IMPLEMENTATION OF AN IOT BASED BILLING SYSTEM TO OPTIMIZE MANAGEMENT OF BILLIARD TABLE USAGE

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Abstract- This research develops an IoT-based billing system for managing billiard table usage, aimed at addressing various issues arising from the use of manual systems. Currently, many billiard table rental businesses still rely on manual methods for transaction recording and lamp control, which increases the risk of rate manipulation, inaccurate transaction reports, and inefficient resource management. The manual process also adds to the workload of operators, especially when billiard tables are located far apart. The developed system utilizes Bluetooth sensors and a web app to automatically control the billiard table lamps, thereby reducing manipulation and improving operational efficiency. Testing shows that the system accurately calculates the usage fees and controls the lamp status based on commands from the web server. As a result, the system not only enhances the accuracy of cost calculation and the reliability of billiard table management but also provides a better user experience. Thus, the implementation of this IoT-based billing system offers significant benefits in optimizing billiard center management.

Keywords*: IoT, Billing System, Billiard Table Management, Automatic Light Control, Cost Calculation Accuracy*

I. INTRODUCTION

Technological progress in the digital era after opening up new opportunities to connect electronic devices to the internet, we will experience very rapid development where almost all fields of work are done using computers.[1]. by using a computer, a job can be completed quickly and accurately. Therefore it can be said that a computer is a very important tool in today's era. With a computer, we can process data accurately and quickly and can control a tool. For that, technology is needed to improve the quality of work and service so that work efficiency can be created[2]. In the Billiard table rental business, there are still many cashier billing applications that are not available for computer devices, so billiard operators/marca must do the work manually. In this manual recording, the rate calculation process can be manipulated and is not real time so that transaction reports are also invalid.[3].

The integration of IoT into billiard table lighting brings significant benefits to billiard center management. Using connected sensors, the system can automatically adjust lighting based on gaming activity or user preferences. Studies show that the use of IoT in billiard table lighting can increase energy efficiency by up to 30% with intelligent lighting adjustments.[4]. This not only reduces operational costs, but also reduces the environmental impact of the billiard center in operation. In addition, the use of IOT in billiard table lights opens up opportunities to enhance the playing experience. With connected sensors, the lights can provide dynamic light effects

according to the movement of the ball or the score achieved. This not only increases the level of player engagement, but also creates a more engaging and interactive experience.[5]. This enhanced experience can increase the appeal of the billiard center and improve customer retention. In the billiard table rental business, manual systems are still commonly used for transaction recording and billiard table light control. This creates several problems such as potential tariff manipulation by operators, inaccurate transaction reports, and inefficient energy resource management. Additionally, the manual process of turning billiard table lights on and off increases the operator's workload, especially when tables are located far from each other. The lack of adequate technology integration, such as an IoT-based billing system, in this business leads to suboptimal operation and management of billiard business premises.[6].

The implementation of IoT technology for billiard table lights offers significant convenience and is predicted to become increasingly popular in the future. The traditional manual control of electrical equipment, such as turning on billiard table lights and tracking time using wall clocks, can be particularly inconvenient, especially when tables are situated far apart. To address these challenges, a Desktop billing application presents an effective solution, particularly for controlling electrical equipment like lights. This billing system serves as proof of payment transactions and offers numerous advantages. The key benefit is the ability to control billiard table lights remotely through a Desktop or PC interface, eliminating the need for manual operation. This automated system streamlines operations by centralizing control and providing an efficient method for managing billiard table lighting and usage tracking.[7].

In this billiard table lamp control system, it can facilitate work in billiard table rental businesses because billiard table lights can be turned on and off automatically controlled by a Desktop or PC. In this way, unused tables will not be lit so that transactions cannot be manipulated by billiard table employees because the lights are not turned on manually. In the studies above, it is only said to use smart sensors in IOT without implementing them, the difference in the research that the author did is implementing a bluetooth sensor to turn the lights on and off using the web app billing system that was created, and also optimizing billiard table management in order to satisfy customers.

II. SIGNIFICANCE OF THE STUDY

A. Literature Study

1. Internet of Things (IoT)

According to Alexandre Menard's analysis from McKinsey Global Institute, the Internet of Things is a technology that allows us to connect machines, equipment and other physical objects with networked sensors and actuators to acquire data and manage their own performance, allowing machines to collaborate and even act on new information obtained independently. This paper emphasizes the role of many technologies used for agriculture, especially IoT, in making agriculture smarter and more effective to meet future needs. The current challenges faced by the industry and future prospects are noted to guide scientists and engineers. Hence, every inch of land is crucial to increase crop production by addressing every inch of land using sustainable IoT-based sensors and communication technologies [13].Indonesia has so far implemented various telecommunications technologies to improve quality and improve quality so that improvements need to be made in all areas, one of which is Telecommunications

Infrastructure. Internet of Things (IoT) technology offers intelligent services and networks. But to implement IoT technology requires a lot of costs and is quite expensive, therefore it is necessary to formulate a suitable strategy to implement IoT technology. To formulate a plan based on the concept of strategic management science using strategy formulation using a strategy process consisting of MEI (Internal Evaluation Matrix), MEE (External Evaluation Matrix), SWOT, External Internal Matrix, and Grand Strategy. After being formulated, it was found that "the 3 R strategy and then slowly implementing IoT technology" is the best strategy and can be implemented [14].

2. Technological Innovation in Recreational Sports Management

This research contributes to the integration of Internet of Things (IoT) technology in the management of billiard facilities. By implementing an IoT-based billing system, the study showcases how emerging technologies can be applied to traditional recreational activities, paving the way for smarter and more efficient management systems in the sports and entertainment sector.

3. Enhanced Operational Efficiency

The IoT-based billing system developed in this study offers substantial improvements in operational efficiency compared to conventional manual systems. By automating time tracking and billing processes, the system significantly reduces human error, minimizes disputes over usage time, and streamlines the overall management of billiard tables. This increased efficiency can lead to improved customer satisfaction and potentially increased revenue for billiard hall owners.

4. Real-time Monitoring and Control

Unlike traditional systems, this IoT-based solution provides real-time monitoring and remote control capabilities. Owners and managers can oversee table usage, occupancy rates, and billing status from anywhere, allowing for more informed decision-making and responsive management. This real-time insight is a significant advancement over manual systems that rely on periodic checks or end-of-day reconciliation.

5. Energy Efficiency and Cost Reduction

The integration of smart lighting control in the system contributes to energy conservation. By automatically managing the billiard table lights based on occupancy, the system helps reduce unnecessary energy consumption, leading to lower operational costs and a smaller environmental footprint for billiard facilities.

6. Data-Driven Business Insights

The system's ability to record and store usage data provides valuable business intelligence. Owners can analyze patterns in table usage, peak hours, and customer preferences, enabling them to make data-driven decisions about pricing strategies, staffing, and promotions. This level of insight is not readily available with traditional manual systems.

7. Scalability and Future Integration

The IoT-based system developed in this study is designed with scalability in mind. It can be easily expanded to manage multiple tables or even entire facilities. Moreover, it lays the groundwork for future integration with other smart systems such as inventory management, customer relationship management, or even AI-powered predictive maintenance.

8. Enhanced Customer Experience

By providing accurate time tracking and automated billing, the system improves transparency and fairness in charging, potentially enhancing customer trust and satisfaction. The modern, tech-driven approach may also appeal to a younger, tech-savvy customer base, potentially attracting new clientele to billiard halls.

9. Economic Benefits for Business Owners

The implementation of this IoT-based system offers tangible economic benefits for billiard hall owners. By reducing operational overhead, minimizing revenue leakage due to manual errors, and potentially increasing customer satisfaction and retention, the system can contribute to improved profitability and business sustainability.

10. Contribution to IoT Research and Development

This study adds to the growing body of research on practical applications of IoT in various industries. By detailing the development and implementation process, it provides valuable insights for researchers and developers working on similar projects in other fields, contributing to the broader advancement of IoT technologies.

11. Addressing Industry-Specific Challenges

The research directly addresses common challenges in billiard hall management, such as disputes over playing time, inefficient table turnover, and energy wastage. By providing targeted solutions to these industry-specific issues, the study demonstrates the potential of customized IoT applications in niche markets.

12. ESP32

ESP32 is a microcontroller equipped with Wi-Fi and Bluetooth connectivity features, developed by Espressif Systems. This microcontroller is known for its high performance, energy efficiency, and ability to be used in various Internet of Things (IoT) applications.[15].

13. Arduino

Arduino is an open-source electronics platform consisting of hardware and software designed to make developing electronics applications easier and cheaper. The platform is used by beginners, hobbyists, and professionals to create a wide variety of electronics projects.[16].

14. Billiards Billing

*Billiards billiards*is a system used to record and calculate the time of use of the billiard table by customers, as well as calculating the fees to be paid based on the duration of the game. This system is usually applied in entertainment venues that provide billiard game facilities such as bars, clubs, or recreation centers.[17].

15. Smart Lamp

*Smart lamp*or smart lights are lights that can be controlled and programmed via smart devices such as smartphones, tablets, or voice assistants. These lights use wireless technology such as Wi-Fi, Bluetooth, or Zigbee to communicate with the controlling device.[18].

B. Research methods

The research method used for the research "Implementation of IoT-Based Billing System to Optimize Billiard Table Usage Management"[19]can be seen on **Figure 1**:

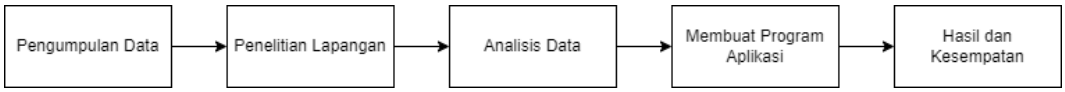


Figure 1. Research Method Flow

1. Data Collection a. Literature Research: At this stage, researchers study and collect information from various sources relevant to the research topic. Some detailed steps that can be taken are: b. Searching for Books and Journals: Search for literature from books, journals, articles, and academic publications discussing billing systems, IoT, and pool table usage management. c. Literature Review: Conduct a literature review to understand existing theories, technologies that have been used, and previous research results relevant to the topic. d. Note-taking: Record important information, concepts, and data that can support the research, and summarize the main findings from the studied literature.
2. Field Research At this stage, researchers collect empirical data from pool table rental locations through direct observation and possibly interviews. Detailed steps that can be taken are: a) Observation: Directly observe the rental process and use of pool tables, note how the current billing system works, and what problems may arise. b) Interviews: Conduct interviews with owners or managers of rental locations as well as pool table users to gain insights into their needs and experiences. c) Document Collection: Collect related documents such as rental records, pool table usage reports, and existing transaction data.
3. Data Analysis After data from literature and field research is collected, the next step is to analyze the data. Some detailed steps in data analysis are: a) Data Grouping: Group data based on relevant categories, such as pool table usage efficiency, billing accuracy, and user feedback. b) Data Processing: Process data to identify patterns, trends, and relationships between variables that have been collected.
4. Creating the Application Program After data analysis is complete, the next step is to create an application program based on the analysis results. Some detailed steps in creating an application program using LabView are: a) System Design: Design the architecture of the IoT-based billing system, including hardware components (sensors, microcontrollers) and software (LabView). b) Software Development: Develop software using LabView. This includes writing code, testing functionality, and debugging. c) Interfacing with Hardware: Ensure hardware (such as sensors and microcontrollers) can communicate effectively with LabView software. d) Unit Testing: Test each program component to ensure every part functions properly. e) System Integration: Integrate all hardware and software components into a fully functioning system. f) System Trial: Conduct a trial of the entire system to ensure the IoT-based billing system functions as intended in real conditions.

5. Results and Conclusion: Based on the test results, Results and Conclusions are compiled to determine the success of the tests that have been made in a more concise form that can be understood by readers.

III. RESULTS AND DISCUSSION

1. Needs Analysis

To present the results of the needs analysis in the form of a table on "Implementation of an IoT-Based Billing System to Optimize Billiard Table Usage Management" according to the results of interviews and observations, here is Table I which includes system requirements, objectives, and required components:

TABLE I

NEEDS ANALYSIS

No	System Requirements	Description of Needs	Objective	Required Components
1	Remote Control for billiard table used	Admin performs remote control regarding time and automation for recording time.	Relay or light control module, presence sensor	Enables remote control of the lights when the table is in use.
2	Usage Time Measurement	Counting the time from when a player starts using the table until it finishes.	Microcontroller, time module (RTC), LabView software	Start counting time when player presence is detected.
3	Automatic Light Settings	Set the billiard table lights to turn on when the table is in use and off when not in use.	Relay or light control module, presence sensor	Turn on the lights when the table is in use.
4	Time Data Recording	Record usage time in database for billing calculation.	Microcontroller, LabView software, database	Stores usage time data for each session.
5	Cost Calculation	Calculate the cost based on the time of use of the billiard table.	Microcontroller, billing module, LabView software	Multiply the usage time by the hourly rate.
6	Report and Recapitulation	Generate reports on time usage and charges incurred for audit and billing purposes.	LabView software, report module	Compile reports on usage time and costs.

2. Designing Testing Tool Requirements

For the design of testing tool requirements in the research "Implementation of IoT-Based Billing System for Optimizing Billiard Table Usage Management," the following is a table of testing tool requirements design along with a description of its function:

TABLE II

DESIGN OF TESTING EQUIPMENT REQUIREMENTS

No	Component	Description	Functions in Testing
1	ESP32	Wi-Fi and Bluetooth based microcontroller with high processing capabilities.	Control the system and connect to the IoT network.
2	Mini Breadboard	Solderless test board for assembling temporary electronic circuits.	A place to temporarily assemble and test electronic circuits.

3	Red, Yellow, Green LED	Colored LEDs used for visual indicators.	Provides visual feedback regarding system status (e.g., active status, error, or other conditions).
4	220 ohm resistor	A passive component that limits the electric current in a circuit.	Protects LEDs and other components from excessive current.
5	Push Button	A mechanical switch operated by pressing a button.	Used for manual input, such as starting or stopping a test.
6	Potentiometer	A component that functions as a variable resistor to adjust resistance.	Set parameters in the circuit, such as changing LED intensity or other settings.
7	Active Buzzer	A component that produces sound when voltage is applied.	Provides audio feedback for system status or errors.
8	Passive Buzzer	A component that produces sound at a certain frequency when given a signal.	Used to provide audio signals with adjustable frequencies.
9	DHT11	Sensor that measures air temperature and humidity.	Collect environmental data such as temperature and humidity for IoT systems.
10	Jumper Cable	Flexible cables used to connect various components on a breadboard.	Connecting various components on the breadboard and microcontroller.

3. System Architecture Design

The following is a system architecture design for "Implementation of IoT-Based Billing System for Optimizing Billiard Table Usage Management." This diagram illustrates how the system components interact with each other in the IoT architecture for a billiard table billing system.

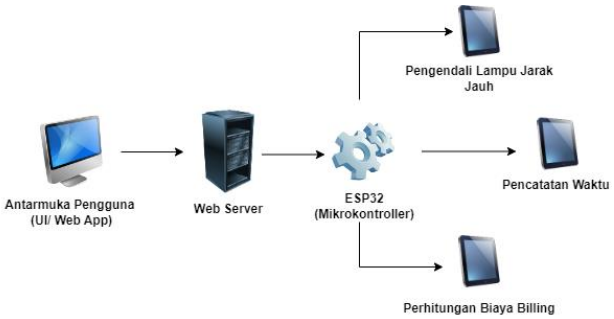


Figure 2. System Architecture Design

1. User Interface, This is the starting point of user interaction with the system. Through the web interface, users can monitor the status of pool tables, control lights, and view billing information.
2. Web Server: Acts as a bridge between the user interface and the ESP32 microcontroller. The web server receives commands from users, processes data, and sends instructions to the ESP32.
3. ESP32 This is the brain of the IoT system. The ESP32 receives instructions from the web server and controls the physical components of the system. Additionally, the ESP32 collects data from sensors and sends it back to the web server.
4. Remote Light Controller: This component is directly connected to the ESP32 and controls the status of pool table lights based on received commands.

5. Time Logging: This module, controlled by the ESP32, records the duration of pool table usage. Recording starts when the light is turned on and stops when it's turned off.
6. Billing Cost Calculation: Based on the recorded time data, this module calculates the cost of pool table usage according to the established rates.

System workflow:

1. Users interact with the Web App UI to send commands or view information.
2. The Web Server processes user requests and communicates with the ESP32.
3. The ESP32 executes commands, such as turning on/off lights through the remote light controller.
4. The ESP32 also starts or stops recording usage time.
5. Usage data is sent back to the Web Server for cost calculation.
6. Calculation results and current status are displayed back to the user through the Web App UI.

4. Application Program Creation

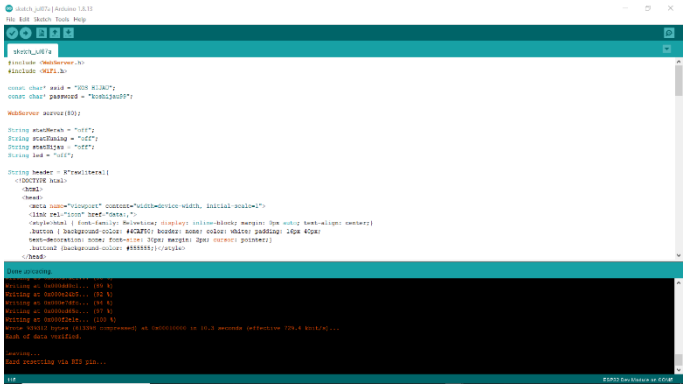


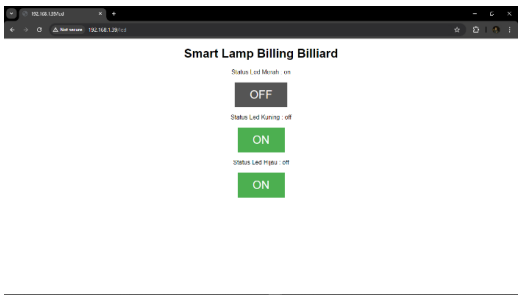
Figure 3. Application Program Design

Figure 3. shows the results of the coding created using the Arduino application to create an interface display that utilizes the Bluetooth webserver library, and WiFi on the ESP32 device to control the lights. In this project, the ESP32 is used as the main microcontroller because it has adequate WiFi and Bluetooth connectivity capabilities. By using the webserver library, the ESP32 is set to become a server that can be accessed via a local network. This allows users to control the lights via a web interface that can be accessed from any device connected to the same network. In addition, by utilizing Bluetooth capabilities, users can also control the lights directly from mobile devices that have a Bluetooth connection. The entire programming code is designed to ensure smooth communication between the ESP32, webserver, and control device, allowing for efficient and responsive light control, as well as examples of the coding created are as follows:

The three program codes are components of a smart lamp control system based on the ESP32 webserver, where Program Code 1 contains HTML code stored in string variables to set up the initial web page display titled "Smart Lamp Billing Billiard" with green and gray control buttons, Program Code 2 contains the handleLed() function that manages LED lamp status control (red, yellow, or green) based on parameters received from HTTP requests, and Program

Code 3 contains the setup() function that runs when the ESP32 is powered on to initialize serial communication, connect to the WiFi network, set up webserver routes ("/", "/L", "/H", "/led"), and configure output pins for LED control, thus enabling dynamic lamp control through a web interface controlled by the ESP32.

5. Creating a Billiard Billing System and Application Testing Application Program



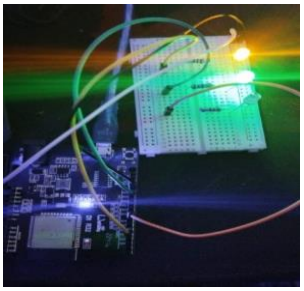


Figure 4. Application Interface Test Results **Figure 5**. Billing Billiard System

A webserver-based IoT system has been implemented for comprehensive light control in billiard table management, featuring three distinct LED indicators: red for Table 1, yellow for Table 2, and green for Table 3. The system automatically records usage time when a table's light is activated and stops recording when turned off, enabling accurate billing calculations based on actual usage duration. As demonstrated in Figure 5's circuit illustration, while Table 1's red LED remains unlit indicating non-use, Tables 2 and 3 show active status with illuminated yellow and green LEDs respectively. This real-time monitoring system allows managers to effectively track table usage, ensure accurate billing, and maintain efficient supervision of the billiard facility. The complete testing of features or Black Box Testing conducted by researchers can be seen in Tables III and IV.

TABLE III

BILLING CALCULATION TEST RESULTS

Tests Performed	Which are expected	Observation	Conclusion
Use of billiard table with lights on for Table 1 for 30 minutes and Table 2 for 45 minutes.	The system calculates the total cost based on the usage time and displays the corresponding total.	The system calculates the total cost correctly and displays the results according to the recorded time.	(Y)accepted ( ) rejected

TABLE IV

LIGHT CONTROL TEST RESULTS

Tests Performed	Which are expected	Observation	Conclusion
Turn on the red LED light for Table 1 and make sure the light is on.	The red LED light is on and the status on the webserver shows Table 1 is in use.	The red LED lights up properly and the webserver status is correct.	(Y)accepted ( ) rejected

Turn off the yellow LED light for Table 2 and make sure the light is off.	The yellow LED light is off and the status on the webserver shows Table 2 is not in use.	The yellow LED goes out properly and the webserver status is correct.	(Y)accepted ( ) rejected

Table 1 illustrates the Blackbox testing for the IoT-based billing system used in billiard table management. The testing includes two main aspects: billing calculation and lighting control. In the billing calculation test, the system is tested to ensure the total cost of billiard table usage is calculated accurately, with testing conducted by turning on the lights for Table 1 for 30 minutes and Table 2 for 45 minutes. The system is expected to calculate costs according to the recorded time and display correct results. Meanwhile, in the lighting control test, the system is checked to ensure that the LED lights representing the billiard tables respond correctly to commands from the webserver, where testing is conducted by turning on the red LED light for Table 1 and turning off the yellow LED light for Table 2.

Discussion

This IoT-based billing system shows a significant increase in accuracy in calculating billiard table usage costs. Previously, calculations were done manually, which was prone to human error and rate manipulation. With the integration of sensors and automatic control, the system is able to calculate the duration of billiard table usage in real-time, based on data obtained directly from the light sensor. When the light is turned on, the system starts counting, and when it is turned off, the calculation stops. This process eliminates the potential for errors that usually occur in manual recording. The test results also showed that the system successfully provided the correct total cost according to the duration of table usage, thereby increasing the overall accuracy of cost calculations.

The reliability of the system lies in the ability of the IoT system to control the status of the billiard table lights in real time and reflect the actual state on the webserver. Tests show that the LED lights representing the billiard table respond correctly to commands from the webserver, both to turn the lights on and off. In addition, the status displayed on the webserver is always in sync with the physical condition of the lights, ensuring that users can rely on information from the system without worrying about any discrepancies. This reliability is also enhanced by the use of an internet network that allows remote control, so that operators can monitor and manage the billiard table from any location. This is important to ensure that there are no technical errors or manual interventions that disrupt system operations. Optimization in billiard table management is achieved by system automation that reduces the manual workload of operators and increases operational efficiency. Previously, operators had to manually turn the lights on and off and calculate usage costs separately, which was time-consuming and risky. With this system, all processes are carried out automatically through a webserver, which not only speeds up operations but also reduces the risk of data manipulation. In addition, unused tables will not be turned on, thus helping to save energy and reduce operational costs. This optimization has an impact on energy efficiency and improved customer experience, where a transparent and automated system provides better service. The implementation of an IoT-based billing system for billiard table management faces several significant challenges and limitations. Network stability issues can disrupt communication between system components,

potentially leading to data loss or inaccurate updates. Sensor reliability is crucial for accurate usage detection, but environmental factors may affect their performance. The initial implementation costs, including hardware, software development, and potential infrastructure upgrades, can be substantial, especially for smaller businesses.

IV. CONCLUSION

The IoT-based billing system for billiard table management has demonstrated promising performance, accurately calculating costs and effectively controlling table usage in real-time. However, this study acknowledges several limitations and challenges. Network stability issues, sensor accuracy in varying lighting conditions, and the need for improved data security measures were identified as key areas for further development. The system's scalability for large-scale implementations and integration with existing management systems require additional research. High initial implementation costs may pose adoption barriers, particularly for smaller businesses. Future studies should focus on addressing these challenges, enhancing user adaptability, and reducing vendor dependencies. While the system has proven effective in improving efficiency and accuracy in billiard table management, further optimization is necessary to ensure its reliability and performance across diverse operational scenarios and conditions.

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