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RESEARCH PAPER

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Python-Based Backend Architecture Design for Commercial Medical IoT Device Integration: A Case Study of Omron HEM-7142T1

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Abstract

The current implementation of Remote Patient Monitoring (RPM) still faces crucial challenges related to the accuracy and integrity of medical data. Many healthcare IoT devices rely on generic sensors that require rigorous manual calibration and exhibit unstable error rates, failing to meet international clinical standards. This study aims to design and implement an integrated backend architecture that bridges certified commercial medical devices with digital health systems. The main contribution is a six-layer IoT architecture specifically designed to integrate the Omron HEM-7142T1 device to ensure data validity in remote blood pressure monitoring. Following the Design Science Research Methodology (DSRM), the system was developed using Python, the Bleak library for Bluetooth Low Energy (BLE) communication, and FastAPI to provide interoperable REST API services. Functional testing in Postman demonstrated that the system successfully extracts medical data, producing JSON output with an HTTP 200 OK status under single-access conditions. However, load testing using Apache JMeter with 10 virtual users revealed limitations in the hardware's point-to-point BLE protocol. The /scan endpoint showed stable performance with a 0% error rate and an average response time of 5.04 seconds. In contrast, endpoints /connect-and-read and endpoint /latest-bp-records recorded error rates of 100% and 90%, respectively, with an average response time of 23.29 seconds when accessed simultaneously, due to the Omron device's locking mechanism. This study concludes that while the six-layer architecture effectively ensures medical data integrity in single-access scenarios, it requires a database caching module in the Logic Tier to overcome parallel access constraints. The implementation provides a foundation for developing secure, standardized professional RPM systems for medical use.

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I. Introduction

The development of the Internet of Things (IoT) has made a significant contribution to the medical world [1]. One example is the Remote Patient Monitoring (RPM) system. The RPM system is effective for remote patient monitoring, especially for patients in remote locations or far from hospitals, critical conditions, and elderly patients [2]. Medical personnel can also detect and monitor patients' physiological parameters in real-time without having to meet face-to-face [3]. All physiological data required by doctors can be collected through the system and sent wirelessly to medical service centers. This allows doctors to evaluate patient conditions and make treatment decisions more quickly and accurately [4], [5]. Blood pressure measurement is one of the main parameters for diagnosing hypertension [6]. Previous research has shown that self-monitoring of blood pressure can help lower blood pressure levels in patients [7]. In addition, regular blood pressure monitoring is crucial for reducing the risk of chronic heart disease (CHD) and suppressing the prevalence of hypertension. Hypertension is one of the most common cardiovascular diseases and a leading cause of premature death worldwide. Therefore, the global target is to reduce the prevalence of hypertension by 25% by 2025 [8].

However, various studies have shown that healthcare IoT systems still face serious issues related to data accuracy. The majority of current RPM research still relies on generic sensors such as the MPX5050 or MPX5700 series, which require a rigorous calibration process. The use of the MPX5050GP analog blood pressure sensor processed through an Arduino Mega microcontroller, for example, is reported to have an accuracy rate ranging from 93% to 94% [9]. This accuracy fluctuation was also found in another study comparing the MPX5050GP sensor with an Omron digital tensiometer, with a maximum error rate of 5.06% for systolic and 6.45% for diastolic [10]. Then, an error was found in the average results of blood pressure ratio testing with the Arduino Uno-based MPX5050GP sensor. The error for the systolic

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ratio was 0.48, and for the diastolic ratio was 0.78 [11]. In fact, testing on ESP32 and NodeMCU-based systems shows that the difference in measurement results with the standard Omron HEM-8712 medical device can reach a significant difference with an average error of 7.09% in systolic and 6.88% in diastolic [12]. This high percentage of error, which in some cases in systolic/diastolic reaches 7.4% / 7.2% [13]. On the other hand, several studies have succeeded in reducing errors to around 2.49% [14] or achieving an accuracy of 96.83% [15]; these results still vary and have not reached the stability of certified medical devices.

Based on previous studies, generic sensors often fail to maintain consistent, accurate blood pressure measurements. Inaccurate blood pressure readings can lead to severe clinical consequences, such as misdiagnosis, inappropriate medication dosing, and failure to detect hypertensive crises. These inaccuracies ultimately elevate the risk of severe cardiovascular events like stroke or heart attack, highlighting the critical need for absolute data integrity in RPM systems. This encourages the need to integrate commercial medical IoT devices that have official marketing authorization, such as Omron (HEM-7142T1) [16], into a structured and interoperable system architecture. In addition, Omron has also gone through a testing process and obtained certification from leading international institutions, namely the American Association for the Advancement of Medical Instrumentation (AAMI) and the British Hypertension Society (BHS) [17]. These certifications guarantee that the device has passed rigorous clinical validation protocols. Meeting these specific standards is essential for ensuring that the data used for remote medical diagnostics is highly reliable.

Various studies have proposed IoT architecture models for smart healthcare systems. Research [18] proposed an IoT architecture based on four main layers: the perception layer, transport layer, processing layer, and application layer. This architecture emphasizes the integration of medical sensors and hospital systems, but still combines data processing functions and application services in a single, centralized layer, thus limiting backend flexibility and scalability. Meanwhile, research [19] proposed a more generic IoT architecture with five layers: the device layer, gateway layer, data management layer, application layer, and business layer. This model provides a broad conceptual overview. Neither study specifically discussed the architecture of IoT systems with commercial healthcare devices. This will be a research gap that will be filled in this study. Additionally, commercial healthcare devices differ from generic sensors in that they often use proprietary communication protocols, local locking mechanisms during data transfer, and closed-system data structures, requiring specialized parsing and integration layers.

To address these limitations, this study proposes a six-layer IoT architecture consisting of: a perception layer, a network layer, a service management layer, a data processing layer, an API service layer, and an application layer. The addition of separate API Service and Data Processing layers aims to improve modularity and data security when interacting with commercial healthcare devices via Bluetooth Low Energy (BLE). The primary objective of this study is to design a Python-based IoT architecture capable of securely and scalably extracting, processing, and distributing data from commercial medical devices.

The contributions of this study are summarized in four main points. The first point is the proposal of a six-layer IoT architecture optimized for standardized commercial medical device integration. The second point is the development of a backend using Python with the Bleak library for BLE communication and FastAPI for high-performance endpoint management. The third point is the development of a data parsing mechanism that converts device-exclusive data into a standard JSON Schema format ready for consumption by various platforms. The fourth point is the provision of a REST API service that supports full interoperability between commercial medical devices and the digital health ecosystem. Collectively, these four contributions provide a comprehensive blueprint for transitioning RPM systems from prototype-grade sensor networks to clinically reliable, interoperable digital health ecosystems.

The systematic structure of this article begins with Section I: Introduction, which presents the background and urgency of the problem. Section II: Materials and Methods provides a detailed explanation of the design for each architectural layer and the device specifications. Section III: Results presents the outcomes of the API functionality and latency testing. Section IV: Discussion analyzes the implications of the research findings in comparison with previous models, and the article concludes with Section V: Conclusion, which summarizes the findings and provides suggestions for future development.

II. Materials And Method

A. Remote Patient Monitoring

Remote Patient Monitoring (RPM) is an innovative healthcare system that allows for the regular tracking of patients' vital signs and health metrics outside of traditional clinical settings through wireless devices such as blood pressure cuffs, oximeters, and glucometers [20]. The implementation of RPM has been officially recommended by professional organizations such as the American College of Cardiology and the American Heart Association in the management of hypertension due to its potential to reduce disparities in healthcare access [21]. The main advantage of this method is its higher accuracy in predicting cardiovascular (CVD) morbidity and mortality compared to blood pressure measurements in medical offices, while also being an effective solution to overcome geographical limitations [22]. Furthermore, RPM has been shown to improve patients' quality of life through medication dose optimization, increased adherence, and early detection of health deterioration without relying on physical clinic visits, thereby significantly reducing

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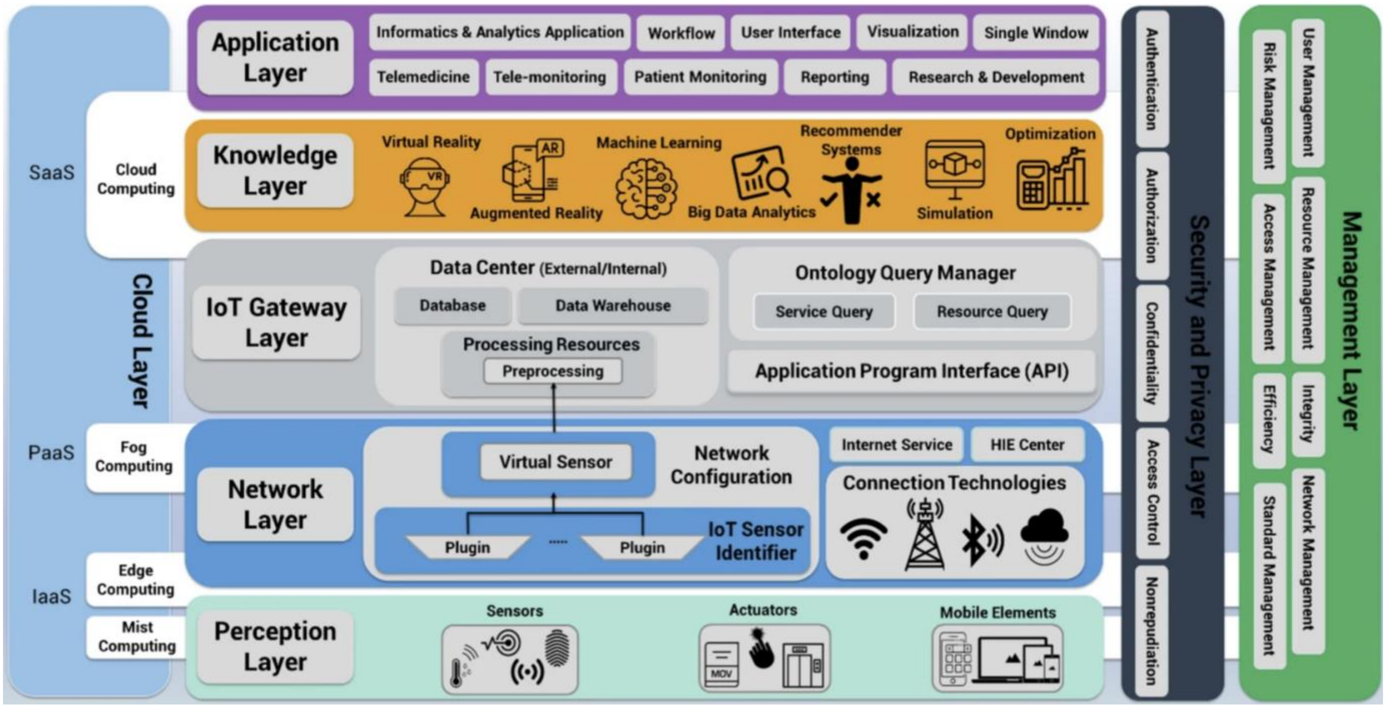

Fig. 2. Layered architecture consisting of five horizo´ntal layers and three vertical functional aspects [18]

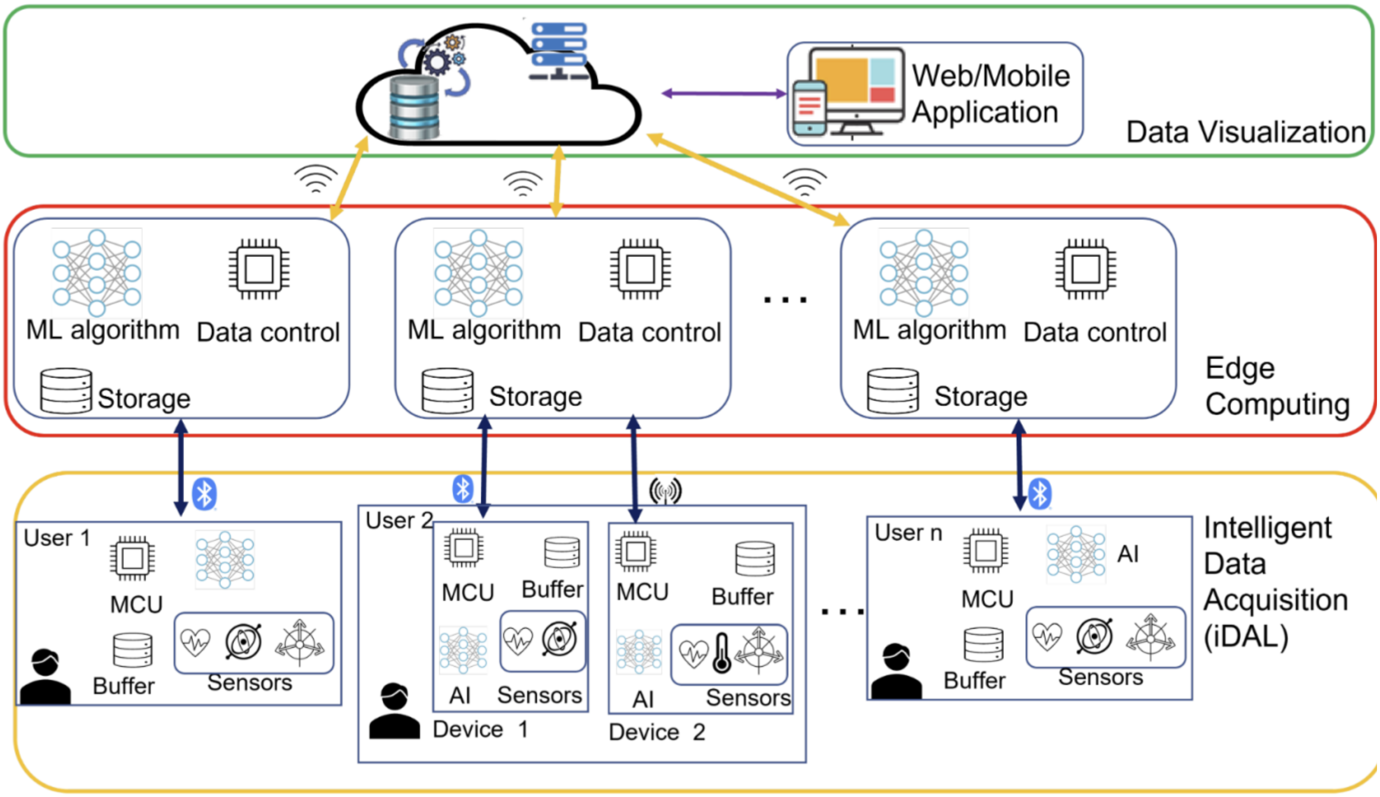

Fig. 1. A three-layer IoT architecture incorporating multi-sensing technology for healthcare usingartificial intelligence [27]

healthcare costs due to unnecessary hospitalizations or emergency department visits [23]. Despite the mentioned benefits, current RPM implementations face difficulties in ensuring ongoing data integrity, hardware interoperability constraints, and complex integration of commercial healthcare devices into backend systems.

B. IoT Implementation on RPM

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The implementation of the Internet of Things (IoT) in Remote Patient Monitoring (RPM) enables the integration of blood pressure sensors into wireless and cloud networks for automated acquisition, analysis, and early warning. This technology bridges sensors with microcontrollers to facilitate real-time monitoring by remote medical personnel. The sensor approach in RPM is dominated by oscillometric methods using cuffs and pressure sensors such as the MPX5050GP series, which boast stable accuracy through precise calibration [12]. Meanwhile, wearable innovations are beginning to utilize photoplethysmography (PPG) or piezoelectric sensors combined with machine learning for more continuous blood pressure estimation [24]. Microcontrollers such as the ESP32, ESP8266, and Arduino serve as the main processing units in this architecture. Some implementations integrate fuzzy logic for cardiovascular risk detection with systolic accuracy reaching 98.2% [25]. Apart from Wi-Fi, the use of LoRaWAN networks has also proven reliable for long-distance data transmission to databases such as Firebase with systolic accuracy of 97.5% and diastolic accuracy of 96.8% [26].

C. IoT Architecture

Fig. 1 shows the architecture proposed in the study [18], adopting a layered model consisting of five horizontal layers and three vertical functional aspects to support the system [18]. The main data flow begins with the Perception Layer, which captures patient vital signs through energy-efficient protocols, and continues to the Network Layer for wireless connectivity, supporting the exchange of health information across hospitals [18]. The next layer, the IoT Gateway, serves as an edge computing bridge to normalize data and significantly reduce transmission latency [18]. The system's intelligent core resides in the Knowledge Layer, which utilizes Big Data analytics and artificial intelligence for health risk prediction, while the Application Layer provides an interface for medical personnel for real-time data visualization [18]. To maintain operational stability, vertical aspects, including resource management, a cloud platform for large-scale storage, and a security layer with GDPR-standard encryption, are implemented across all horizontal layers [18]. This design follows the Design Science Research (DSR) methodology through three systematic phases: problem identification, design considerations, and an evaluation framework using the Architecture Tradeoff Analysis Method (ATAM) [18]. The use of ATAM allows for a comprehensive assessment of the system's qualitative attributes. Evaluation results demonstrate that the integration of edge computing and the HL7 FHIR standard API can accelerate clinical detection and effectively reduce readmission rates [18]. Furthermore, Fig. 2 shows an architecture designed by [27], enhanced by the use of advanced sensing technologies such as ultra-thin and flexible piezoelectric sensors that enable high-precision biosignal measurements [27]. Moving data processing to the sensor level through the Intelligent Data Acquisition Layer (iDAL) has been shown to provide drastic performance improvements, including 99.947% data reconstruction accuracy and efficient wireless data transmission [27]. Researchers [28] also developed an Ontology-Driven IoT System utilizing a three-layer architecture (Sensor, Fog,

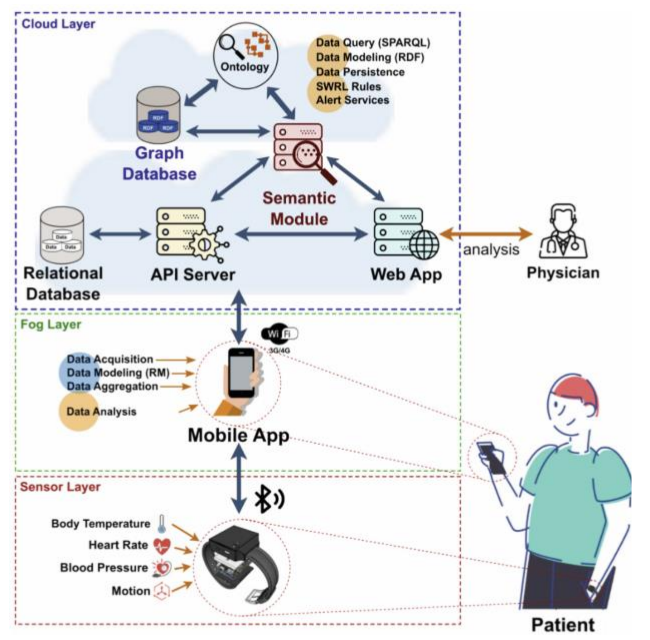

Fig. 3. Utilization of three-layer architecture in Ontology-Driven IoT System for Monitoring Hypertension [28]

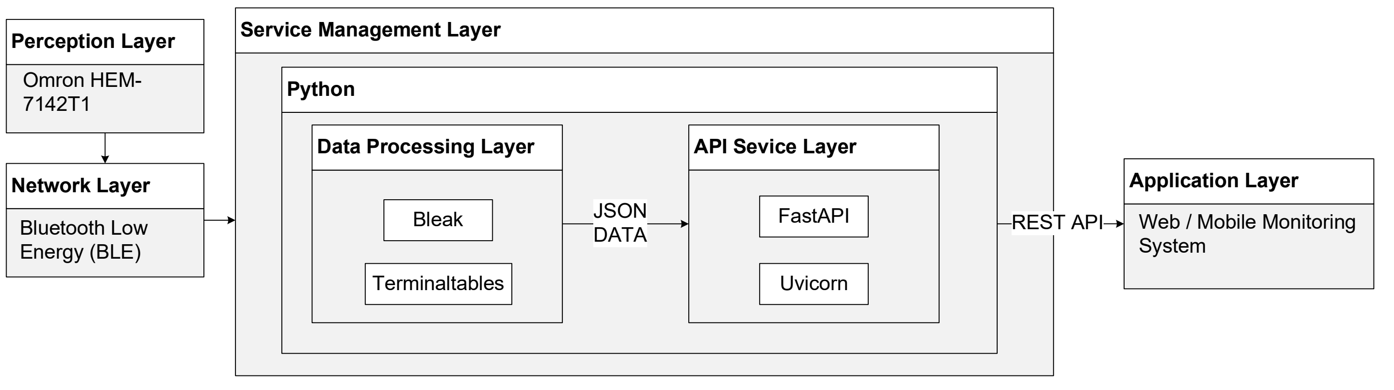

Fig. 4. Proposed Internet of Things architecture for blood pressure monitoring system

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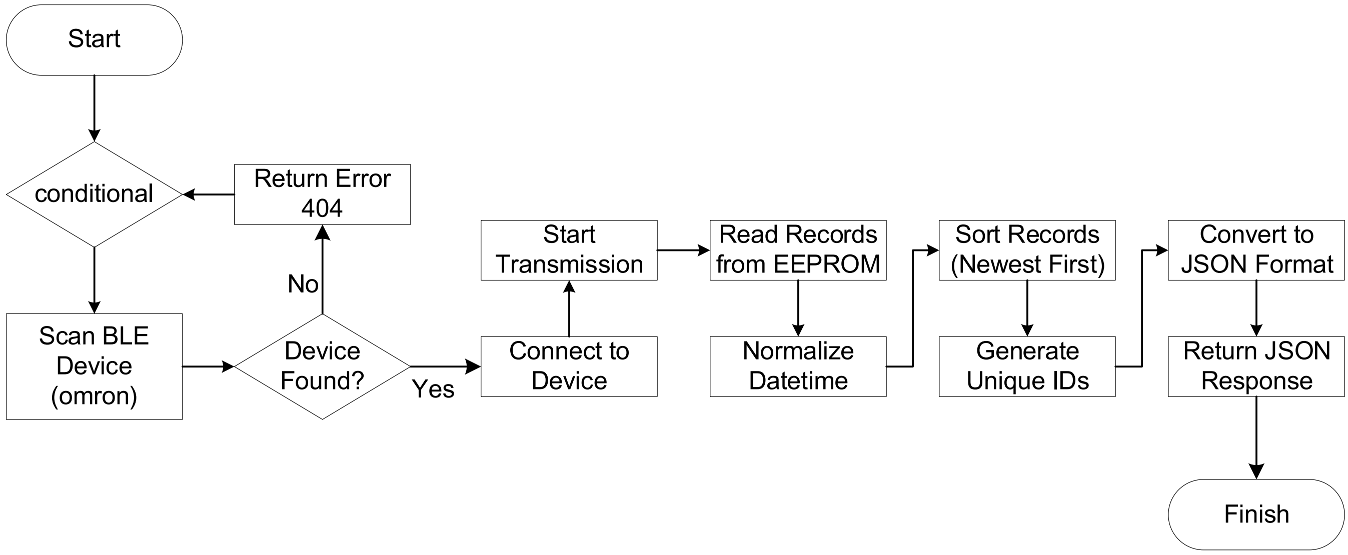

Fig. 5. Illustration of the system workflow steps depicted with a flowchart diagram

Table 1. Correlation between the application of design science research methodology and research

DSRM Phase	Implementation in This Study
Identify Problem & Motivate	Identifying issues with existing IoT system architecture, namely non-medical-grade blood pressure monitors. Emphasize the importance of accurate, real-time blood pressure monitoring to support hypertension diagnosis.
Define Objectives of a Solution	Proposes an IoT architecture design for blood pressure monitoring using the official Omron HEM-7142T1 medical device, connected via Bluetooth Low Energy (BLE), and processed by Python to produce a flexible and scalable API.
Design & Development	Designing a 6-layer IoT architecture by building a BLE–Python integration module, as well as developing an API for integration with digital health applications.
Demonstration	Testing the API using Postman and JMeter as client simulations to access the API, and ensuring that blood pressure data can be transferred and processed correctly.
Evaluation	Evaluate the system based on test results on Postman and JMeter, and compare performance with previous research.
Communication	Publish research results to journals with Sinta 2 index

and Cloud) as shown in Fig. 3. The system aims to monitor hypertensive patients in a structured manner, where clinical data is processed and archived for the analysis needs of healthcare professionals [28]. By combining the flexibility of a layered model and the efficiency of edge computing, the proposed architecture is able to provide a health monitoring solution that is modular, secure, and responsive to critical patient conditions. Previous architectures lacked a separation between the data processing and service layers, resulting in reduced scalability and tight coupling between system components.

D. Method

The Design Science Research Methodology (DSRM) [29], also known as the Peffers approach, consists of six main stages in conducting design science research. These stages are generally followed sequentially in problem-centered initiation research studies [30]. DSRM emphasizes the development of innovative solutions to address existing problems [31] and is now increasingly applied in engineering and other disciplines [32]. DSRM encompasses six phases: (1) identify the problem and motivate, (2) define the solution objectives, (3) design & development, (4) demonstration, (5) evaluation, and (6) communication [33]. Table 1 illustrates the relationship between the application of Design Science Research Methodology (DSRM) and the research conducted. In the Identify Problem & Motivate phase, this research focused on identifying problems in the IoT system architecture that still use non-medical blood pressure monitors, and emphasized the urgency of accurate, real-time blood pressure monitoring to support hypertension diagnosis.

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Next, the Define Objectives of a Solution phase was implemented by proposing an IoT architecture design based on the official Omron HEM-7142T1 medical device connected via Bluetooth Low Energy (BLE) and processed using Python to produce a flexible and scalable API. The Omron HEM-7142T1 was selected due to its widespread availability, BLE capability, and validated clinical accuracy. In the Design & Development phase, Python code was specifically developed that leverages the Bleak library to parse Omron's hexadecimal code into a standard JSON schema, enabling seamless API creation. The Demonstration phase was conducted by testing the API using Postman and JMeter as client simulations, ensuring that blood pressure data could be transferred and processed correctly. The Evaluation phase then assessed system performance based on the test results and compared them with previous research. Finally, the Communication phase was realized with the publication of the research results in a reputable journal with a Sinta 2 index.

III. Results

A. Proposed Architecture

This research produces an architecture designed to bridge data communication between a blood pressure measuring device, namely Omron (model HEM-7142T1), with a frontend application through an Application Programming Interface (API) service. This integration is carried out using the Bluetooth Low Energy (BLE) protocol, which enables wireless data transmission with low power consumption [34]. In addition to having medical standards, Omron devices are also used as instruments and validation references in various previous studies [10], [14], [25], [35], [36], so their selection strengthens the reliability and validity aspects of measurements in this study. This research is also in line with the concept of Smart and Secure Health Monitoring, especially in the data transmission and data collection phases, which emphasize the efficiency of patient data collection and transmission [37], [38].

Fig. 4 shows a proposed six-layer system architecture to support IoT-based health monitoring. In the Perception Layer, the Omron HEM-7121 medical device serves as the primary data source by measuring the patient's blood pressure. The measurement data is then sent via the Network Layer using the BLE communication protocol, ensuring efficiency and energy savings. Next, the data enters the Service Management Layer, built in the Python programming language. This layer is divided into two sublayers: the Data Processing Layer, which utilizes Bleak and TermiNatables to handle BLE connections and data processing, and the API Service Layer, which uses FastAPI and Uvicorn to provide API-based services. The separation of the Data Processing and API Services layers aims to increase modularity, enable secure data transformation, and support scalable system integration. The processed data is packaged in JSON format for easy integration. Finally, the data is sent to the Application Layer via a REST API. This layer displays the measurement results in the form of a web-based monitoring system or mobile application, allowing users and medical personnel to access real-time blood pressure information.

Fig. 5 illustrates the system workflow using a flowchart [39], [40]. The process begins with a scan for nearby BLE devices. If no device is found, the system returns a 404 error and re-scans. If found, the system connects to the device and initiates data transmission. Next, the system reads the blood pressure recordings from the EEPROM (Electrically Erasable Programmable Read-Only Memory), normalizes the time to match the system's time zone, and sorts the data from most recent to least recent. The system then generates a unique ID for each recording and converts it to JSON format. Finally, the measurement results are sent back as a JSON response.

B. API Endpoint Development

From the proposed architecture, a system was developed that has three main endpoints, namely /scan, /connect-and-read, and /latest-bp-records. The /scan endpoint functions to scan BLE devices around the system, in order to detect and identify Omron devices that will be used in the blood pressure data collection process. Meanwhile, the /connect-and-read endpoint functions to retrieve all measurement data stored in the Omron device memory, and the /latest-bp-records endpoint is used to obtain the latest blood pressure data measured by the user. These three endpoints were successfully implemented and tested using a functional testing approach to validate that communication between the server and client, as well as

Table 2. Data structure of Omron device measurement results in JSON format

Data	Description
Movement (mov)	Movement indicator during measurement
Irregular Heartbeat (ihb)	Indicator of an irregular heartbeat detected during measurement.
Systolic (sys)	Systolic blood pressure value (the highest pressure when the heart contracts).
Diastolic (dia)	Diastolic blood pressure value (the lowest pressure when the heart relaxes).
Heart Beat Rate (bpm)	Number of heart beats per minute
Datetime	Time and date the measurement was taken

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the request and response process, runs as expected [41]. After functional testing is carried out, load testing will be carried out. These tests are carried out using Postman, an API testing tool that has been widely used in previous studies due to its reliability in testing the performance and accuracy of API services [42], [43].

C. Functional Testing

Functional testing was conducted to ensure the /scan endpoint's ability to detect devices. Testing was conducted using the HTTP GET method via the Postman application, without requiring a request body. The test results showed that the server responded with an HTTP 200 OK code, indicating a successful BLE device scanning process. From the testing, a device named BLESmart_00000480FE4EAF4F7F7AC, namely the Omron HEM-7142T1, was detected. The device has a Received Signal Strength Index (RSSI) of -63 dBm, indicating a stable BLE connection, and can proceed to the data reading stage [44], [45].

Functional testing on the /latest-bp-records endpoint was performed to ensure the system's ability to retrieve the latest blood pressure measurement data from the Omron HEM-7142T1 device. The test results showed that the system returned an HTTP 200 OK response, indicating that communication between the Omron device and the backend was successful. Furthermore, functional testing on the /connect-and-read endpoint returned an HTTP 200 OK response code, confirming that the BLE connection, data handshake, and data parsing processes were successful.


```
{
  "mov": 1,
  "ihb": 0,
  "dia": 80,
  "sys": 110,
  "bpm": 86,
  "datetime": "04.10.2025 21:47:50"
}
```


Fig. 7. Successful data extraction produces standard structured JSON output for application use

The data received from the Omron device is structured in JSON format as Fig. 6, including vital parameters required for elderly health monitoring. This data structure is described in Table 2. This functional success demonstrates the validity of the proposed IoT architecture model in ensuring data integrity and interoperability with security-certified medical devices. Next, load testing was conducted to measure API performance under simultaneous access loads.

D. Load Testing

Load testing was performed using 10 Virtual Users (VUs) for 1 minute to evaluate the stability and efficiency of three main endpoints: /scan, /connect-and-read, and /latest-bp-records. As shown in Fig. 7, Postman recorded a total of 92 requests with an average response time of 6.24 seconds and an overall error rate of 59.78%. More specifically, the /scan endpoint demonstrated the most stable performance with 36 requests, no errors (0%), and an average response time of 5.04 seconds. This indicates that the BLE device scanning process is efficient because it only involves passive detection operations without direct interaction with the device's memory. In contrast, the

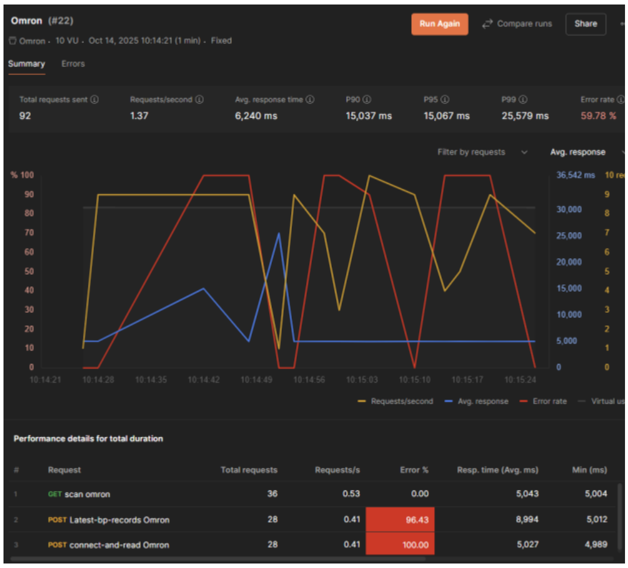

Fig. 6. Load testing results with Postman using 10 Virtual Users for 1 minute

Table 3. Load testing results with JMeter using 10 Virtual Users for 1 minute

Endpoint	Status Code	Response Message	Number of Samples	Success	Failed	Average Response Time (ms)	Time Span (ms)
/scan	200	OK	10	10	0	5030	5013 – 5067
/latest-bp-records	200 & 500	OK & Internal Server Error	10	1	9	24900	15044 – 41455
/connect-and-read	422	Unprocessable Entity	10	0	10	4–6	2 – 6

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/connect-and-read and /latest-bp-records endpoints had high failure rates, 100% and 96.43%, respectively, with average response times of 5.03 seconds and 8.99 seconds.

Load testing was also conducted using Apache JMeter with a configuration of 10 threads (virtual users), a ramp-up period of 1 second, and a loop count of 1, as shown in Table 3. JMeter is an open-source load-testing framework for measuring and analyzing the performance of various system services [46], [47]. The test results show that the /scan endpoint is able to respond to all requests with a successful status (HTTP 200 OK) consistently, with an average response time of around 5 seconds. This indicates that the BLE device scanning process runs stably, although it is still synchronous. In contrast, the /latest-bp-records and /connect-and-read endpoints experience a fairly high failure rate (errors). On /latest-bp-records, most requests experience delays with an average response time of 24.9 seconds, and some of them fail to be processed. The /connect-and-read endpoint even shows a complete failure (100% error), with an average execution time of 4-5ms (milliseconds), indicating that the BLE connection cannot be opened for parallel requests. This phenomenon is consistent with the test results in Postman, where the failure of simultaneous requests is caused by the limitations of point-to-point BLE communication on the Omron HEM-7142T1 device. The device can only handle one active connection at a time, so when multiple virtual users try to connect simultaneously, other requests are immediately rejected or fail because the device is still in an active session with another user.

IV. Discussion

A. Interpretation of Research Results

Functional testing results demonstrate that the proposed Python-based backend architecture reliably bridges data communication between the Omron HEM-7142T1 commercial medical device and a frontend application via a REST API in a single-user scenario. The success of the /scan, /connect-and-read, and /latest-bp-records endpoints in generating HTTP 200 OK responses indicates that the integration of Bluetooth Low Energy (BLE) with the FastAPI framework has been carried out in accordance with the proposed six-layer architecture design.

Specifically, the stability of the /scan endpoint demonstrates that the BLE device detection process is lightweight and does not require direct interaction with the device's memory. This confirms that the separation of functions in the Service Management Layer, between the scanning process and the data reading process, is an appropriate approach in the medical IoT backend architecture. In contrast, the high failure rate of the /connect-and-read and /latest-bp-records endpoints is due to the point-to-point nature of BLE communication, where the Omron device can only handle one active connection at a time. When multiple Virtual Users simultaneously attempt to access the same device, subsequent requests are rejected or fail because the device enters a busy or fail due to the Omron device's locking mechanism, which activates once an initial connection session is established. This phenomenon confirms that the current API architecture, which still runs synchronously and sequentially, does not yet support parallel multi-user access. Therefore, even if the backend system functions correctly under single-user conditions, system performance will degrade significantly under high-load scenarios due to communication limitations at the BLE hardware layer. Thus, these results confirm that the proposed architecture is successful in terms of system design and interoperability, but is still limited by physical limitations and communication protocols at the device layers (Perception and Network Layers). This is because the BLE transceiver on the Omron device does not support multiplexing of multiple incoming client requests simultaneously, which causes direct connection timeouts when the transceiver is busy.

B. Comparison with Previous Research

Compared to previous studies developing IoT-based blood pressure monitoring systems, most of these studies focused on sensor accuracy and measurement result validation using Omron devices as benchmarks. Studies such as [9], [48] reported systolic and diastolic accuracy rates ranging from 90% to 96% [15], but the system architecture used was still monolithic and device-oriented.

Unlike these approaches, this study does not use Omron as a benchmark device, but rather as the primary, medically certified data source. This approach shifts the research focus from sensor accuracy validation to designing a backend architecture that is interoperable, modular, and ready to integrate with various healthcare application systems.

Furthermore, previous studies generally relied on third-party IoT platforms such as Firebase, Cayenne, or ThingSpeak as the backend layer [13]. While this approach simplifies implementation, it limits architectural flexibility and control over medical data flow. In contrast, this study proposes a standalone backend based on Python and a REST API that enables integration across web and mobile platforms without reliance on proprietary services. Furthermore, a standalone backend provides full control over data processing, reduces reliance on third-party platforms, and ensures higher data integrity and privacy.

C. Research Limitations

Although the proposed architecture was successfully implemented and functionally tested, this study has several limitations. First, the system still relies on synchronous, direct BLE communication with the Omron device, thus not supporting parallel multi-user access. This causes API performance to degrade significantly in high-load scenarios, as demonstrated by load testing results using Postman and Apache JMeter.

Second, the system does not implement a centralized data storage mechanism (database), so each data read request still requires a direct connection to the device. This prevents the system from performing longitudinal

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health analytics, tracking historical hypertension trends, or integrating with a comprehensive Electronic Medical Record (EHR). This severely limits physicians' ability to make long-term, data-driven clinical decisions.

D. Research Implications

Theoretically, this research contributes to the development of healthcare IoT architectures by demonstrating that certified commercial medical devices can be directly integrated into an API-based backend without the need for additional sensors or recalibration. This broadens the perspective of healthcare IoT research, which has previously focused on hardware development. Practically, the proposed six-layer architecture can serve as a reference for developers of remote health monitoring systems, particularly in designing interoperable backends that are ready to be integrated with various frontend applications. Findings regarding the limitations of point-to-point BLE also provide important insights for developers in designing mitigation strategies, such as message queues that can serialize incoming requests, ensuring that devices only receive one command at a time. Furthermore, data caching can address the lack of centralized storage by temporarily storing the most recent readings, instantly serving subsequent user requests without waking the device.

V. Conclusion

This research has successfully addressed the need for a secure and accurate blood pressure monitoring system architecture by proposing a six-layer IoT architecture that integrates the commercial Omron HEM-7142T1 medical device via the Bluetooth Low Energy (BLE) protocol. The main objective of the research to design a Python-based backend system capable of bridging proprietary data from commercial medical devices into flexible API services has been fully achieved. Based on the test results, it was found that the basic functions on the three main endpoints (/scan, /connect-and-read, and /latest-bp-records) ran successfully with HTTP 200 OK status under single access conditions. However, load testing using Apache JMeter revealed limitations in the hardware point-to-point BLE protocol, where although the /scan endpoint remained stable with a 0% error rate, critical endpoints such as /connect-and-read experienced complete failure with a 100% error rate due to the Omron device's locking mechanism when accessed simultaneously. As a follow-up, future research will focus on integrating a database caching module with a message queue. Using this setup, incoming parallel requests will be queued sequentially to prevent BLE hardware lockups. Once successfully retrieved, the read will be cached, allowing subsequent immediate requests to retrieve this cached data without triggering excessive device connections.

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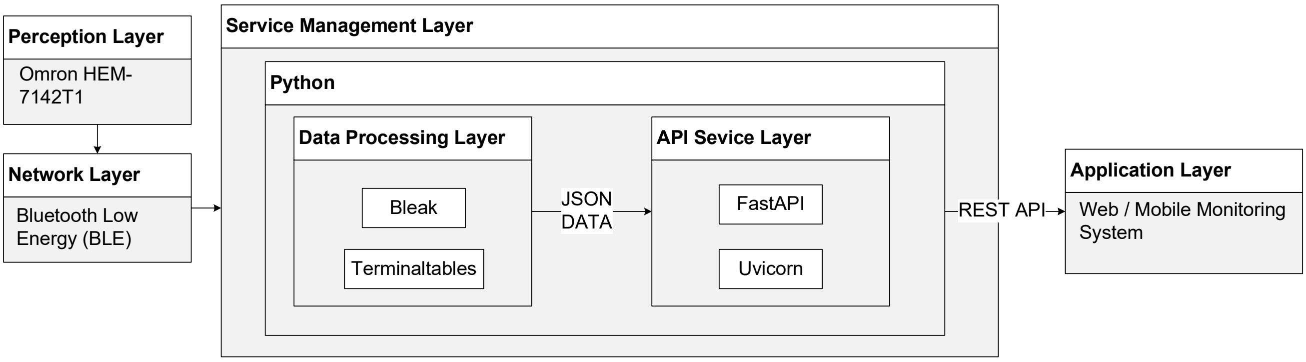

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