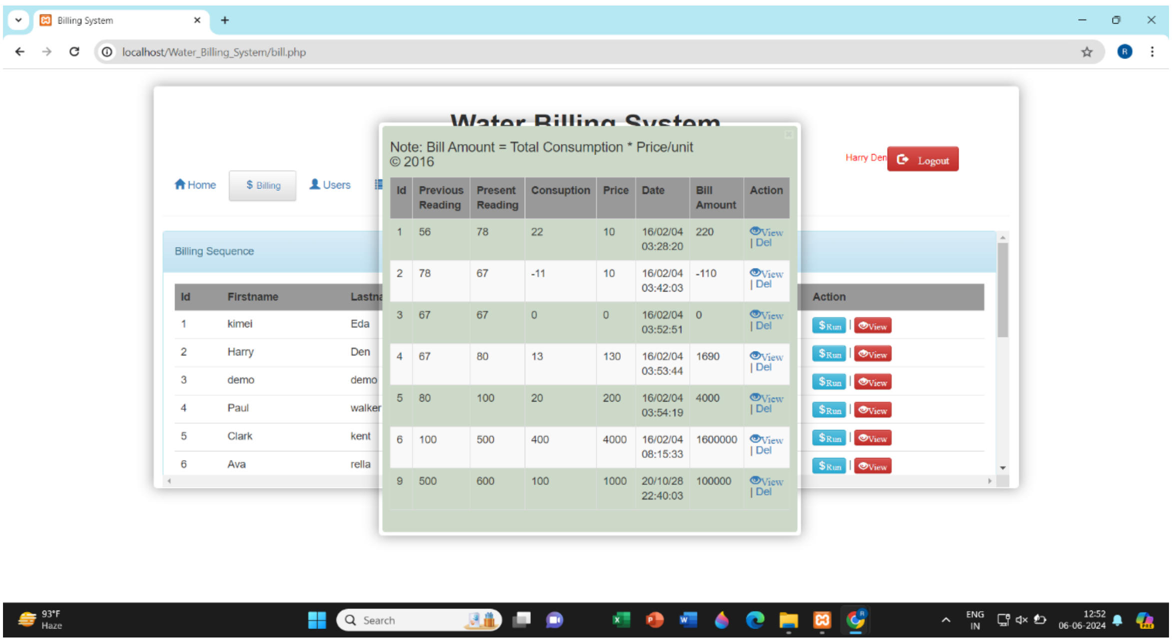
2.User and Client login:



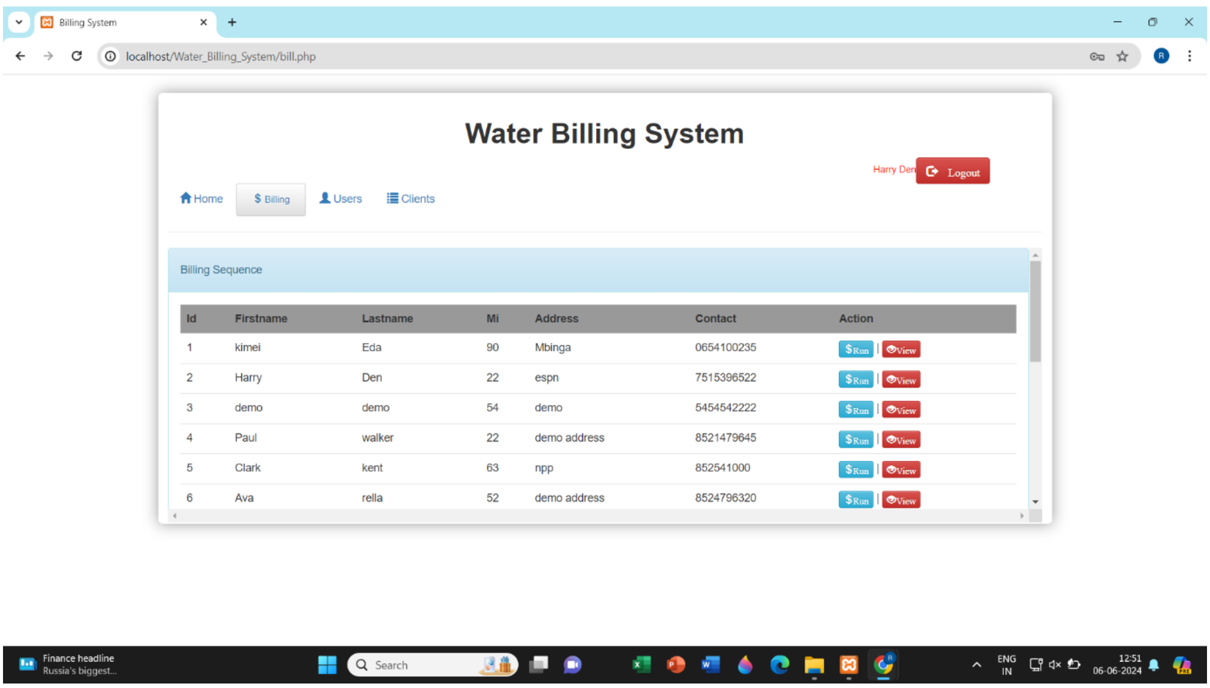


3.BILLING DETAILS:

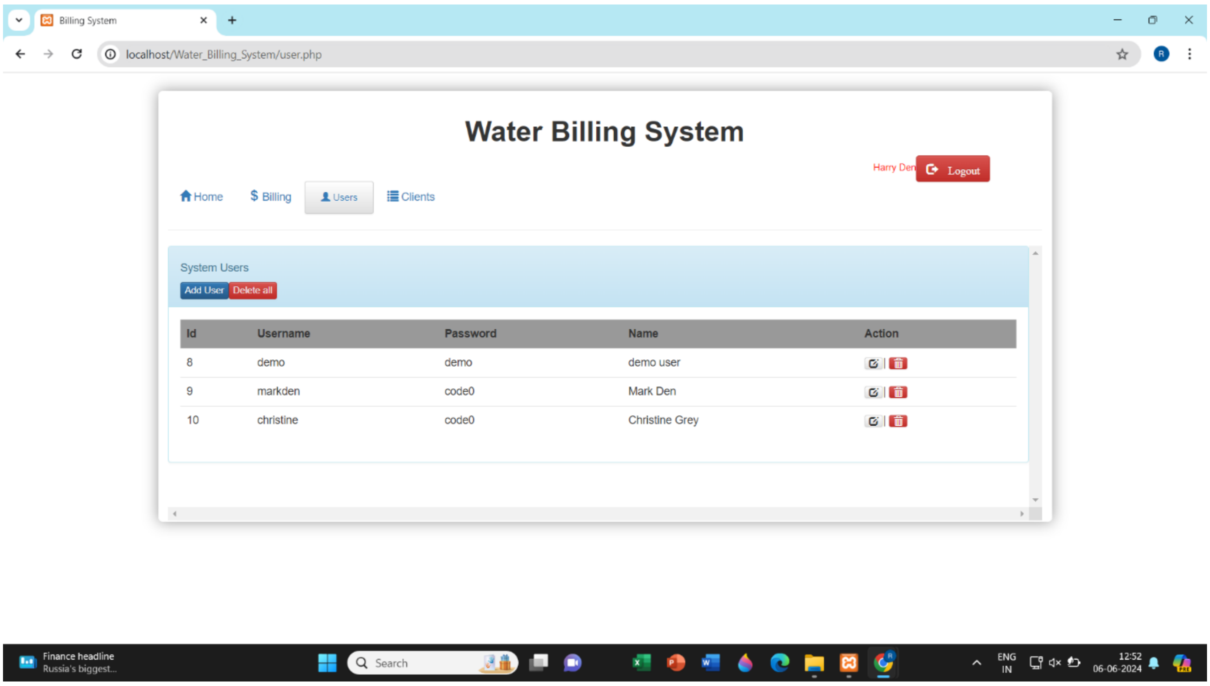




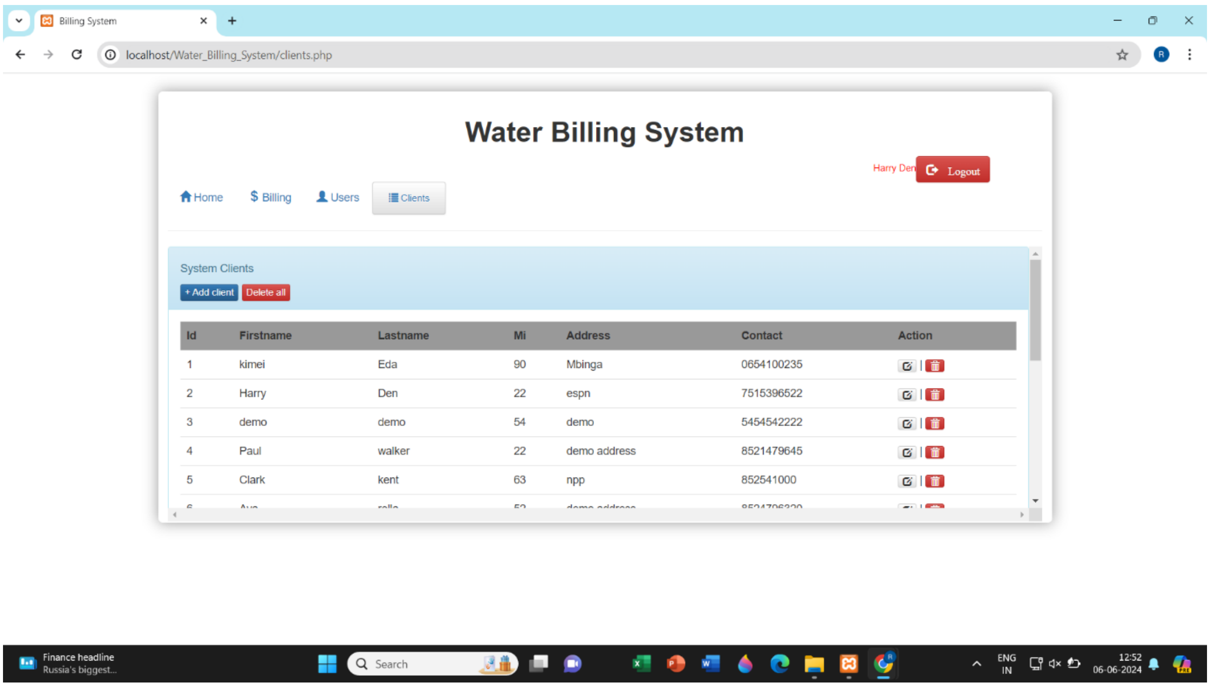
4.Viewing billing details:



5.User details:



6.Client details:



CONCLUSION

- In conclusion, the Water Bill Management System (WBMS) represents a crucial tool for efficiently managing water resources, optimizing billing processes, and promoting sustainability in the water utility sector. Through its comprehensive functionalities and robust features, the WBMS addresses the diverse needs of water utility companies, municipalities, and consumers, ensuring transparency, accuracy, and efficiency in water resource management.By leveraging advanced technologies such as IoT sensors, data analytics, and secure payment gateways, the WBMS enables real-time monitoring of water consumption, data-driven decision-making, and streamlined billing and payment processes.
- It empowers consumers with access to their consumption data, personalized conservation tips, and convenient payment options, fostering awareness and responsible water usage practices.Moreover, the WBMS facilitates compliance with regulatory standards, industry best practices, and environmental conservation guidelines, ensuring adherence to legal and ethical requirements. Its scalability, interoperability, and adaptability make it suitable for various operational contexts, from urban to rural environments, while its user-friendly interfaces and comprehensive support services enhance the overall customer experience.
- Overall, the Water Bill Management System represents a significant advancement in water resource management, offering efficiency, transparency, and sustainability. By promoting efficient water usage, equitable access to resources, and collaborative stewardship of water systems, the WBMS contributes to the conservation of water resources and the well-being of communities, both now and in the future.

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