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Decentralized Street Light Control Using Blockchain and ESP32

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Abstract
Purpose: This study aims to design and implement a decentralized street light control system using blockchain technology and ESP32 microcontrollers. By leveraging blockchain's immutability and decentralized architecture, the system aims to ensure tamper-proof logging of street light status, optimize energy usage through sensor-based automation, and enable secure, transparent, and autonomous control without reliance on centralized infrastructure. This approach addresses the limitations of traditional street lighting systems by enhancing reliability, accountability, and efficiency in urban and rural lighting infrastructure.

Keywords: Decentralized Control, Smart Street Lighting, IoT, Secure Automation.

Introduction
Traditional street lighting systems often rely on centralized control mechanisms, leading to inefficiencies, delayed maintenance, and vulnerability to system failures. With the growing need for smart and energy-efficient infrastructure, integrating Internet of Things (IoT) devices with decentralized technologies presents a promising solution. This paper proposes a blockchain-based street light control system utilizing ESP32 microcontrollers to automate and securely manage lighting operations. The system enhances reliability, transparency, and scalability in public lighting infrastructure by recording operational data on a tamper-proof distributed ledger and enabling autonomous decision-making at the edge.

Findings/Resul
The proposed system successfully automated street light control based on environmental conditions using ESP32 and sensors. All operational events were securely logged on the blockchain, ensuring transparency and traceability. The decentralized approach reduced reliance on centralized servers and demonstrated improved system reliability and energy efficiency.

Literature review
Sharma et al. [1] proposed a blockchain-based secure and energy-efficient model for smart city sensor networks, highlighting decentralized control benefits. Kamel and Atia [2] designed an IoT-based smart street lighting system using microcontrollers and sensors for automation, though lacking blockchain integration. Reyna et al. [3] discussed challenges and opportunities in merging blockchain with IoT, emphasizing scalability and trust. Chakraborty and Aithal [4–10] explored ESP-based automation in various domains, including smart locks, Alexa-enabled devices, and AI kitchens. Their contributions support the use of ESP32 and decentralized technologies for secure, low- cost, and responsive IoT systems, forming the basis for this study.

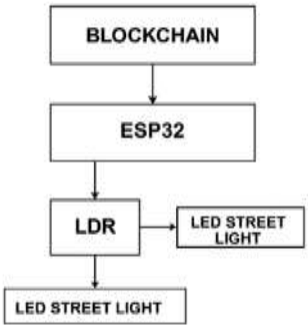

Fig. 1: Project Block diagram.

Methodology

Figure 1 shows the project block diagram. Now, we see the description of the components.

Blockchain

This technology acts as a decentralized and tamper-proof ledger to record all control actions, status updates, and sensor data from the street light system. It ensures transparency and security.

- ESP32 Microcontroller: The core controller that reads sensor data and triggers street lights. It communicates with the blockchain to fetch and write operational events.
- LDR (Light Dependent Resistor): A sensor that detects ambient light levels. When darkness is detected, it signals the ESP32 to activate the lights.
- LED Street Light: The LED Street light receives control signals from the ESP32 to turn ON or OFF based on real-time sensor data and predefined blockchain rules.

Conclusion

This study presents a decentralized street light control system leveraging blockchain technology and ESP32 microcontrollers to enhance energy efficiency, transparency, and automation. Integrating sensor-based lighting with secure, tamper-proof data logging on a distributed ledger eliminates reliance on centralized servers and reduces operational overhead. The successful implementation demonstrates the feasibility of combining IoT and blockchain to build robust, scalable smart city infrastructure. Future work can focus on integrating AI for predictive lighting control and expanding the system to cover larger geographic areas or other public utility services.

References

1. Sharma, V., You, I., Palmieri, F., Singh, G., & Kumar, R. (2020). Secure and energy-efficient transmission in wireless sensor networks for smart cities using blockchain. *Sensors*, *20*(4), 1029. https://doi.org/10.3390/s20041029
2. Kamel, R. M., & Atia, R. (2020). Design and implementation of an IoT-based smart street lighting system. *International Journal of Electrical and Computer Engineering*, *10*(4), 3821–3828. https://doi.org/10.11591/ijece.v10i4.pp3821-3828
3. Reyna, A., Martín, C., Chen, J., Soler, E., & Díaz, M. (2018). On blockchain and its integration with IoT. Challenges and opportunities. *Future Generation Computer Systems*, *88*, 173–190. https://doi.org/10.1016/j.future.2018.05.046
4. Chakraborty, S. & Aithal, P. S. (2024). WhatsApp Based Notification on Low Battery Water Level Using ESP Module and TextMeBOT. International Journal of Case Studies in Business, IT, and Education (IJCSBE), 8(1), 291-309. DOI: https://doi.org/10.5281/zenodo.10835097
5. Chakraborty, S. & Aithal, P. S. (2023). Smart Magnetic Door Lock for Elderly People Using AWS Alexa, IoT, Lambda and ESP Module. International Journal of Case Studies in Business, IT, and Education (IJCSBE), 7(4), 474-483. DOI: https://doi.org/10.5281/zenodo.10467946
6. Chakraborty, S., & Aithal, P. S. (2023). Alexa Enabled IoT Device Simulation Using C# And AWS Lambda. International Journal of Case Studies in Business, IT, and Education (IJCSBE), 7(3), 359-368. DOI: https://doi.org/10.5281/zenodo.8329375
7. Chakraborty, S., & Aithal, P. S. (2023). Let Us Create an Alexa-Enabled IoT Device Using C#, AWS Lambda and ESP Module. International Journal of Management, Technology, and Social Sciences (IJMTS), 8(3), 256-261. DOI: https://doi.org/10.5281/zenodo.8260291
8. Chakraborty, S. & Aithal, P. S. (2024). AI Kitchen. International Journal of Applied Engineering and Management Letters (IJAEML), 8(1), 128-137. DOI: https://doi.org/10.5281/zenodo.10810228
9. Chakraborty, S., & Aithal, P. S. (2024). Communication Channels Review for ESP Module Using Arduino IDE and NodeMCU. International Journal of Applied Engineering and Management Letters (IJAEML), 8(1), 1-14. DOI: https://doi.org/10.5281/zenodo.10562843
10. Chakraborty, S., & Aithal, P. S., (2023). MVVM Demonstration Using C# WPF. International Journal of Applied Engineering and Management Letters (IJAEML), 7(1), 1-14. DOI: https://doi.org/10.5281/zenodo.7538711