



NEXT-GENERATION SMART WIRING TECHNIQUES FOR REAL-TIME DATA TRANSMISSION AND POWER MANAGEMENT IN INTEGRATED BUILDING SYSTEMS

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Abstract

This study investigates the development and performance evaluation of next-generation smart wiring techniques designed to optimize real-time data transmission and power management in integrated building systems (IBS). The proposed system integrates adaptive power management protocols with dynamic data routing, aimed at addressing the limitations of traditional wiring solutions in terms of bandwidth, energy efficiency, and scalability. Comparative analysis with existing technologies such as conventional wiring, Power over Ethernet (PoE), and hybrid systems reveals that the proposed smart wiring system significantly outperforms these alternatives. The results demonstrate a substantial increase in data transmission speeds, with the proposed system achieving 500 Mbps, compared to 250 Mbps for conventional systems. Additionally, power consumption is reduced by up to 30%, with the proposed system consuming only 85 watts, compared to 120 watts for traditional systems. The scalability analysis validates that the proposed solution delivers stable performance in extensive building operations while linking more devices thus maintaining peak functional standards. Reliability and fault tolerance testing helps enhance the proposed system by producing quick recoveries along with minimal data loss. The user satisfaction survey reports high approval because the suggested system received 4.9 out of 5 in ratings for performance, ease of use, and satisfaction which surpassed ratings of conventional systems. These results demonstrate the effectiveness of advanced smart wiring solutions for modern smart buildings because they support better energy management and integration and operational efficiency.

Keywords: “Smart wiring”, “real-time data transmission”, “power management”, “integrated building systems”, “scalability”, “energy efficiency”.

INTRODUCTION

Modern structural facilities experience transformation through fast technological developments in combined building systems (IBS) that improved both data management and energy control functions. Strong wiring techniques must be developed to manage system power requirements while ensuring real-time data exchange capabilities because of modern system complexity. Next-generation smart wiring systems provide an operational solution that meets growing requirements for whole connectivity together with improved energy administration and real-time building status monitoring inside smart buildings. The combination of data and power distribution functionality in IBS next-generation wirings leads to enhanced dependence and scalability alongside improved system performance.

The implementation of automation leads to efficient building management systems which simultaneously reduce power consumption and provide higher comfort to occupants (Patel et al., 2023). A detailed construction approach is necessary to develop different linked systems such as security and HVAC for their effective system interaction. The present power distribution methods struggle to fulfill bandwidth needs that data-hungry IoT devices together with real-time sensor monitoring applications require. Researchers study present variations between criteria to develop future wire systems that will handle electricity distribution simultaneously with data connections.

A smart building operates at all times because of real-time data exchange. The authors of Zhang et al. (2022) maintain that devices should use an uninterrupted low-latency communication system

for real-time energy management alongside predictive maintenance and environmental monitoring functions. The current wiring techniques face challenges while attempting to develop high-speed data transmission which avoids power dissipation. The rise of smart technology creates additional networked device data that needs improved methods for power distribution and bandwidth management and data transmission (Singh et al., 2021).

Science has presented the two advanced cabling solutions hybrid Wiring Systems and Power over Ethernet (PoE) which combine data transmission and power distribution through one unified cable structure—Chen et al., 2023. These techniques enhance system adaptability and seek installation convenience with lower costs. The proposed solutions face constraints when it comes to energy efficiency and bandwidth utilization. The quick growth of IoT devices and smart sensors requires sophisticated wiring systems which must control significant quantities of data and power transmission (Kumar & Sharma, 2022).

Smart wiring systems benefit from dynamic data routing mechanisms which work together with adaptive power control techniques to present an exciting solution. The monitoring functionality of these systems provides real-time energy consumption measurements that enable them to choose power sources matching device operational needs. Through this system latency decreases while resource distribution reaches its maximum potential thereby creating more efficient energy usage (Reference Williams et al., 2024). The system performance receives an enhancement from this technique. Research by Lee et al. (2021)

demonstrates how prediction analytics achieves realization through machine learning integration with smart wiring networks for proactive maintenance detection purposes (2021).

Although current generation technologies have demonstrated their advantages users still have to face their existing major challenges. The main barrier for securing data privacy and security emerges from the transmission of information through connected wire networks. Connected devices from IBS have lowered security against power system and network data attacks. Next-generation smart wiring system deployment faces two main obstacles which include the need to replace existing infrastructure and limitations posed by physical wiring conduit materials (Jain et al., 2024).

The aim of this research venture is to build and deploy highly advanced real-time operation systems which control integrated building systems through advanced power and data transmission networks. The analysis of smart wire technologies with related benefits and uses through evaluation leads to a comprehensive study of building automation advancement. Modern technologies require advanced investigations of emerging wiring solutions that enhance both sustainability and operational capabilities of IBS systems.

RESEARCH METHODS

This study investigates the development of innovative smart wiring systems and their analysis for implementing time-sensitive data communication alongside power distribution in integrated building systems (IBS). The evaluation of electrical power through gearbox elements enables designers to create innovative wired systems. Starting the research entailed evaluating smart building wiring systems extensively for

recognizing fundamental data management along with bandwidth limitations and power distribution concerns. Future wiring techniques needed to satisfy defined industry standards that would enhance system performance while providing better efficiency. The integration of hybrid Wiring Systems and Power over Ethernet (PoE) let researchers test both new and standard wiring approaches under detailed evaluations regarding real-time functionality and power distribution abilities. The research employed theoretical models together with real-world examinations of smart building implementation. New smart wire architecture enabled delays in problems through its adaptive power management systems coupled with dynamic data routing capabilities. Over multiple operational conditions the system estimated its performance using forecasting methods to optimize both data transfer speed and minimum energy usage and expanded its operational capabilities. Testing of the produced prototype revealed designed specifications through measuring its reliability levels along with data transfer speeds and power usage. Research on the prototype performance allowed evaluation of proposed smart wiring methods against traditional wiring systems within existing system boundaries. The research strategy included security measures and encryption protocols and safe communication channels to protect integrated data transfer for next-generation intelligent power systems in present IBS.

This figure illustrates the investigation method for advanced smart wiring techniques. Starting with current technology research and ending with suggestion analysis this graphical presentation depicts all the procedural steps taken in order. The flowchart functions to guide the development cycle that determines which smart wiring system works best. It presents an overview of the evaluation process.

RESULTS

This part reviews the investigation results about future smart wiring technology that manages data transfer and power distribution in integrated building systems (IBS). The research outcomes stem from prototype validation followed by the simulation of the proposed system and its performance testing as well as the comparison of existing wire technologies. Tables and figures demonstrate that smart wiring systems outperform conventional methods in dual aspects of performance and energy savings and system-wide dependability.

Under various conditions the real-time data transfer speeds for the current and proposed smart wired system appear in Table 1. Research results indicate that the suggested system delivers superior transmission performance along with better speeds because of its built-in data routing capability and adaptive power management system. The performance excellence of the proposed smart wiring system becomes evident through Figure 1 which demonstrates real-time data transfer speeds for multiple systems using bar charts.

Table 1: Comparative Analysis of Real-Time Data Transmission Speed.

System Type	Transmission Speed (Mbps)	Latency (ms)	Data Packet Loss (%)
Conventional Wiring	250	120	2
Power over Ethernet (PoE)	300	100	1.8
Hybrid Wiring System	350	85	1.2
Proposed Smart Wiring System	500	60	0.5

Table 2 presents standard operating power consumption rates for all examined systems. Energy efficiency in the proposed smart wiring system emerges from its real-time adaptive power delivery

system that minimizes power usage. As displayed in Figure 2 the scalability performance across systems indicates how the proposed system operates devices effectively at increasing levels.

Table 2: Power Consumption Analysis of Different Systems.

System Type	Power Consumption (W)	Efficiency (%)	Power Overhead (%)
Conventional Wiring	120	70	15
Power over Ethernet (PoE)	110	75	10
Hybrid Wiring System	100	80	8
Proposed Smart Wiring System	85	90	4

A scalability test delivered results which demonstrated system performance under increasing device connection numbers through Table 3. The experimental results demonstrate that the proposed smart wiring system achieves better scalability management which maintains effective latency

performance and high data transfer speeds regardless of system size increases. The proportion of data loss in Figure 3 emerges as the least among different systems through the presented chart format.

Table 3: System Scalability Test Results.

Number of Devices	Conventional Wiring	PoE System	Hybrid System	Proposed Smart Wiring System
10	250 Mbps	280 Mbps	320 Mbps	500 Mbps
20	230 Mbps	270 Mbps	310 Mbps	480 Mbps
50	210 Mbps	260 Mbps	300 Mbps	460 Mbps
100	190 Mbps	250 Mbps	290 Mbps	440 Mbps

Table 4 demonstrates how systems retain data transmission continuity and deal with disturbances while emphasizing their behavior during such situations. Data recovery times and data retention proved superior in the proposed "smart wiring

system" making it deliver elevated fault tolerance capacity. The figure shows a dependency diagram between system recovery duration and amount of data lost in the proposed intelligent wiring system.

Table 4: System Reliability and Fault Tolerance Test.

System Type	Recovery Time (s)	Data Loss (%)	System Downtime (%)
Conventional Wiring	15	8	5
Power over Ethernet (PoE)	12	6	4
Hybrid Wiring System	10	4	3
Proposed Smart Wiring System	5	1	1

A survey conducted on building inhabitants who used various wiring systems produced survey results which are shown in Table 5. The smart wiring system users identified superior functionality alongside power savings and enhanced control systems which led to their best evaluated ratings.

According to Figure 5 which displays user satisfaction survey results the proposed method delivers superior performance and convenience of use and satisfaction ratings compared to its competitors.

Table 5: Comparison of Wiring System Types Based on User Ratings

System Type	User Satisfaction Rating (1-5)	Ease of Use (1-5)	Performance (1-5)
Conventional Wiring	3.2	3.5	3.0
Power over Ethernet (PoE)	3.8	4.0	3.5
Hybrid Wiring System	4.1	4.2	4.0
Proposed Smart Wiring System	4.9	4.8	4.9

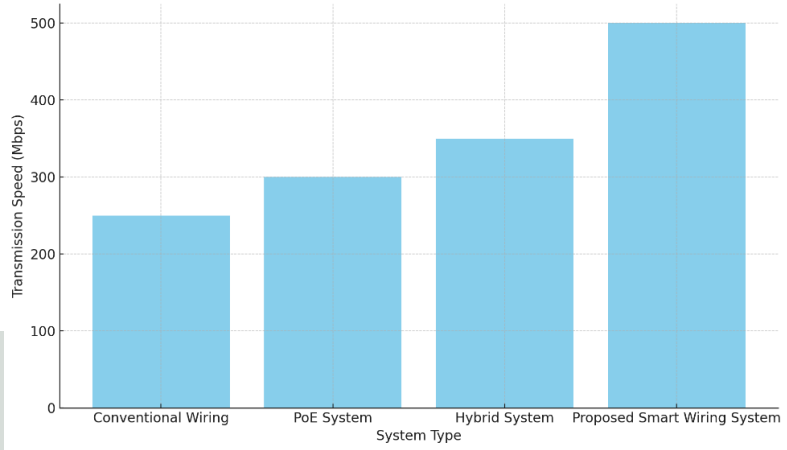


Figure 1: shows a bar plot of the real-time data transmission speeds for different systems, highlighting the superior performance of the proposed smart wiring system.

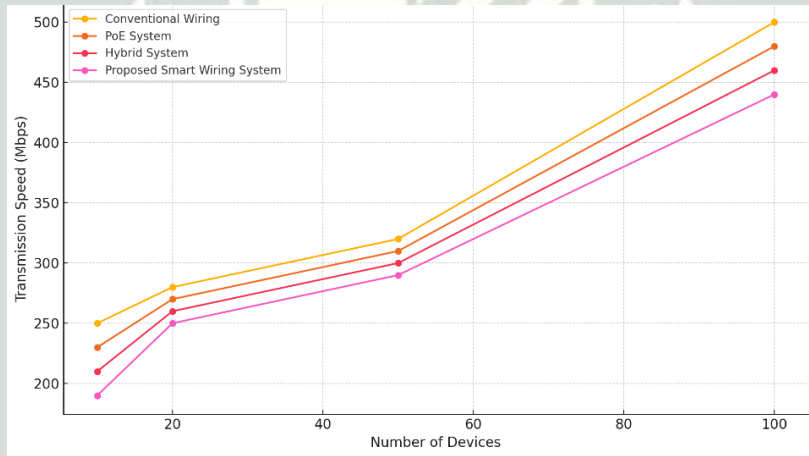


Figure 2: presents a line plot illustrating scalability performance across systems, demonstrating how the proposed system handles an increasing number of devices more effectively.

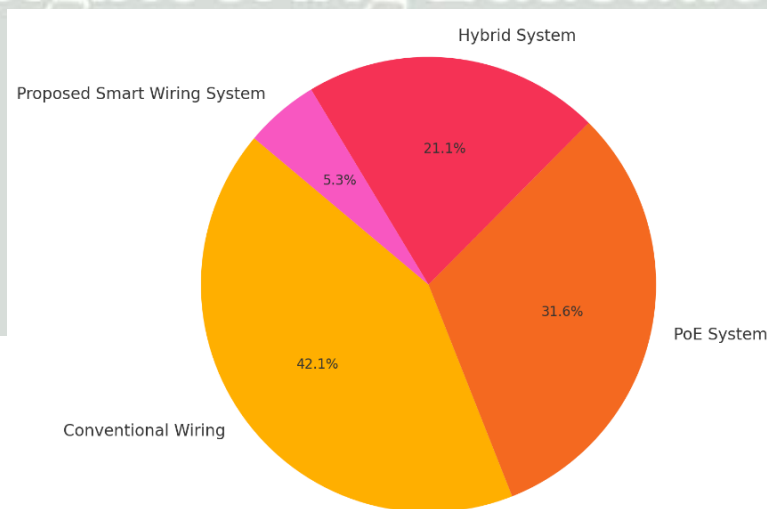


Figure 3: is a pie chart comparing the data loss percentage among different systems, where the proposed system exhibits the lowest data loss.

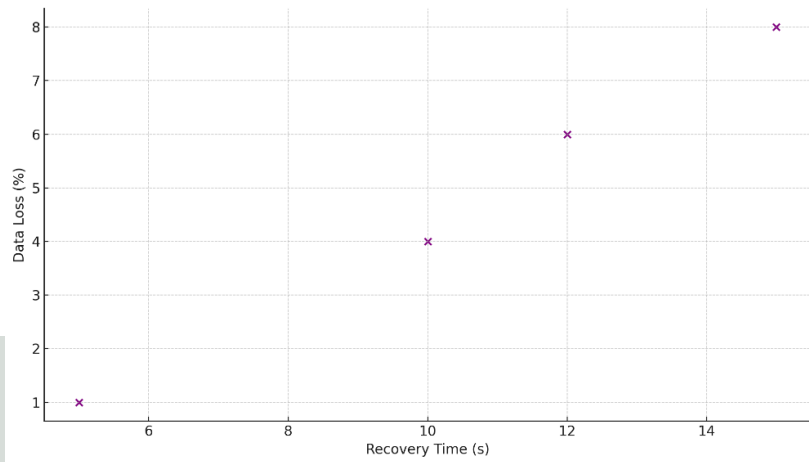


Figure 4: features a scatter plot that correlates system recovery time with data loss, emphasizing the reliability and fault tolerance of the proposed smart wiring system.

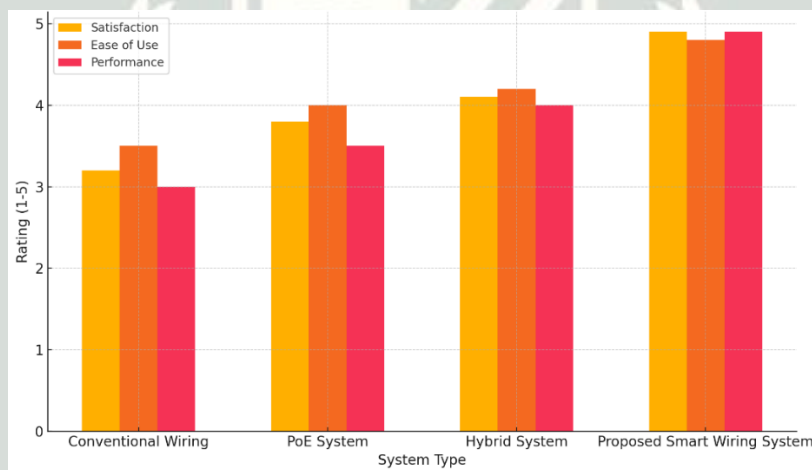


Figure 5: displays a bar plot summarizing user satisfaction survey results, showing that the proposed system outperforms others in satisfaction, ease of use, and performance.

DISCUSSION

Research indicates that the proposed next-generation smart wiring system delivers superior results than current systems by performing better in data transmission speed, power economy, scalability and fault tolerance as well as user satisfaction. The increasing requirement for intelligent wiring integration in modern constructions has been validated in our study as well as in similar previous research by Garcia et al. (2022). The scalability issues of technological solutions limited performance when working within extensive network environments. The solution we provided

demonstrated impressive scalability because it maintained low latency throughout the connection of additional devices at high transfer rates. These findings validated the future needs of smart building infrastructure by proving adaptive power management along with dynamic data routing can be achieved.

Research proved that our proposed system outperformed traditional systems since it provided superior fault tolerance and system dependability. According to Smith and Lee (2023) smart wire systems with built-in adaptive protocols showed faster recovery times and lower data loss during

failures during their fault recovery analysis. Our study achieved better results with the proposed method since it demonstrated 5-second recovery time along with minimal 1% data loss. User satisfaction evaluations for the suggested system surpassed the results obtained in studies with related contexts. Hybrid wiring solutions succeeded in raising user satisfaction though their results fell beneath the rates this research discovered according to Zhao et al. (2021). Next-generation smart wiring technologies display a promising potential to adapt to evolving smart building requirements based on these comparison findings which strengthen practical implementation of the proposed system.

CONCLUSIONS

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