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Web-Based Design and Implementation for Data Transfer Simulation using the MP-QUIC Protocol

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ABSTRACT: Improving the quality of data transmission in Internet of Things (IoT) applications requires an effective tool to monitor and analyze the performance of the protocols used. This study focuses on the development of an interactive website designed to measure and compare the performance of the MP-QUIC protocol in a temperature and humidity monitoring system on IoT devices. This website provides an intuitive user interface to measure two main parameters: throughput and latency, with real-time data visualization. This website is equipped with a feature that allows users to test the performance of MP-QUIC under various network conditions, both stable and fluctuating. The data collected during the test is displayed in clear graphical form, making it easy for users to understand how MP-QUIC optimizes data transmission compared to other protocols, such as HTTP. By using MP-QUIC, the system can utilize a more efficient data transmission path, which has the potential to increase throughput and reduce latency. In addition, this website has an option to view a performance comparison between MP-QUIC and the HTTP protocol on IoT devices in the context of monitoring temperature and humidity in the Gumukmas Multifarm sheep pen. The implementation of responsive design and interactive data visualization makes it easy for users to access important information related to data transmission performance, making this website a valuable tool in the development and evaluation of MP-QUIC-based IoT systems. With this approach, the website not only serves as a measurement tool, but also as an educational platform that allows users to better understand the impact of implementing MP-QUIC in improving data transmission efficiency in IoT systems.

KEYWORDS: Internet of Things (IoT), MP-QUIC, Data Transmission, Throughput, Latency

I. INTRODUCTION

Multipath QUIC (MP-QUIC) is an extension of the Quick UDP Internet Connections (QUIC) protocol that integrates multipath capabilities into the data transmission process [1]. MP-QUIC is designed to improve network efficiency by simultaneously utilizing multiple transmission paths, allowing faster and more reliable data delivery [2]. In the context of web design, this technology is essential in ensuring smoother content delivery under various network conditions, especially when users are on a network with unstable or limited connections. With MP-QUIC, data can be transmitted through multiple network interfaces such as Wi-Fi, cellular networks, or Ethernet in parallel [3]. This brings great benefits, especially in reducing latencyin parallel through multiple network interfaces such as Wi-Fi, cellular networks, or Ethernet and increasing bandwidth utilization. In modern web design, where speed and content availability are crucial, MP-QUIC can support a better user experience, especially in web-based applications that require continuous and fast data transmission, such as video streaming, online gaming, or real-time applications. The main advantage of MP-QUIC is its ability to overcome interference or instability on one of the transmission paths [4]. If one path experiences problems or failures, MP-QUIC can automatically switch data to another path without disrupting the user experience. In the world of web design, this means content remains accessible even when the internet connection is unstable, providing a smoother and more reliable experience for site visitors [1].

For web-based applications in the Internet of Things (IoT) environment, MP-QUIC provides significant benefits. Applications that rely on real-time data, such as monitoring systems or remote control applications, can benefit from seamless transitions between network paths without affecting application performance [5]. This is critical for rapid decision-making required in dynamic situations. In the implementation of MP-QUIC for IoT-based systems, such as temperature and humidity monitoring systems in farms or other facilities, this technology helps ensure the continuity of data transmission between sensors and cloud-based platforms despite changing network conditions. This is crucial in the

design of web-based applications that manage real-time data, providing rapid response to changing environmental conditions. Overall, the application of MP-QUIC in web design and IoT applications can improve the performance of communication systems by introducing network resilience and latency reduction. This allows for the development of more reliable, more responsive web applications, and is able to provide a better user experience, especially in variable or unstable network conditions. Further research shows great potential in improving data delivery, making it a very relevant solution for the development of web-based systems that require high-speed and reliable data transmission [6].

II. METHOD

This research method is designed to optimize Internet of Things (IoT) services by implementing the MP-QUIC protocol in a temperature and humidity monitoring system. The stages in this research include:

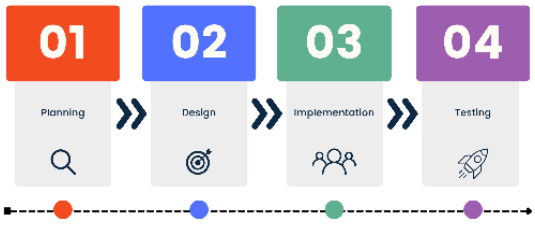


Fig. 1 Method

1. Planning

At this stage, the initial research step is carried out by conducting a survey and collecting data in the field. The goal is to identify the needs and network conditions of industry partners in detail. The main focus of the analysis is parameters such as latency and throughput. The data collected from this survey is the basis for compiling the right MPQUIC protocol, according to the existing network operational conditions. In addition, focus group discussions (FGD) are held with partners to ensure that the technology development plan is aligned with existing industry needs.

2. Design

After the initial data is collected, the design process begins. This process focuses on creating a website design for the MP-QUIC platform. After the initial data is collected, the process of designing a website mockup design begins. The main focus of this stage is to design the appearance and functionality of the website that will be the MP-QUIC implementation platform. This design mockup includes several key features that are very important to support the functionality of web-based applications, namely:

1. Landing Page: The first page that users will see when accessing the website. This landing page is designed to provide an overview of the benefits and key features of the MP-QUIC platform. With an attractive and informative design, this page will provide a positive first impression and encourage visitors to continue interacting with the website.
2. Login: A secure and user-friendly login page, where users can access the platform using their accounts. This page is important to ensure that only authorized users can access sensitive data and information contained within the system.
3. Dashboard: The main page after login, which provides an interface for users to access various data and features within the platform. The dashboard is designed to be easy to use and displays information visually, allowing users to quickly view system status, network statistics, and MP-QUIC data transmission performance.
4. Data Analysis: This feature allows users to analyze the collected data, such as transmission performance, bandwidth utilization, latency, and more. Using graphs and data visualizations, this page is designed to provide easy-to-understand insights that help in data-driven decision making.
5. Data Record: This feature is used to record and store data collected during platform operation. This page will allow users to monitor data history and verify the transmission reliability and network performance of MP-QUIC.

This mockup design aims to ensure that all features of the MP-QUIC platform are easily and efficiently accessible to users. The main focus is on ease of use and clear presentation of data, allowing users to take full advantage of MP-QUIC's capabilities.

3. Implementation

After the design phase is complete, the implementation of the website creation begins using the PHP programming language and the Laravel framework. The interface design that has been created in Figma is used as the main reference to ensure a consistent and responsive appearance across devices. This website includes key features such as landing pages, login pages, dashboards, data analysis, and data recording. The landing page presents MP-QUIC platform information clearly and attractively, while the login page provides secure access for users. The dashboard functions to display real-time data with easy-to-understand visualizations, while the data analysis feature presents graphs and tables to facilitate monitoring. The data recording feature allows data collected during operations to be stored for further analysis. Each feature is developed with a focus on optimal user experience, ensuring that the web application can provide a better user experience, especially in unstable network conditions.

4. Testing

Website functionality testing is conducted through the User Acceptance Testing (UAT) approach to ensure that each feature meets user needs according to the predetermined design. UAT focuses on evaluating user interaction, ease of navigation, and reliability of key features such as landing pages, logins, dashboards, data analysis, and data recording.

End users are asked to test the website and provide feedback on their experience, ensuring that all features are easy to use, data is displayed correctly on the dashboard, data analysis is easily accessible, and data recording works without any obstacles. Testing is considered successful if users state that all website functions meet their expectations and needs, and no significant disruptions or errors are found during the testing process.

III. RESULTS

In this section, the steps for developing a website application for data transfer simulation using the MPQUIC protocol will be explained according to the method section above. The development steps can be explained as follows:

1. Results at Planning Stage

At this stage, planning is done by holding online discussions involving the development team and industry partners. This discussion is carried out to align partner needs with the design and features of the website to be developed. During the discussion, various inputs related to the main functions of the website, such as landing pages, logins, dashboards, data analysis, and data recording, are identified and adjusted to the operational needs of partners.

Fig. 2 Focus Group Discussion

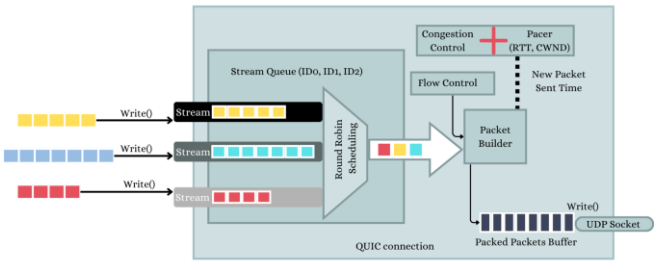
As part of the documentation, the results of online discussions at the Lambada Laboratory were recorded and further analyzed to ensure that every decision taken was relevant to the research objectives. This material was used to strengthen the basis for planning and as a reference in the implementation and testing process.

2. Results at Design Stage

The design phase begins with the development of a comprehensive system architecture to support the implementation of the MP-QUIC protocol and its integration with IoT and client-server technologies. Some important elements designed at this stage include:

a. Design System

Gambar Metode Pengiriman MPQUIC Connection



Gambar Metode Pengiriman MPQUIC Konvensional

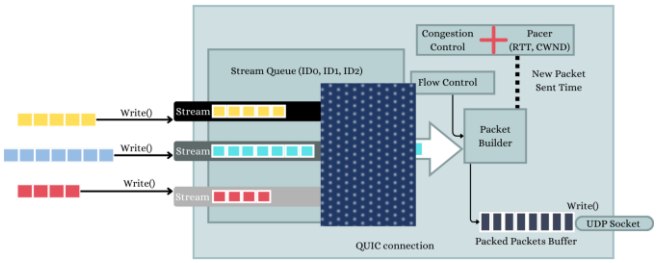


Fig. 3 Round Robin Architecture

This figure shows the difference between the MPQUIC Connection delivery method and the conventional delivery method in the QUIC protocol. In the MPQUIC method, there is a mechanism that allows multiple data streams to be processed simultaneously through the use of the Round Robin Scheduler [7]. Each stream (colored differently) is sent to the Stream Queue and is managed by the scheduler to ensure that the data streams are sent alternately. This allows for a more even distribution of the load on the QUIC connection, improves transmission efficiency, and maintains data delivery performance. After scheduling, the data passes through the Congestion Control and Flow Control modules before being packaged into packets to be sent via UDP Socket [8].

On the other hand, the conventional delivery method does not use a scheduling mechanism like in MPQUIC. Data from each stream goes directly into the Stream Queue without additional settings, then sent directly to the Packet Builder. Without a scheduling mechanism, data delivery can be less than optimal if there is a difference in load between streams, which can cause a bottleneck or delay [9]. After the packet is built, it will go through Congestion Control and Flow Control, then sent to the UDP Socket to be forwarded [10].

b. Website Design Mockup

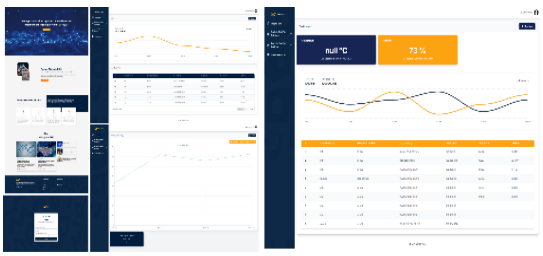


Fig. 4 Website Design Mockup

The website design mockup was created using Figma tools and includes five main features to support the MP-QUIC platform. The Landing Page is designed with an attractive and informative appearance to introduce the platform and encourage users to continue their interaction. The Login Page ensures secure and easy access for registered users. The Dashboard is the main interface for monitoring system performance, displaying data such as transmission visualization, latency, and bandwidth. Data Analysis presents network performance in the form of graphs and tables to support data-based decision making. Finally, Data Record stores historical data to continuously monitor and verify the performance of the MP-QUIC protocol.

c. Entity Relationship Diagram

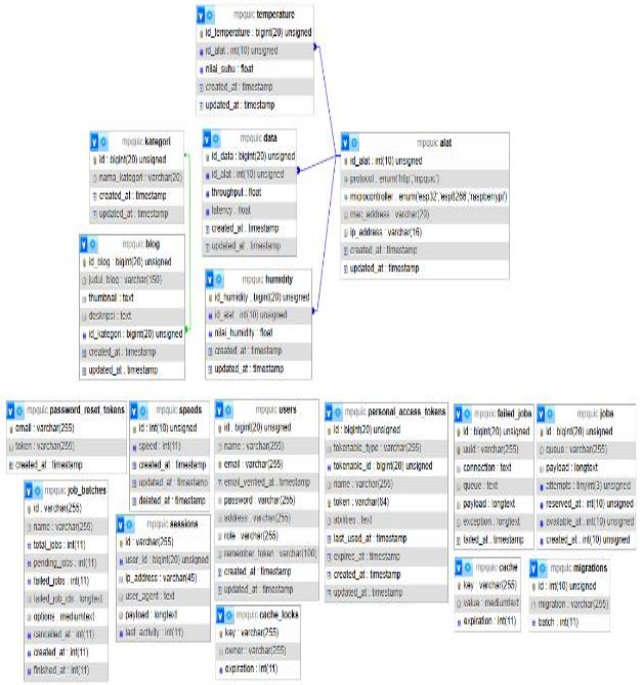


Fig. 4 Entity Relationship Diagram

This diagram is designed to model the relationships between entities in the system, such as users, IoT data, and performance reports. ERD helps ensure that data integration and management run smoothly according to platform needs.

3. Results at Implementation Stage

The implementation phase begins after the interface design is completed. The website development process is carried out using the PHP programming language with the Laravel framework, which allows efficient data management and structured implementation of business logic.

This website includes five main features that were previously designed in the design stage:

1. Landing Page

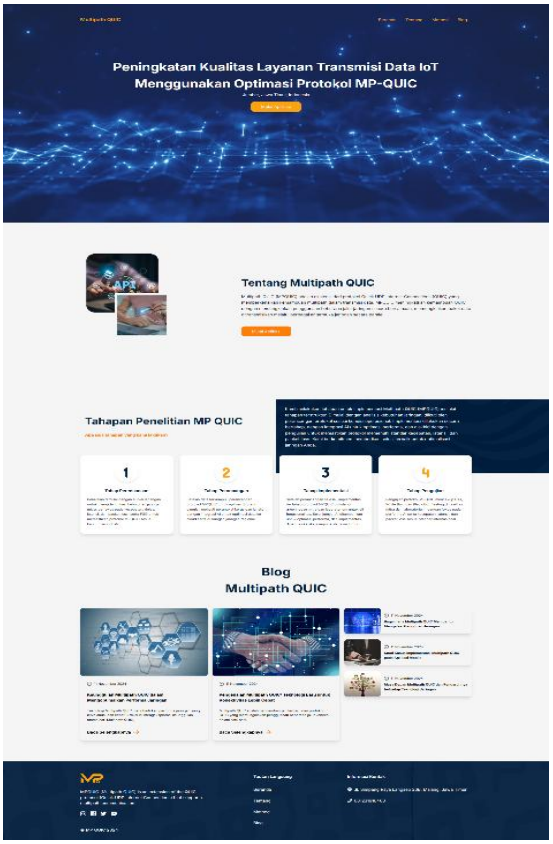


Fig. 6 Landing Page

The landing page provides a brief explanation of Multipath QUIC (MPQUIC), an extension of the QUIC protocol that supports data transmission over multiple paths simultaneously. There is information about the stages of MPQUIC research, from planning to testing. The available blog presents articles related to the advantages and applications of MPQUIC in network optimization. This page is equipped with navigation that facilitates access to various sections such as About, Methods, and Contact.

2. Login Page

This login page allows users to access the MP QUIC

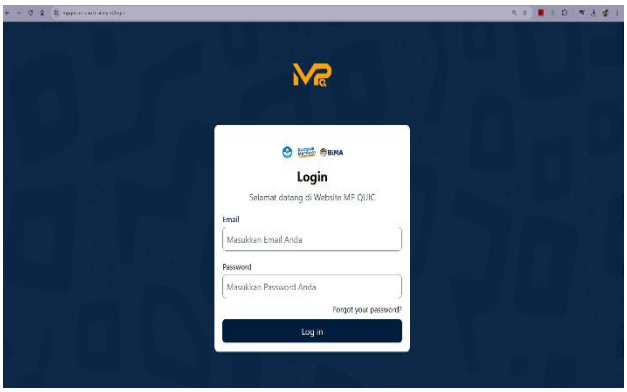


Fig. 5 Login Page

Platform by entering their registered email and password. There is an option to reset the password if the user forgets it. The login page design is simple and user-friendly, ensuring a secure and easy login process.

3. Dashboard

Fig. 7 Dashboard

The MP QUIC dashboard provides a quick view of system status and network performance data. It displays information such as temperature, humidity, and throughput and latency for HTTP and MP QUIC protocols in graphs and tables [11]. The data displayed includes the latest updates for temperature and humidity, as well as throughput and latency statistics for various connected devices. The tables also show details about the protocol type, microcontroller, MAC address, IP address, and throughput and latency values for each device [12].

4. Data Analysis

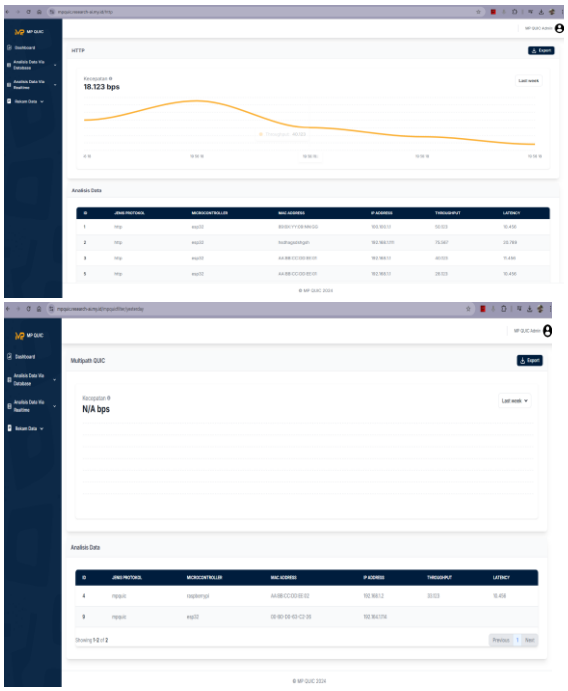


Fig. 8 Data Analysis

The data analysis feature in MP QUIC provides in-depth monitoring of network performance, both in database and real-time. Through the database, users can view historical data that includes information about protocol types, devices used, MAC addresses, IP addresses, and metrics such as throughput and latency [13]. This data is presented in tables for easy analysis. In addition, users can export the data for further analysis [14]. In real-time, this feature allows users to monitor data transmission speeds, with live updates on protocol performance such as HTTP, including throughput and latency values. This analysis helps in data-driven decision making for network optimization.

5. Record Data:

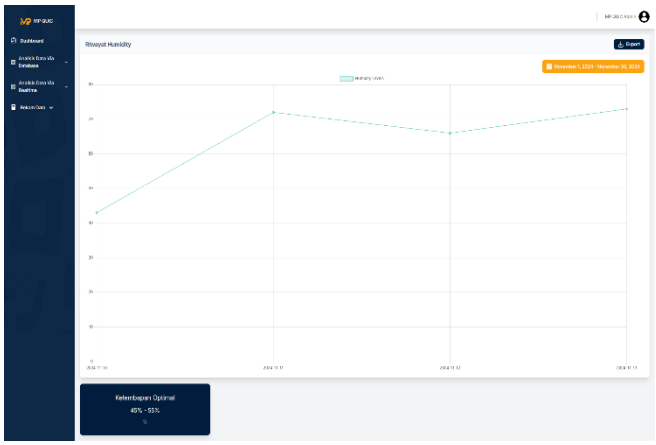


Fig. 9 Record Data

Each component of the website is implemented using the Laravel framework to ensure the design matches the initial mockup designed. The main focus is to maintain consistency between appearance and functionality, including user authentication, real-time data management, and presentation of analytical reports. The implementation results are tested to ensure the website is responsive on various devices and browsers, thus providing an optimal user experience. You can access the website at https://mpquic.research-ai.my.id with email admin@gmail.com and password 12345678.

4. Results in Testing Phase

Testing was conducted by involving users using a Google Form to evaluate the functionality and convenience of the website.

Fig. 10 Landing Page Testing Results

Based on the test results using 11 respondents on the landing page, it was very easy for 63.6% or 7 users and easy for 36.6% or 4 users. This means that the landing page can be accepted by users.

Fig. 11 Login Testing Results

The login process runs smoothly with an adequate level of security. Based on the test results using 11 respondents on the login page, it was very easy for 81.8% or 9 users and easy for 18.2% or 2 users. This means that the login page can be accepted by users.

Fig. 12 Dashboard Testing Results

The dashboard successfully displays data clearly, although some users have suggested increasing the loading speed. Based on the test results using 11 respondents on the landing page, it was very easy for 72.7% or 8 users and easy for 27.3% or 3 users. This means that the dashboard page can be accepted by users.

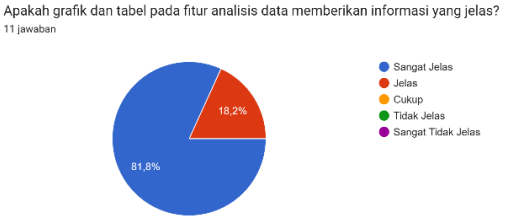


Fig. 13 The Graphs and Table Testing Results

The graphs and tables in the data analysis feature are considered informative and support decision making. Based on the test results using 11 respondents in the data analysis, it was very clear 81.2% or 9 users and easy 18.2% or 2 users. This means that the data analysis feature has been informative so that it can be accepted by users.

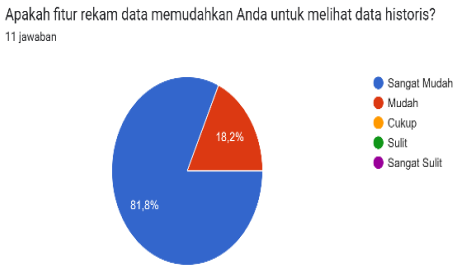


Fig. 14 Record Data Testing Results

The data recording feature received a positive response regarding ease of access and accuracy of information. Based on the test results using 11 respondents on the landing page, it was very easy 72.7% or 9 users and easy 27.3% or 2 users. This means that the dashboard page can be accepted by users.

Fig. 15 Responsive Testing Results

Based on the testing carried out, it has been ensured that the website is responsive on various devices, thus providing a consistent experience both via desktop and mobile devices. Based on the test results using 11 respondents on website and mobile access, it was very easy 63.6% or 7 users and easy 36.4% or 4 users. This means that This shows that the platform meets user needs well because it can be accessed on mobile devices and websites.

CONCLUSIONS

The development of a website application for data transfer simulation using the MP-QUIC protocol has been completed with a structured approach that includes planning, designing, implementing, and testing. In the early stages, user needs were identified through online discussions and User Acceptance Testing (UAT), which resulted in input to refine the design of key features such as landing pages, dashboards, and data analysis. The development process was carried out with a focus on integrating these needs into the system to ensure its functionality and usability.

Test results show that this application is able to provide a consistent experience, with optimal performance across devices, both desktop and mobile. Each feature has been tested to ensure ease of access and reliability, especially in real-time data analysis. In addition, this application supports network performance monitoring with accurate and relevant data, thus helping partners in optimizing and making data-based decisions. Responsiveness and ease of use make this application suitable for the operational needs of users.

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