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Smart Electricity Billing System for PG & Hostels with Attendance-Based Cost Sharing

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ABSTRACT
In shared houses and hostels, where there is no traditional electricity meter, the electricity bill is usually calculated manually, which can lead to billing errors, delayed billings and unfair billing between the residents. This paper introduces an Smart Electricity Billing System for PG & Hostels with Attendance-Based Cost Sharing which helps to distribute the electricity expenses fairly according to the attendance of the individual. The framework used for developing the proposed system is MERN stack, which has MongoDB, Express.js, React.js and Node.js. There are separate modules for Administrators, Managers, and Residents for managing room allocation, attendance tracking, bill generation, and payment processing. Through experimental results, it is proven that it takes less time to bill, is more accurate, has more transparency than the conventional manual billing method. The solution is proposed as an efficient and scalable solution for modern hostel management.
Keywords *- Smart Billing, MERN Stack, Hostel Management, Electricity Billing, Attendance Tracking, Cost Sharing*

I. INTRODUCTION

The uses of electricity in residential, commercial, or industrial buildings are extremely important in the present times. Managing electricity use in shared accommodation, like hostels, paying guest (PG) houses, apartments and rentals, can be difficult because of the fact that several people share common resources. In such settings, electricity billing is typically done manually, with administrators manually determining the overall electricity consumption and then allocating the electricity cost amount. This process is not transparent, slow and prone to errors.

A number of current systems have manual data collection from electricity meters and fixed tariff rates for calculating the bills. The techniques often result in billing errors, late billing, resident disagreements, and resident contribution tracking. The issue is more complicated in shared accommodation, as part of the household may be missing for a few days, and equal bill sharing might not be fair. Record of attendance and bill sharing are also manual tasks that add to the burden. As digital technologies and smart management systems develop and become more popular, it is necessary to have an automated solution that can help to simplify electricity billing and provide equitable distribution of costs. Automation can save a ton of manpower, enhance billing accuracy, and offer clarity to the administrator and residents.

In this paper, a Smart Electricity Billing System for PG & Hostels With Attendance-Based Cost Sharing is proposed based on the MERN stack (MongoDB, Express.js, React.js, and Node.js) [11] to distribute the electricity expenses fairly according to the attendance records of the individuals. The system automatically calculates the electricity bill based on the total electricity consumption along with the tariff rate and attendance record of the residents. It offers administrator, manager and resident modules to handle various operations efficiently.

Administrator module provides management of rooms, residents, managers and electricity configurations. The module manager is responsible for attendance, room monitoring and the generation of bills. The resident module provides users with access to their bills, attendance records, billing reports and the ability to pay online.

The proposed system enhances transparency by informing the residents on how their bills are being calculated. It reduces manual work, decreases billing mistakes and offers a scalable answer for hostels, PG lodging and rental accommodation.

The main objectives of this system are:

- To automate electricity bill calculation
- To create fair sharing of bills based on attendance.
- To decrease the manual calculation errors
- To enhance the billing transparency.
- To make bill access and payments available online

This project illustrates the use of the latest Web technologies to address a real-world utility management problem, and introduce efficiency to shared accommodation.

The key contribution of this paper is that it unifies an attendance-based cost allocation, automated electricity booking generation, role-based management and online

payment processing in a single platform for electricity bill management in hostels.

II. LITERATURE REVIEW

The implementation of electricity billing automation and hostel management systems has been gaining widespread focus, particularly in the context of resource management in shared housing.

Gupta and Sharma [1] suggested an automated Electricity Billing System that used web technology to minimize human mistakes and automate the process of generating bills. Yet it did not have the concept of cost sharing based on attendance.

Kumar and Singh [2] proposed an automatic energy management system for smart buildings which enhanced electricity monitoring but could not be applied to hostels.

Most of the existing hostel management systems [9] are just student registration, room allocation and fee management without any feature to bill electricity.

Electricity monitoring systems based on IoT are able to monitor electricity usage in real-time, but also costly to set up.

Smart energy optimisation systems with IoT [8] enable energy saving in electricity use; however, they can be challenging to deploy in small hostels and PG rooms.

Online payment integration systems [10] enable easier online payments but do not provide any transparent electricity billing mechanism.

The current systems available are largely limited to specific features like billing, attendance and payments. There are very few systems that combine all of these features in one. The proposed system aims to overcome this limitation by implementing automated billing and attendance-based cost sharing, role-based access control, and on-line payment options.

But current systems are primarily geared toward billing automation, hostel management or payment processing separately. Few systems provide all three of these features, attendance-based fair cost sharing, role-based access and online payment in one platform. These drawbacks are tackled in this research by a single solution based on MERN.

III. SYSTEM ANALYSIS

Hostel electricity billing systems currently use manual meter reading, manual bill calculation and share the cost equally among residents. This results in incorrect billing, delayed processing, unfair cost sharing, and inadequate transparency. Using attendance records, tariff rates, and access modules for admin/manager and residents, the proposed system will automatically calculate electricity. Improved billing accuracy and decreased administrative workload.The analysis and requirement identification process for the proposed system follows standard software engineering methodologies and system planning principles discussed in [13] and [15].

It also helps to make better decisions by keeping historical billing records and attendance reports.The system. By monitoring monthly electricity consumption trends, administrators can identify rooms with more frequent usage. It facilitates hostel management in implementing more efficient energy saving techniques and optimizing operational costs.

IV. SYSTEM DESIGN

There are four significant modules that make up the proposed system: The Admin Module, Manager Module, Resident Module and Billing Module [15]. The Admin is in charge of managing the tariff settings and overseeing the management of rooms. The Manager oversees attendance and keeps track of electricity consumption. Payrollers have the ability to view bills and make payments.The Billing module calculates electricity charges automatically by taking into account attendance and electricity consumption [14].

It also has built-in authentication and authorization mechanisms to allow secure access to different modules. The authorization of user roles is tailored to prevent the disclosure of confidential billing data. New bills, payment deadlines, and successful payments are communicated to residents through a notification module that sends them dashboard alerts or emails. These supplementary features enhance system security, communication, and user experience.

The objective of the system is to preserve flexibility and scalability for future expansion. The management of new hostel blocks, additional rooms, and resident data can enhance system efficiency without affecting the rest of the system. Various electricity tariff structures can be managed by the billing module, which enables administrators to update pricing policies at any time. Detailed logs of attendance changes, bill generation history and payment transactions are kept by the system to aid auditing and reporting.

A. System Architecture

React.js frontend, Node.ls/Express.la backend and MongoDB database are the three layers of architecture used for the system. It has a frontend that allows for user interaction, while the backend handles requests and stores data in MongoDB.

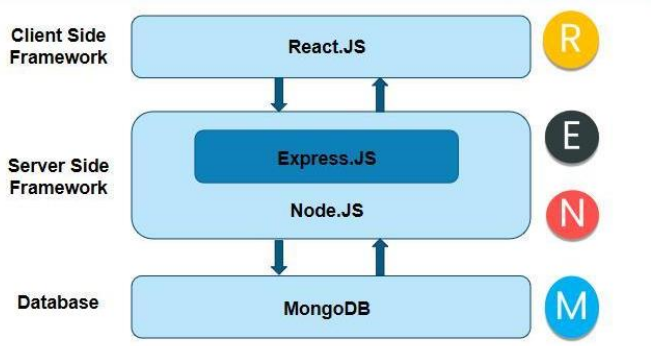

Fig. 1 System Architecture

B. Data Flow Diagram (DFD)

Users and system modules are shown to move through electricity usage data, attendance records (Data Flow Diagram), billing information, and payment transactions.

C. Database Design

The efficient management of data in MongoDB involves the retention of user information, room information and attendance records, billing data, and payment history [6].

D. Database Entity Relationship Diagram

The Entity Relationship (ER) Diagram is a framework for depicting the relationships between entities.

Main entities include:

- User.
- Room.
- Bill.
- Attendance.

Relationship:

One Room → Many Residents.

One Resident → Many Bills.

One Resident → Attendance Records.

Maintaining proper database relationships and avoiding data redundancy is achieved through this.

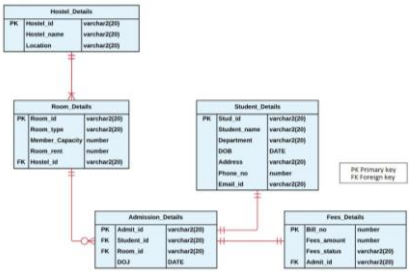

Fig. 2 ER Diagram

V. BILL GENERATION ALGORITHM

The first step is to gather the data from the electricity meters.

Step 2: Determine the total amount of electricity used.

Step 3: Applying tariff slab rates.

Step 4: Retrieve attendance records of residents.

Step 5: Determine the amount of individual share based on attendance.

Step 6: Generate final bills.

Keeping the bill details in the database is required at step seven.

Introducing bills to inhabitants in step 8.

VI. IMPLEMENTATION

Implementation is the stage where the system design is converted into an operational system. The system proposed, Smart Electricity Billing and Attendance Based Cost Sharing System is developed using the MERN Stack as a web application. Four steps of implementation are frontend development, backend development, database integration, and deployment.

A. Frontend Implementation

Frontend is written in React.js, HTML and CSS for creating responsive user interfaces [4].

The client side functionality and dynamic interaction used JavaScript [5].

The user interface is easy to use, responsive and simple for all users.

B. Backend Implementation

The use of modern programming concepts and object oriented principles, the backend is developed with Node.js and Express.js.Java programming concepts and backend development practices referenced in [14] helped in implementing efficient server-side logic.

Communication between the frontend and backend components is through REST APIs.

C. Bill Calculation Logic

Electricity charge is automatically generated by billing module based on the tariff slabs and room consumption.

The tariff logic that has been implemented is:

Bill=(100×5)+(200×7)+(Remaining Units×10)

The following formula is used to determine the individual electricity bill:

Individual Share= Resident Attendance/Total Room Attendance×Total Room Bill

Example:

Total room bill = ₹2400

Student A has attended 30 days.Student A has been in school for 30 days.

Student B has been absent for 20 days.Student B missed 20 days of school.

Total attendance = 50 days

Student A share = ₹1440

Student B share = ₹960

The total bill is then split up according to attendance figures.

D. Database Implementation

The application data is stored in the database as MongoDB.

The database stores:

- User details
- Room information
- Attendance records
- Billing history
- Payment records

MongoDB is flexible and efficient when it comes to large data sets.Database configuration and documentation support were referred from [18].

E. System Integration

All modules are combined together to create a whole system after individual modules are developed.

System workflow:

- User logs into the system
- Manager records attendance
- The use of electricity is recorded
- Handle billing logic on the backend.Backend side of billing logic.
- Database stores records

Residents are presented with final bill.Final bill presented to residents.

This integration will allow seamless communications between system elements.

F. Deployment

The application is deployed on cloud platforms like Render and stored in a cloud database like MongoDB Atlas.Official development documentation was referred for implementation support [16], [17].

G. Implementation Challenges

In practice, some difficulties arose including the management of accurate attendance synchronization, verifying electricity input and payment security for integration. The challenges encountered during the deployment with MongoDB Atlas related to database connectivity. One of the biggest issues was fair bill distribution when customers were added and/or removed from rooms during the billing cycle.

These issues were addressed by appropriate validation procedures, test, debugging and optimization methods at the back end of the system to ensure smooth performance.

The implementation phase is a successful process that transforms the designed model into an actual application that automates electricity billing and enhances management efficiency of shared accommodation.

VII. RESULTS AND DISCUSSION

The proposed Smart Electricity Billing and Attendance Based Cost Sharing System was successfully developed and deployed in the real-time web environment. The system works well to automate the process of generating the electricity bill,

attendance processing and payment collection for shared accommodation arrangements like hostels and PGs.
The application is user-friendly and has separated administrator, manager and resident level interfaces, which supports easy operation and role-based access control.

A. *Role Selection and Login Module*

When users log into the system, they can log in as one of the following:

- Admin
- Manager
- Resident

Successful login redirects each user to his/her dashboard.

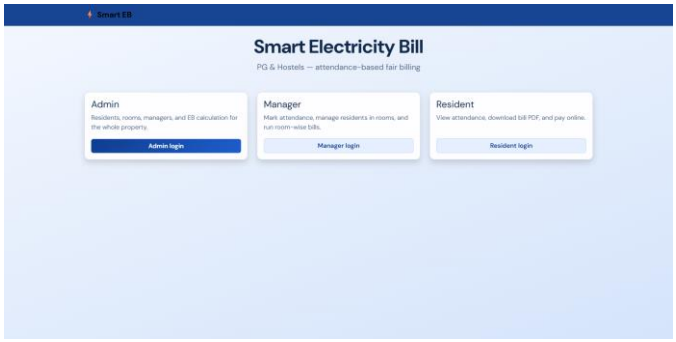

Fig. 3 Login Page

B. *Admin Dashboard Results*

The admin dashboard is able to do the following:

- Managing rooms
- Adding residents
- Assigning managers
- Configuring tariff rates
- Monitoring billing activities

The dashboard has been improved to provide more unified, integrated control of the system.

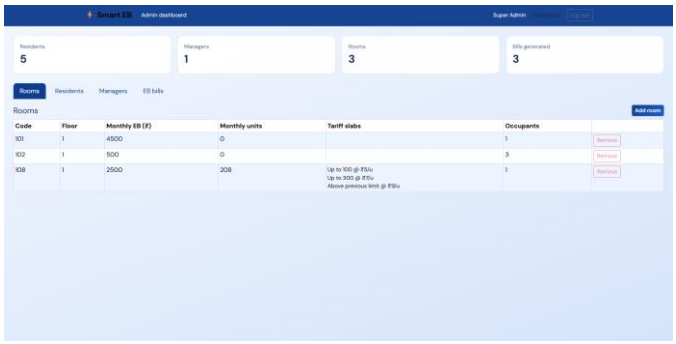

Fig. 4 Admin Dashboard

C. *Resident Dashboard Results*

Residents can:

- View individual bill details
- Check attendance records
- Download billing reports
- Make online payments

This improves transparency and user convenience.

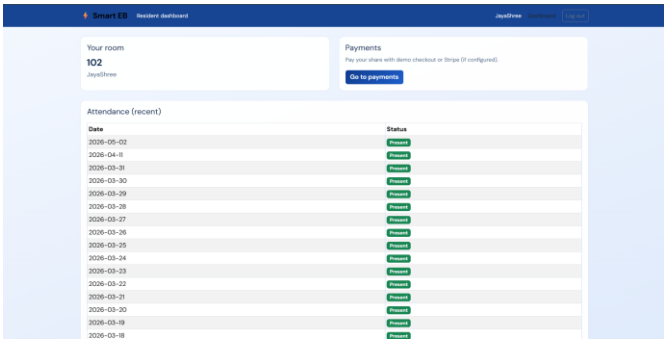

Fig. 6 Resident Dashboard

D. *Bill Generation Results*

The application correctly computes electricity bills in accordance with the electricity tariffs and the attendance of the employees.

For example:

Total units consumed = 350 units

Generated bill = ₹2400

If the bill isn't paid, it is automatically allocated to the resident who attended.

Total Bill = ₹2400

This can minimize manual calculation errors and ensure cost sharing.

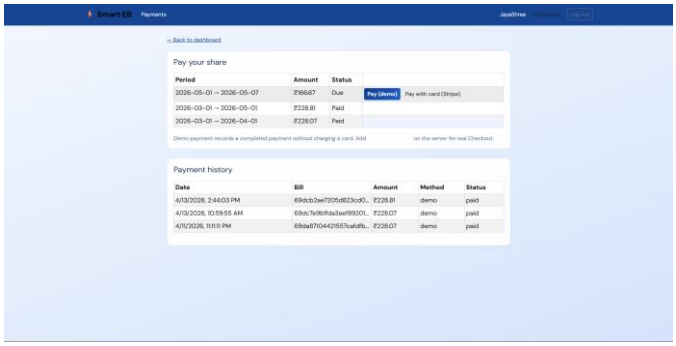

Fig. 7 Payment Page

E. System Testing Results

The system was tested using various inputs and all modules performed successfully.

TABLE III
TEST RESULTS

Test Case	Input	Expected Output	Result
T1	100 units	₹500	Pass
T2	250 units	Correct bill	Pass
T3	350 units	₹2400	Pass
T4	Invalid input	Error message	Pass
T5	Negative input	Validation error	Pass

The testing results confirm that the system produces accurate outputs and handles invalid inputs effectively.

F. Performance Analysis

The application demonstrated:

- Fast response time
- Accurate bill generation
- Secure role-based access
- Efficient database operations
- User-friendly interaction

TABLE IV
PERFORMANCE COMPARISON

Parameter	Manual System	Proposed System
Billing Time	30 mins	2 mins
Calculation Errors	High	Very Low
Transparency	Low	High
Record Maintenance	Manual	Automated
Payment Process	Offline	Online

This system is successful in reducing the manual workload and operation efficiency in the process of billing management of shared accommodations.

Various user scenarios were used to test the system with a range of room sizes and power use. Multiple users were able to use the system at the same time, and results demonstrating consistent performance were observed. The application managed to record the activities accurately and generated bills without any delay and proved to be scalable for larger hostel settings.

Similar cloud-based billing systems have shown improved efficiency in recent studies [19].

VIII. CONCLUSION

The Smart Electricity Billing and Attendance-Based Cost Sharing System was designed and implemented successfully to overcome the drawbacks of the conventional electricity billing systems in shared accommodation units like hostels and paying guest system. Manual billing can lead to inaccurate calculations, late billings, opacity and trouble apportioning electricity costs shared by several households.

The developed application is automated electricity bill calculating application which provides all the required functionalities for electricity bills calculating on a single platform, e.g. electricity consumption, attendance tracking, tariff based bills, online payments & everything. Separate administrative, management and resident modules streamline system organization and provide efficient billing operations.

By leveraging the MERN stack, the application became user-friendly, responsive, and scalable, meeting the demands of real-time operation.By using the MERN stack, the application was developed to be user-friendly, responsive, and scalable, which is essential for real-time operations. The system will effectively save time and effort from manual work, bring accuracy to the billing process, provide fair cost sharing according to attendance statistics and create transparency for residents.

The experimental results show that the system creates precision bills, keeps records of the bills efficiently and gives the user better convenience by allowing online access to the bills and also by offering payment facilities.

The system can be improved in future by incorporating AI-based consumption prediction using data mining techniques [12].

In conclusion, the proposed system offers a promising and efficient approach to electricity billing management in modern living spaces, showcasing the benefits of automation in optimizing the operation of shared housing systems.

Possible future improvements include the ability to use smart meters that will be connected to IoT networks for automatic electricity consumption data collection[20], a mobile application to facilitate easier access, an AI-based electricity consumption prediction feature, and advanced analytics dashboards for the hostel administrator. These enhancements can further optimize and automate resources.

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