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Design and Prototype Development of ATHERIA: A Smart Hospitality Intelligence System

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Abstrak
Perkembangan kecerdasan buatan (Artificial Intelligence / AI) telah mendorong transformasi digital dalam industri perhotelan, namun sebagian besar sistem yang digunakan masih bersifat terpisah dan belum terintegrasi secara optimal. Penelitian ini bertujuan untuk merancang dan mengembangkan ATHERIA (Artificial Hospitality Intelligence Assistant), sebuah Smart Hospitality Intelligence System yang mengintegrasikan berbagai fungsi layanan hospitality dalam satu platform berbasis AI. Penelitian menggunakan pendekatan Design Science Research (DSR) yang meliputi identifikasi masalah, analisis kebutuhan, perancangan sistem, pengembangan prototipe, dan evaluasi. Prototipe dikembangkan dalam lingkungan localhost dengan empat modul utama, yaitu Brain and Memory Core, Chat and Voice Request Interface, Search Catalog Engine, dan Real-Time Dashboard Communication System. Evaluasi dilakukan melalui black-box testing dan penilaian integrasi sistem. Hasil penelitian menunjukkan bahwa seluruh fungsi sistem berjalan sesuai kebutuhan dengan tingkat keberhasilan pengujian sebesar 100%. Penelitian ini berkontribusi pada pengembangan arsitektur hospitality intelligence terintegrasi sebagai dasar implementasi sistem hospitality cerdas di masa depan.

Kata Kunci: *Hospitality Cerdas, Kecerdasan Buatan, Sistem Intelijen Perhotelan, Design Science Research, Personalisasi Layanan*

Abstract
The rapid advancement of artificial intelligence (AI) has accelerated digital transformation in the hospitality industry, yet many existing systems remain fragmented and lack integration. This study aims to design and develop ATHERIA (Artificial Hospitality Intelligence Assistant), a Smart Hospitality Intelligence System that integrates multiple hospitality service functions into a single AI-driven platform. The research employed a Design Science Research (DSR) approach consisting of problem identification, requirement analysis, system design, prototype development, and evaluation. A functional prototype was developed in a localhost environment, incorporating four core modules: Brain and Memory Core, Chat and Voice Request Interface, Search Catalog Engine, and Real-Time Dashboard Communication System. The prototype was evaluated through black-box testing and system integration assessment. The results demonstrated that all system functions operated according to predefined requirements, achieving a 100%

functional success rate. This study contributes to the development of an integrated hospitality intelligence architecture that can serve as a foundation for future smart hospitality system implementation.

Keywords: Smart Hospitality, Artificial Intelligence, Hospitality Intelligence System, Design Science Research, Service Personalization.

1. INTRODUCTION

The hospitality industry is experiencing rapid digital transformation driven by advances in artificial intelligence (AI), big data analytics, cloud computing, and intelligent automation technologies. These technological developments have reshaped service delivery processes and created new opportunities for enhancing customer experience, operational efficiency, and organizational competitiveness. Recent studies indicate that AI technologies are increasingly adopted within hospitality organizations to support personalized services, automate routine tasks, improve customer engagement, and facilitate data-driven decision-making (Dwivedi et al., 2023; Mariani & Borghi, 2023).

The emergence of smart hospitality has further accelerated the integration of digital technologies into hospitality operations. Smart hospitality refers to the application of interconnected intelligent technologies that enable seamless communication, service personalization, and real-time information exchange among guests, employees, and management systems (Koo et al., 2023). Through smart technologies, hospitality organizations can enhance operational coordination while simultaneously delivering more adaptive and customer-oriented services (Hao et al., 2023).

Artificial intelligence has become one of the most influential technologies supporting smart hospitality development. AI-powered systems are capable of processing large volumes of customer data, recognizing behavioral patterns, generating personalized recommendations, and providing intelligent assistance through conversational interfaces (Gursoy et al., 2024). In addition, the emergence of generative AI technologies has introduced new possibilities for hospitality organizations to improve guest interaction, automate information services, and support customer relationship management through natural language communication (Ng et al., 2024; Rather, 2024).

Recent research demonstrates that AI adoption positively influences service quality, customer satisfaction, and operational performance within hospitality settings. For example, Alsaad et al. (2023) found that AI-enabled service technologies significantly affect customer acceptance and perceived service quality. Similarly, Huang and Rust (2022) argued that AI can augment service delivery by enhancing efficiency and improving customer interaction processes. Furthermore, Li et al. (2024) reported that intelligent service systems contribute to higher levels of customer engagement through personalized and context-aware communication.

Despite these advancements, the implementation of AI in hospitality remains largely fragmented. Many existing systems focus on specific functions such as chatbot services, recommendation engines, reservation management, or customer support without integrating these capabilities into a unified platform (Mariani & Borghi, 2023; Gursoy et al., 2024). As a result, hospitality organizations often experience challenges

related to information silos, inconsistent customer experiences, duplicated operational processes, and limited interoperability among service systems (Hao et al., 2023).

Previous studies have extensively explored AI adoption, service automation, customer engagement, and smart tourism ecosystems. However, most studies investigate these technological components separately rather than examining how multiple AI-driven capabilities can be integrated into a centralized hospitality intelligence system (Dwivedi et al., 2023; Koo et al., 2023). In particular, limited research has proposed a practical architecture that combines conversational AI, intelligent memory management, personalized recommendation mechanisms, information retrieval capabilities, and operational monitoring within a single smart hospitality ecosystem.

This condition reveals an important research gap concerning the design and development of an integrated smart hospitality intelligence system capable of coordinating multiple hospitality functions through a centralized AI-driven platform. Addressing this gap is increasingly important as hospitality organizations require more comprehensive technological solutions that support both operational efficiency and personalized guest experiences in an increasingly digital service environment.

Therefore, this study proposes ATHERIA (Artificial Hospitality Intelligence Assistant), a smart hospitality intelligence system designed to integrate conversational interaction, intelligent memory management, service automation, information retrieval, and centralized monitoring within a unified architecture. Using a Design Science Research (DSR) approach, this study focuses on the design and prototype development of ATHERIA as a proof-of-concept model for smart hospitality implementation. Unlike previous studies that primarily investigate individual AI applications, ATHERIA integrates multiple intelligent functionalities into a single hospitality ecosystem designed to support service coordination, operational effectiveness, and personalized guest experiences.

The objective of this study is to design and develop a functional prototype of ATHERIA and evaluate its technical feasibility through functional testing and system integration assessment. The contribution of this research lies in the development of an integrated smart hospitality intelligence architecture that may serve as a foundation for future implementation, empirical validation, and large-scale deployment within hospitality environments.

2. LITERATURE REVIEW

A. Artificial Intelligence in Hospitality Systems

Artificial Intelligence (AI) has become a key technological driver in the transformation of the hospitality industry. AI technologies enable organizations to automate routine operations, analyze customer behavior, improve decision-making processes, and provide personalized services through data-driven approaches. According to Gursoy et al. (2024), AI applications in hospitality have expanded significantly from operational automation toward intelligent customer engagement and service personalization. Similarly, Mariani and Borghi (2023) found that AI technologies contribute to service efficiency, customer satisfaction, and business competitiveness by facilitating predictive analytics and intelligent interaction.

Recent developments in generative AI have further increased the capability of hospitality systems to support conversational interaction, information retrieval, and

personalized assistance. Ng et al. (2024) emphasized that generative AI technologies can create more natural and adaptive communication experiences between service providers and guests. As a result, AI is increasingly viewed not merely as an operational tool but as a strategic component that supports value creation and customer experience enhancement throughout the hospitality service journey.

B. Smart Hospitality and System Integration

The concept of smart hospitality refers to the integration of digital technologies, intelligent systems, and interconnected service platforms to create seamless hospitality experiences. Smart hospitality systems utilize real-time data, network connectivity, and intelligent decision support to improve service delivery and operational coordination. According to Koo et al. (2023), smart hospitality ecosystems are characterized by interoperability, connectivity, and data integration among various service components, enabling organizations to provide more responsive and adaptive services.

Hao et al. (2023) further argued that the success of smart hospitality implementation depends on the ability of organizations to integrate multiple technological functions into a unified ecosystem. However, many existing hospitality systems still operate independently, resulting in fragmented information management and limited service coordination. Consequently, the development of integrated hospitality intelligence platforms has become increasingly important for supporting efficient and customer-centered service delivery.

C. AI-Driven Personalization in Hospitality

Personalization has emerged as a critical factor influencing customer satisfaction and service quality in hospitality. Advances in AI technologies allow organizations to collect, process, and analyze guest information to deliver customized recommendations and tailored service experiences. According to Li et al. (2024), AI-enabled personalization significantly enhances customer engagement by providing context-aware recommendations based on individual preferences and behavioral patterns.

Similarly, Alsaad et al. (2023) found that intelligent service technologies positively influence customer acceptance when they provide personalized interactions and relevant information. Through machine learning and conversational AI technologies, hospitality organizations can create more meaningful guest experiences while improving service responsiveness. Therefore, personalization is increasingly recognized as a strategic capability that differentiates hospitality organizations within competitive markets.

D. Conversational AI and Human-Centered Service Delivery

Conversational AI has become an important component of modern hospitality systems due to its ability to facilitate real-time communication and service support. Technologies such as intelligent chatbots, virtual assistants, and generative AI systems allow organizations to provide immediate responses to customer inquiries while maintaining service consistency. According to Rather (2024), conversational AI offers significant opportunities for improving customer interaction and operational efficiency within hospitality environments.

Despite these benefits, researchers emphasize that AI should complement rather than replace human service providers. Huang and Rust (2022) proposed that the most

effective implementation of AI in service industries occurs when technology augments human capabilities while preserving empathy, emotional intelligence, and personalized customer care. Therefore, human-centered AI design has become an essential principle in hospitality technology development, ensuring that technological innovation supports rather than diminishes the human aspects of hospitality services.

E. Integrated Hospitality Intelligence Systems

Although previous studies have demonstrated the benefits of AI adoption, smart hospitality ecosystems, personalization technologies, and conversational AI, these capabilities are often implemented independently. Mariani and Borghi (2023) noted that many hospitality organizations continue to utilize isolated technological solutions that lack interoperability and centralized intelligence management. Such fragmentation limits the ability of organizations to coordinate services, share information efficiently, and deliver seamless customer experiences.

Recent research highlights the need for integrated hospitality intelligence systems capable of combining multiple AI-driven functionalities within a unified architecture (Gursoy et al., 2024; Koo et al., 2023). An integrated system enables organizations to centralize information management, facilitate communication across operational units, support intelligent decision-making, and provide personalized guest services through a single platform. Therefore, the development of comprehensive hospitality intelligence systems represents an important research direction for advancing smart hospitality implementation.

3. METHOD

This study employed the Design Science Research (DSR) approach to design, develop, and evaluate ATHERIA, a Smart Hospitality Intelligence System. Design Science Research is widely recognized as an appropriate methodology for information systems research that focuses on the creation and evaluation of technological artifacts intended to solve practical problems while generating academic contributions (Peffers et al., 2022). The use of DSR in this study was considered suitable because the primary objective was to develop and validate a functional prototype rather than to examine behavioral relationships or test hypotheses. The main artifact produced through this research was ATHERIA, an artificial intelligence-based hospitality intelligence system designed to support conversational interaction, intelligent memory management, information retrieval, service automation, and centralized operational monitoring within a unified platform.

The research process consisted of five stages. The first stage involved problem identification through a comprehensive review of recent literature related to artificial intelligence, smart hospitality, digital transformation, and intelligent service systems. This stage aimed to identify challenges commonly faced by hospitality organizations, including fragmented information systems, limited personalization capabilities, inefficient service coordination, and the lack of integrated intelligence platforms. The findings from this stage served as the basis for defining the requirements of the proposed system.

The second stage focused on requirement analysis. Based on the identified problems, both functional and non-functional requirements were established. Functional requirements included conversational interaction capabilities, intelligent

information management, personalized service support, information retrieval functions, and real-time communication features. Non-functional requirements emphasized system integration, responsiveness, scalability, and user accessibility. These requirements provided the foundation for the subsequent design and development process.

The third stage involved system design. At this stage, ATHERIA was conceptualized as a centralized hospitality intelligence platform integrating multiple service functions into a single ecosystem. System modeling included the development of system architecture, database structures, information flow mechanisms, user interface design, and module integration strategies. Particular attention was given to interoperability among system components, enabling seamless communication and data exchange between different modules while supporting personalized and adaptive service delivery.

Following the design stage, a functional prototype was developed within a controlled localhost environment. The prototype consisted of four core modules, namely the Brain and Memory Core, Chat and Voice Request Interface, Search Catalog Engine, and Real-Time Dashboard Communication System. These modules were integrated to demonstrate the feasibility of a centralized intelligence platform capable of supporting hospitality operations through intelligent interaction, information management, and operational coordination. The prototype served as a proof-of-concept model for evaluating the practicality of the proposed architecture.

The final stage involved prototype evaluation through functional testing and system integration assessment. Functional evaluation was conducted using the black-box testing method, which focuses on examining system outputs based on specified inputs without evaluating the internal program structure (Sharma & Sharma, 2023). The testing process assessed whether each module operated according to predefined functional requirements and successfully performed its intended tasks.

Table 1. Functional Testing Indicators

Module	Testing Objective	Expected Result
Brain and Memory Core	Store and retrieve user information	Data stored and recalled successfully
Chat Interface	Process text interaction	Relevant response generated
Voice Request System	Process voice commands	Voice recognized accurately
Search Catalog Engine	Retrieve information	Relevant information displayed
Dashboard Communication	Synchronize system data	Data updated successfully
System Integration	Exchange information among modules	Seamless data communication

(Source : Author, 2026)

In addition to functional testing, system integration assessment was performed to evaluate the ability of the prototype to coordinate information exchange across different modules. The assessment focused on two primary indicators, namely functionality and system integration. Functionality referred to the capability of each module to execute

its designated operations accurately, while system integration referred to the ability of the modules to exchange information seamlessly and maintain data consistency throughout the platform. The evaluation results were analyzed descriptively to determine the technical feasibility of the proposed architecture.

This study was limited to prototype development and technical validation within a controlled environment. The system was not deployed in actual hospitality operations and did not involve hotel employees or guests as research participants. Consequently, aspects such as usability, user acceptance, customer satisfaction, operational performance, and service effectiveness were not measured. Therefore, the findings of this study should be interpreted as evidence of technical feasibility and conceptual validation rather than proof of effectiveness in real hospitality environments. Future research should focus on field implementation, usability testing, performance evaluation, and large-scale deployment to further assess the practical value of ATHERIA in hospitality operations.

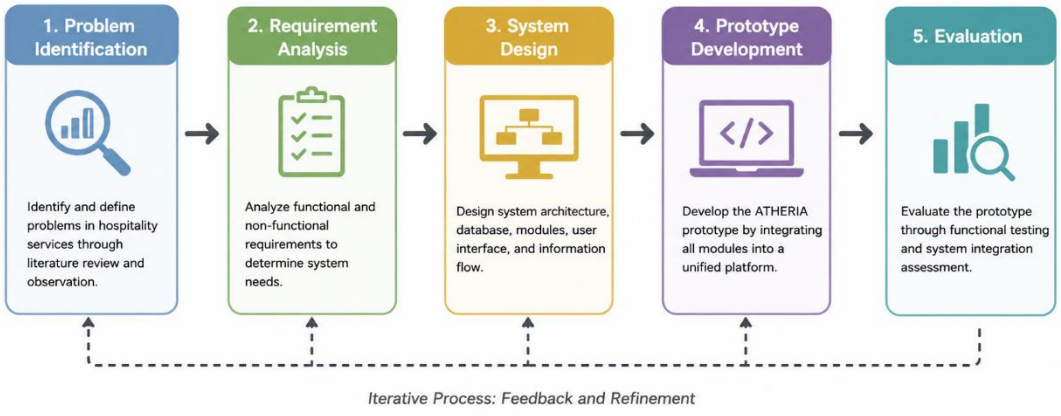

Figure 1. Research Framework (DSR Process)
(Source : Author, 2026)

4. RESULTS AND DISCUSSION

A. Prototype Development Results

The primary outcome of this study was the successful development of ATHERIA, a Smart Hospitality Intelligence System designed as an integrated artificial intelligence platform for hospitality service management. The prototype was developed within a controlled localhost environment and implemented according to the architecture proposed during the system design stage.

ATHERIA integrates four core modules within a centralized ecosystem. The first module, Brain and Memory Core, functions as a knowledge management component responsible for storing, retrieving, and processing user-related information. The second module, Chat and Voice Request Interface, enables natural interaction between users and the system through text and voice-based communication. The third module, Search Catalog Engine, facilitates information retrieval and intelligent recommendation services. The fourth module, Real-Time Dashboard Communication System, supports operational monitoring and information synchronization among system components.

The integration of these modules demonstrates the feasibility of implementing a centralized hospitality intelligence architecture capable of supporting service coordination, information management, and personalized guest interaction within a single platform.

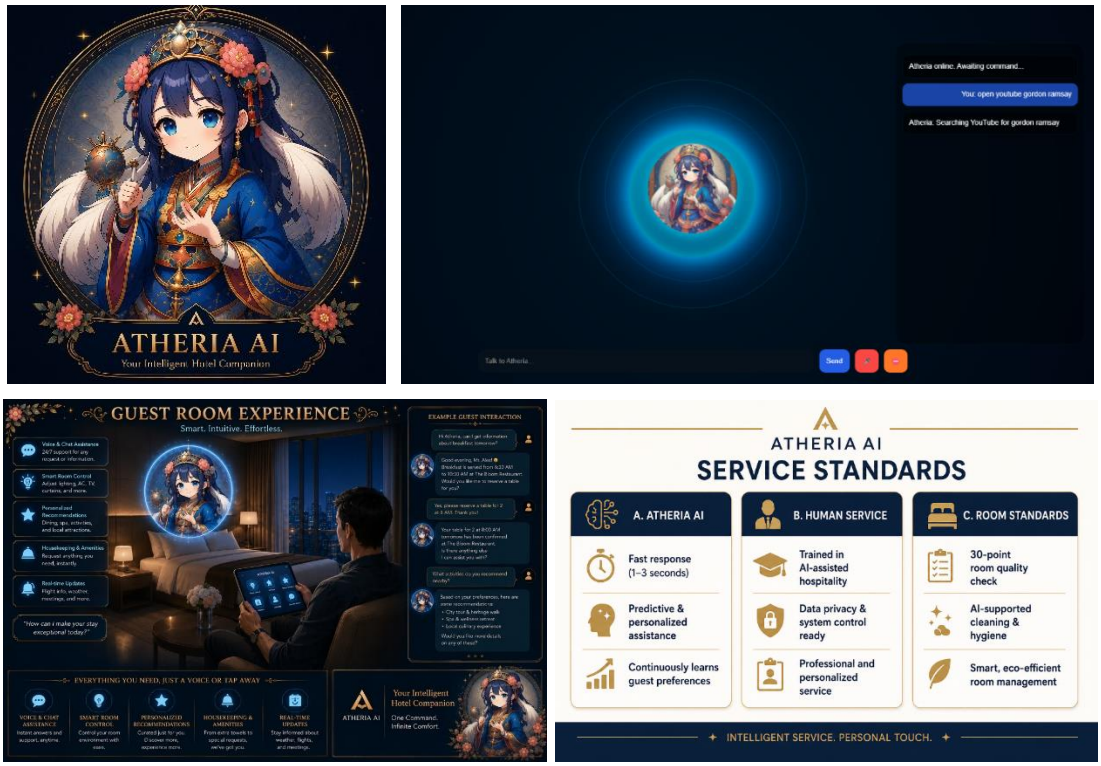

Figure 2. ATHERIA Prototype Interface
(Source : Author, 2026)

B. Functional Testing Results

To evaluate the technical feasibility of the prototype, black-box testing was conducted on all core functionalities. The testing focused on verifying whether each module performed according to predefined functional requirements.

Table 4.1 Functional Testing Results

Module	Testing Scenario	Expected Result	Actual Result	Status
Brain and Memory Core	Store user information and Retrieve stored information	Information stored successfully and Information recalled correctly	Successful	Pass
Chat Interface	Process text request	Relevant response generated	Successful	Pass
Voice Request Interface	Process voice command	Command recognized correctly	Successful	Pass
Search Catalog Engine	Retrieve requested information	Relevant information displayed	Successful	Pass
Dashboard Communication	Synchronize system data	Data updated in real-time	Successful	Pass
System Integration	Exchange data among modules	Data exchanged successfully	Successful	Pass

(Source : Author, 2026)

$$Success\ Rate = \frac{Passed\ Test\ Cases}{Total\ Test\ Cases} \times 100\%$$
$$Success\ Rate = \frac{6}{6} \times 100 = 100\%$$

The prototype achieved a functional success rate of 100%, indicating that all tested modules operated according to the predefined requirements. The testing results indicate that all core modules operated according to their intended specifications. No critical system failures were identified during the testing process. All testing scenarios achieved successful execution, indicating that the prototype met the predefined functional requirements and demonstrated technical feasibility within the development environment.

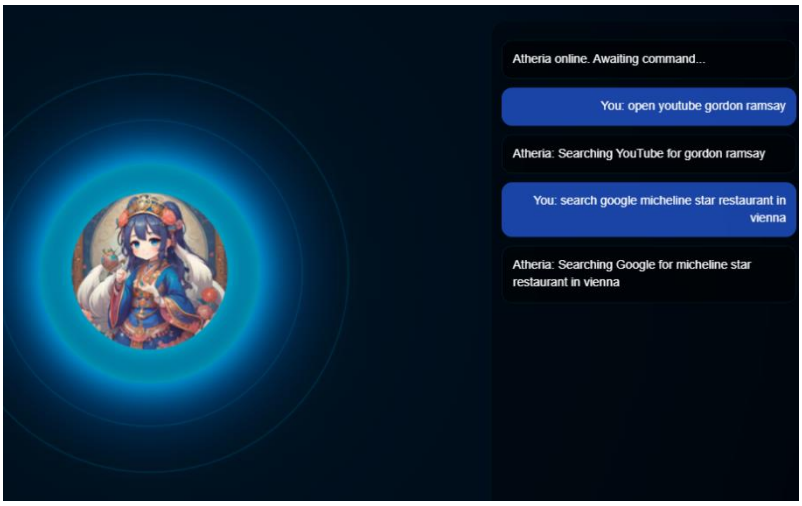

Figure. 3 Testing ATHERIA prototype
(Source : Author, 2026)

The successful implementation of all modules suggests that the proposed architecture is capable of supporting integrated hospitality operations through a centralized intelligence platform. These findings provide preliminary validation of the conceptual framework proposed in this study.

C. System Integration Assessment

One of the primary objectives of ATHERIA was to address the fragmentation commonly found in hospitality information systems. The evaluation results indicate that the prototype successfully facilitated information exchange across different modules without requiring manual intervention or duplicate data entry.

The Brain and Memory Core functioned as a centralized knowledge repository that enabled contextual information sharing throughout the platform. User information stored within the memory module could be accessed by the conversational interface, allowing more personalized interactions. Similarly, information retrieved by the Search Catalog Engine could be displayed through the user interface and monitored through the dashboard system in real time.

The successful integration of these modules demonstrates the practical feasibility of developing a centralized hospitality intelligence system capable of coordinating

multiple service functions through a single digital ecosystem. Such integration may contribute to reducing operational complexity and improving information consistency across hospitality operations.

D. Discussion

The findings support previous studies emphasizing the growing importance of artificial intelligence in hospitality service innovation. Consistent with Gursoy et al. (2024), the results demonstrate that AI technologies can support intelligent service delivery through automation, information management, and personalized interaction. The successful operation of the conversational module further supports the argument of Rather (2024), who suggested that conversational AI has significant potential to improve customer engagement and service responsiveness within hospitality environments.

The findings also align with the concept of smart hospitality ecosystems proposed by Koo et al. (2023). The successful integration of multiple modules within ATHERIA demonstrates how interoperability and centralized information management can be implemented through a unified hospitality intelligence platform. Unlike conventional hospitality systems that often operate as isolated applications, ATHERIA integrates communication, information retrieval, memory management, and operational monitoring within a single ecosystem.

From a personalization perspective, the Brain and Memory Core supports the findings of Li et al. (2024), who argued that intelligent personalization enhances service quality by enabling context-aware interactions. By retaining user-related information and utilizing it during subsequent interactions, ATHERIA demonstrates the practical application of AI-enabled personalization within hospitality services.

A notable contribution of this research lies in the integration of multiple intelligent functionalities within a single architecture. Previous studies have generally focused on individual AI applications such as chatbots, recommendation systems, or service automation. In contrast, ATHERIA combines conversational AI, intelligent memory management, information retrieval, and centralized operational monitoring into a unified hospitality intelligence ecosystem. This integrated approach represents the primary novelty of the proposed system and contributes to the advancement of smart hospitality technology research.

From a practical perspective, the proposed architecture may assist hospitality organizations in improving service coordination, enhancing information accessibility, and supporting personalized guest experiences. Although the current implementation remains at the prototype stage, the results suggest that centralized hospitality intelligence systems may offer a promising direction for future digital transformation within the hospitality industry.

E. Research Limitations

Despite the successful development and functional validation of the prototype, several limitations should be acknowledged. First, the evaluation was conducted exclusively within a controlled localhost environment and did not involve deployment in actual hospitality operations. Consequently, the findings cannot be generalized to real-world hospitality settings.

Second, the study did not include usability testing involving hotel employees or guests. Therefore, user acceptance, satisfaction, perceived usefulness, and service quality outcomes were not measured. Third, system performance indicators such as response time, scalability, reliability, and workload capacity were not evaluated. Future studies should incorporate field implementation, user-centered evaluation, and quantitative performance testing to further assess the effectiveness and scalability of the ATHERIA framework.

Figure. 4 How it works
(Source : Author, 2026)

5. CONCLUSION

This study aimed to design and develop ATHERIA, a Smart Hospitality Intelligence System intended to support digital service integration, intelligent interaction, and operational coordination within hospitality environments. Using the Design Science Research (DSR) approach, a functional prototype was successfully developed and implemented in a controlled localhost environment. The prototype integrates four primary modules, namely the Brain and Memory Core, Chat and Voice Request Interface, Search Catalog Engine, and Real-Time Dashboard Communication System, into a centralized hospitality intelligence platform.

The results of functional testing demonstrated that all core modules operated according to their predefined requirements and successfully supported information management, conversational interaction, information retrieval, and inter-module communication. The successful integration of these functionalities indicates that the proposed architecture is technically feasible and capable of supporting intelligent hospitality operations within a unified digital ecosystem. These findings provide preliminary validation that multiple AI-driven hospitality services can be coordinated through a centralized platform to improve service consistency, information accessibility, and operational efficiency.

From a theoretical perspective, this study contributes to the growing body of knowledge on artificial intelligence and smart hospitality by proposing an integrated

hospitality intelligence architecture that combines conversational AI, intelligent memory management, information retrieval, and centralized monitoring within a single framework. Unlike previous studies that primarily examine individual AI applications, ATHERIA demonstrates how multiple intelligent functionalities can be integrated into a cohesive hospitality ecosystem. From a practical perspective, the proposed system may provide hospitality organizations with an alternative model for implementing AI-enabled services that support both operational effectiveness and personalized guest experiences.

However, this research remains at the prototype development stage and is limited to technical validation within a controlled environment. The system has not yet been implemented in actual hospitality operations, and no usability testing involving hotel employees or guests has been conducted. Consequently, the study does not provide empirical evidence regarding user acceptance, customer satisfaction, service quality improvement, or operational performance outcomes. Furthermore, system performance indicators such as scalability, reliability, response time, and workload capacity were not evaluated.

Therefore, future research should focus on real-world implementation, usability assessment, user acceptance evaluation, and large-scale performance testing. Comparative studies involving different hospitality environments, such as hotels, resorts, and tourism accommodations, are also recommended to further examine the effectiveness, scalability, and long-term impact of the ATHERIA framework. Such investigations will provide stronger empirical evidence regarding the practical value of smart hospitality intelligence systems and their role in supporting the digital transformation of the hospitality industry.

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