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# Evaluation of System Response Time in RFID-Enabled Mobile Applications for Managing Infectious Disease Patients: A Solution for Pandemic Outbreaks

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**Abstract:** The global pandemic has changed the paradigm for treating infectious disease patients. This study aims to evaluate the response speed of a mobile application system integrated with RFID technology to assist nurses in monitoring inpatients with infectious diseases in hospitals. When a patient presses the emergency button on the mobile application, this will trigger an API call to retrieve the patient's location data based on their RFID tag before notifying the nurse through the hospital management system. Testing was carried out on API response times using Android devices with OS versions 8, 10, and 13. Test results showed optimal response times under 2 seconds on average for all versions, with the fastest time of 1.081 seconds on Android 10. Analysis indicated Android 10 had the lowest lag, while Android 13 saw increased lag, likely due to more complex software. These findings suggest that RFID integration with mobile applications can enable rapid emergency response, where system optimization is critical for efficiency.

***Keywords:*** *RFID, optimization, Android, paradigm, API*

## 1. Introduction

In an era where technology integration is increasingly rampant, analyzing response times from mobile applications to websites through the use of APIs has become an essential basis for evaluating the performance of information technology systems. The fast and consistent response between the two platforms is not only a determining factor in ensuring a smooth user experience. Still, it is also a fundamental element in ensuring the successful functionality of the various services provided.

Optimal response time between mobile applications and websites via API dramatically influences the quality of user experience. When a user performs an action or request via a mobile application, then the data must be passed to the website via API for further processing. Speed and consistency in this process are critical. A lag or delay in response can significantly impact the overall user experience, especially in situations that require real-time interactions or short-term transaction completion (Belkhir et al., 2019).

Several factors that have a significant influence on the response time between mobile applications and websites via API include the quality of the internet connection from the user's device, server performance and the infrastructure used on both sides. Applications and websites, the efficiency of the code implemented in the API and related applications, the system's ability to handle sudden spikes in requests, and the reliability and speed of data processing on the server side (Laso, Linaje, Garcia-Alonso, Murillo, & Berrocal, 2020).

The importance of in-depth analysis of response times is not only as a tool to identify potential bottlenecks or areas requiring improvement but also as a basis for developing better technology. By understanding and evaluating the response time from mobile applications to websites via API, technology developers can optimize communication processes, increase overall system efficiency, and improve the quality of services provided to end users. Continuous efforts to improve and optimize these response times will significantly impact the user experience and overall system success in facing increasingly complex technological demands in the future (de Rosal Ignatius Moses Setiadi et al., 2019).

The urgency of our research is of course very useful for fulfilling the needs of distance learning, especially in sensor and transducer practicum lessons through the use of trainers as IoT-based learning media. At present, of course, it is still rare to find practicum learning devices that support distance learning. So far, teachers and students only use simulation-based virtual online software or applications to conduct practical experiments remotely [18,19,20]. Of course, this simulation method is very suitable if the practicum equipment in the laboratory is still limited. The purpose of this research is to develop a distance learning device on IoT-based sensor and transducer practicum, and determine the effectiveness of using IoT-based sensor and transducer trainer learning media on teachers and students in vocational high schools.

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## 2. Methods

### System Flow

At this stage, the flow of the system developed to assist patients in calling the nurse on duty will be explained. The following is an overview of the system being developed. The research and development steps used are the ADDIE model [21], Based on this sequence of steps, this research has been at the implementation and analysis stages.

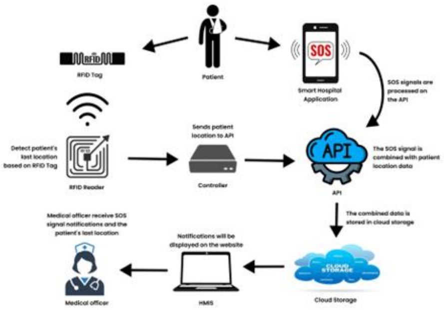


**Fig 1.** System Flow

Referring to the image above, the patient presses the emergency button on the mobile application, and the emergency signal will be processed in the API, where during emergency signal processing time, it will retrieve the patient's last location data based on where the patient was last detected by his RFID tag. After the data has been processed, it will be stored in cloud storage. Then, medical staff will receive an emergency signal notification from the patient, which is displayed on the hospital management information system.

### Application Programming Interface

API (Application Programming Interface) is a set of rules and protocols that allow various software applications to communicate with each other and exchange information in a structured manner. It serves as an intermediary between software, allowing it to access functions, services, and data from other applications or systems, often over the internet network (Mathijssen, Overeem, & Jansen, 2020).


**Fig 2.** How APIs Work

With clear documentation, APIs enable developers to use functionality provided by other software or platforms in their application development, extending functionality and improving interoperability between systems (Haris, Chen, Song, & Pou, 2023).

### Cloud Storage

Cloud storage refers to data storage services provided by cloud service providers. It allows users to store their files and data on servers hosted by cloud service providers, usually over the Internet. With this service, users can store, manage, and access their data from anywhere with an internet connection rather than relying solely on local storage such as hard drives or other physical storage devices (Syed, Purushotham, & Shidaganti, 2020).

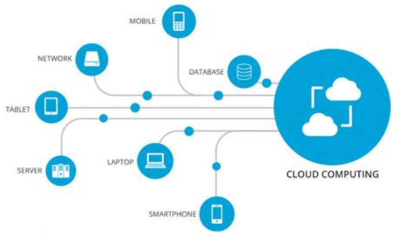


**Fig 3.** Cloud Storage Illustration

Cloud storage services offer various features such as scalability (the ability to increase or decrease storage capacity as needed), automatic backup, strong data security (through encryption), easy file sharing, and accessibility from various devices, enabling more efficient collaboration and access. Easy way to store information. Some of the leading cloud storage service providers include Amazon Web Services (AWS) with Amazon S3 services, Microsoft Azure Storage, Google Cloud Storage, Dropbox, and iCloud from Apple (Yang, Song, Ding, Ou, & Fan, 2022).

### RFID

RFID (Radio-Frequency Identification) is a technology that allows the identification and tracking of objects using radio waves. This system consists of an RFID tag that has a microchip to store information and an antenna to communicate with the reader. When the tag is within range of the reader, the antenna on the tag sends a radio signal to the reader, allowing reading of the information stored on the tag (Landaluce et al., 2020).

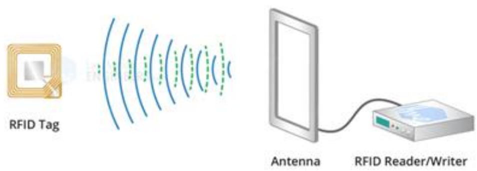


**Fig 4.** RFID

The advantages of RFID include efficiency in the automatic tracking of objects, identification capabilities without direct contact, and the capacity to read multiple tags simultaneously. However, this technology also has obstacles, such as initial implementation costs, privacy issues related to tracking, as well as limited reading distance and signal interference in specific environments. Nonetheless, continuous development and integration with other systems have expanded RFID applications in various industrial sectors such as logistics, healthcare, manufacturing, and transportation (Azizi, 2019).

RFID has a series of calculations that can be used as a reference in determining the distance between the reader and the tag, thus allowing an estimate of the time required by the reader to read data from the RFID tag. By utilizing RSSI (Received Signal Strength Indication) measurements, it is possible to estimate the distance between the tag and the reader using the range operation method (Li et al., 2020). The signal strength received by the reader can be described as:

$$P_{received} = P_{TX} G_{TX}^2 G_{RX}^2 M \chi^2 \left( \frac{\lambda}{4\pi d} \right)^4 |H|^4$$

In this situation, λ represents the wavelength of the conducting signal, while d refers to the distance between the reader antenna and the tag during the reading process. PTX represents the power the reader radiates, while GTX and GRX represent the gain of the reader and tag antennas, respectively. In addition, χ is the coefficient value for polarization matching, while M is the coefficient for modulation backscattering. H represents complex factors that reflect channel response. In situations where line-of-sight occurs, the value of the variable H equals 1 (Peng, Jiang, & Qu, 2021).

### Mobile Apps

Mobile apps, or mobile applications, are software designed specifically for mobile devices such as smartphones or tablets. The app provides a variety of services, functions and content that users can access practically at their fingertips. With a wide range of purposes, these applications cover everything from entertainment such as gaming, music streaming, and video content, to productivity needs, such as banking applications, online shopping, social networking, and health instruments. App development involves the process of designing an attractive user interface (UI) as well as specific programming for a particular platform, such as iOS or Android. App distribution is done through official app stores such as the Apple App Store or Google Play Store, where users can download and install apps according to their needs (Milne-Ives, LamMEng, de Cock, van Velthoven, & Ma, 2020). Data security and user privacy are primary concerns in app development, while developers make regular updates to fix bugs, improve performance, or add new features. By leveraging device features such as cameras, GPS, and other sensors, mobile applications enrich the user experience and enable more personalized and connected interactions with technology more broadly (Ming et al., 2020).

### Hospital Management Information System

The Hospital Management Information System (HMIS) is a technology platform designed to manage operations, administration and health services in a hospital environment. HMIS has integrated functions that enable the management of patient data, financial information, and inventory management, as well as provide analysis and reporting tools to support effective decision-making within the hospital (Febrita, Martunis, Syahrizal, Abdat, & Bakhtiar, 2021). With HMIS, hospitals can manage patient data concisely and structuredly, including medical information, treatment history and other administrative processes. This helps facilitate access to information needed by medical personnel and improves coordination in health services (Rochmah, Fakhruzzaman, & Yustiawan, 2020).

In addition, HMIS also allows hospital financial management to be more efficient, tracking expenses, income and other financial resources. Inventory management, including medicines, medical equipment and other supplies, can also be managed through this platform. The main aim of using a HMIS is to improve efficiency, coordination and quality of service in hospitals. By utilizing information technology, HMIS helps manage various aspects of health and administrative activities in hospitals in a more focused and integrated manner. This enables better decision-making, improves operational processes, and improves the health services provided to patients (Lenny & Kridanto, 2019).

### Testing Scenarios

Round Trip Time (RTT) is a measurement of the time required for data to travel from the sender to the receiver and back to the sender again. In the context of computer networks, RTT describes the time lag from when data is sent to receiving confirmation or a response from the final destination. Factors that influence RTT include the physical distance between the sender and receiver, network traffic density, connectivity quality, and the time required for processing and routing data through various network devices (Xu, Jin, & Kim, 2019). RTT has an essential role in evaluating network and application performance, where a low RTT indicates a fast and consistent response between devices. In contrast, a high RTT can indicate problems in the network that require repair to correct communication delays (Tanwani, Anand, Gonzalez, & Goldberg, 2020).

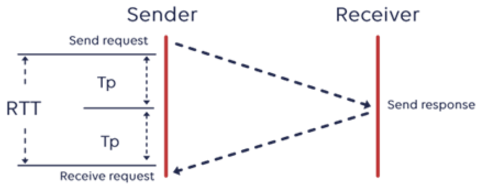


**Fig 5.** Round Trip Time Illustration

Round Trip Time (RTT) can be calculated using a simple formula that measures the time it takes for data to travel from point A to point B and back to point A.

$$RTT = RAT + RDT$$

Response Arrival Time (RAT) is the time when a response or confirmation is received back after data transmission. Request Delivery Time (RDT) is the time when the data or request is first sent.

## 3. Results and Discussion

At this stage, an analysis of the results of the test scenarios in this research is carried out. In the first test, patients used cell phones with Android OS version 8 to find out how quickly emergency signals were sent to medical personnel. The test was carried out with ten patients, and ten emergency signals were sent. Following are the test results when the patient used an Android phone OS version 8.

**Table 1.** Testing With Android Version 8

| No | Testing | OS Version | Average Time |
|---|---|---|---|
| 1 | Patient 1 | Android 8 | 1.303 |
| 2 | Patient 2 | Android 8 | 1.333 |
| 3 | Patient 3 | Android 8 | 1.497 |
| 4 | Patient 4 | Android 8 | 1.306 |
| 5 | Patient 5 | Android 8 | 1.593 |
| 6 | Patient 6 | Android 8 | 1.546 |
| 7 | Patient 7 | Android 8 | 1.739 |
| 8 | Patient 8 | Android 8 | 1.497 |
| 9 | Patient 9 | Android 8 | 1.559 |
| 10 | Patient 10 | Android 8 | 1.443 |

Based on the results of tests carried out by ten patients with ten trials using an Android cellphone with OS 8 version, the average delay time was 1 second, where the fastest average delay time was 1,303 and the longest delay time was 1,739. The data is represented in graphical form in the image below.

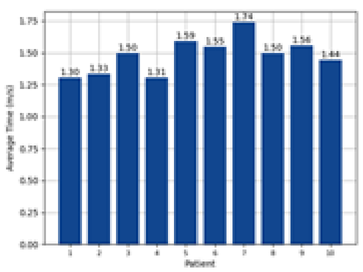

**Fig 6.** Testing Graphics on Android OS 8

In the second test scenario, there is a change in the OS version of the cellphone using Android version 10 to find out how the time for sending emergency signals to medical personnel differs. Just like the previous test, this test will be carried out by ten patients, with each patient experimenting ten times.

**Table 2.** Testing with Android Version 10

| No | Testing | OS Version | Average Time |
|---|---|---|---|
| 1 | Patient 1 | Android 10 | 1.217 |
| 2 | Patient 2 | Android 10 | 1.288 |
| 3 | Patient 3 | Android 10 | 1.503 |
| 4 | Patient 4 | Android 10 | 1.394 |
| 5 | Patient 5 | Android 10 | 1.204 |
| 6 | Patient 6 | Android 10 | 1.425 |
| 7 | Patient 7 | Android 10 | 1.537 |
| 8 | Patient 8 | Android 10 | 1.782 |
| 9 | Patient 9 | Android 10 | 1.081 |
| 10 | Patient 10 | Android 10 | 1.607 |

Testing with Android version 10 gets average results that are not that far from testing on Android version 8; in testing with Android version 10, the average time is still at 1 second, and the fastest average delay is 1,081 seconds, while the average delay the longest is 1,782. To see the difference more clearly, you can see the graph below.

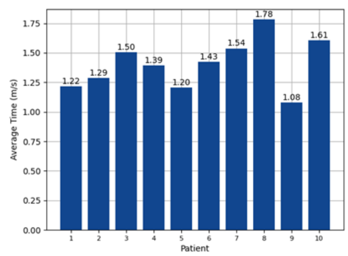


**Fig 7.** Testing Graphics On Android OS 10

The final test was carried out on the latest version of Android, namely OS version 13. The following are the results of the test, which was carried out on ten patients with ten trials.

**Table 3.** Testing With Android Version 13

| No | Testing | OS Version | Average Time |
|---|---|---|---|
| 1 | Patient 1 | Android 13 | 1.672 |
| 2 | Patient 2 | Android 13 | 1.297 |
| 3 | Patient 3 | Android 13 | 1.973 |
| 4 | Patient 4 | Android 13 | 1.865 |

| | | | |
|---|---|---|---|
| 5 | Patient 5 | Android 13 | 1.857 |
| 6 | Patient 6 | Android 13 | 2.094 |
| 7 | Patient 7 | Android 13 | 1.434 |
| 8 | Patient 8 | Android 13 | 1.439 |
| 9 | Patient 9 | Android 13 | 1.606 |
| 10 | Patient 10 | Android 13 | 1.910 |

In the last test using the Android 13 version, there was an increase compared to using the Android 8 or 10 versions, where the test with the Android 13 version got the highest delay of up to 2 seconds, and other tests got a higher average than the tests on the two previous OS versions.

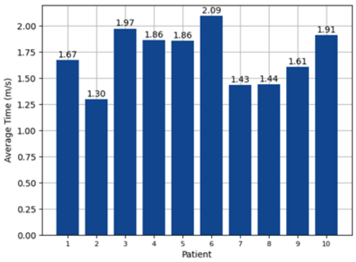


**Fig 8.** Testing Graphics on Android OS 13

The following comparisons were obtained based on tests that have been carried out using three different OS versions.

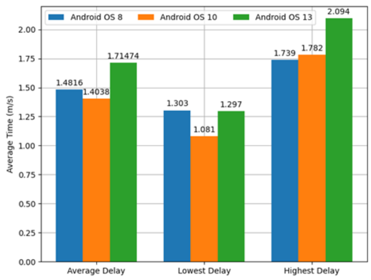


**Fig 9.** Comparison of Test Results

Based on the overall test results, three different scenarios were used. The average delay generated based on three different OS versions is not that far, where the average for each OS version is still under 2 seconds, and the OS that has the slightest delay is Android with OS 10 version while the OS that has the highest delay is Android with OS 13 version.

## 4. Conclusion

This research generally aims to evaluate the performance of a mobile application system integrated with RFID technology in terms of response speed to help nurses monitor the condition of hospitalized infectious disease patients. The mechanism is that when the patient presses the emergency button on the mobile application, the system will automatically call the API to retrieve the patient's current location data based on the information on the RFID tag worn. Next, this information is forwarded to the hospital management system so that nurses can immediately respond to the patient's emergency. To test the response speed performance of this system, research was carried out with simulations on Android devices versions 8, 10, and 13. From the test scenario, it was found that the average latency or response time was under 2 seconds for the three versions, with the best performance being 1.081 seconds on Android version 10. Further analysis indicates that Android 10 has the lowest latency level compared to Android 8 and Android 13. This shows that implementing integration between mobile applications and RFID technology has great potential to increase the speed of emergency response in the monitoring system of a hospital environment, especially for infectious disease patients. Overall, continuous innovation and development of mobile applications need to continue to be optimized so that they can become an effective solution in the system for alerting and handling outbreaks and infectious diseases in the future. With solid technological support and fast response, the level of preparedness to face the threat of infectious diseases can continue to be improved.

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