



Research Article

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The development of Web-based information system using Quick UDP Internet Connection

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Abstract

The Academic Information System (xSIA) is built to its users to manage Study Program modules, including student academic grades. xSIA applying the Moodle Learning Management System (LMS) was developed by implementing Quick UDP Internet Connection (QUIC) technology with the HTTP/3 protocol which can demonstrate protocol transaction speed performance. The design of information systems and databases employs the Convention Over Configuration paradigm. The Prototyping Model is used to graphically represent the workflow of the system with an experimental research design. System modeling utilizes Unified Modeling Language (UML) tools, Data Base Management System (DBMS) using PostgreSQL, and UDP ports as a means of data communication. The implementation of Quick UDP Internet Connection (QUIC) on the xSIA moodle LMS is effective for real-time communications that do not require conditions to open, maintain, or terminate connections as in streaming video conference. It is also optimal because the UDP data is transferred individually and checked for its integrity upon arrival. When a video streaming transaction last 02:36 seconds with a file size of 4.1mb, there is a significant difference of 100.98ms at the waiting time to first byte (ttfb).

Keywords: xSIA; QUIC; HTTP/3.

Introduction

Currently, web-based information systems are increasingly required to have more optimal capabilities in several processes such as file transfers, data downloads, access in data steering, and system security. The need for fast data communication access between regions and the high public demand for online services are often hampered due to poor internet networks, especially when accessing public web pages. This often happens, especially in some areas of central and eastern Indonesia.

A number of information sites in the central and eastern regions of Indonesia were built by implementing HTTP/2 for all forms of data exchange on the internet network. The protocol used by HTTP/2 in sending data is called the TCP protocol. Major browser requires websites to implement SSL (Secure Socket Layer) encryption [1] to provide secure communications, the benefit of HTTP/2. However, this sometimes causes computational overhead that makes the speed increase imperceptible. There were even cases where users reported slowdowns after switching to HTTP/2.

HTTP/2 applies TCP (Transmission Control Protocol) where data transmission between packets request is sent one by one. This causes the data transfer process to slow down if there is unresponded request causing the request to be repeated from the beginning. Users of web-based information systems often have difficulties in carrying out long data transactions.

Therefore, it is necessary to develop an information system using QUIC (QUICK UDP Internet Connections), a new version of the hypertext transfer protocol, namely HTTP/3, which has now been established as the standard data transfer protocol over the internet. HTTP/3 is able to execute one request for all packets so that the data transfer transaction continues even though there are packets that are not responded. Thus, the system can be accessed in a better speed when compared to web pages developed with HTTP/2.

This research is a case study of the development of an academic information system (xSIA)[2][3] which is still applying HTTP/2. The existing system's performance will be improved by implementing QUIC in transferring data, so that delays in data access by users can be minimized.

Method

A. Academic Information System

Information systems can be defined as a collection of elements that are interconnected to integrate data, to process and store data, and to disseminate information. Satoto [4] proposes that the Academic Information System is software that is used to present information and manage administration related to academic activities. The use of this software will facilitate the management of academic administrative activities and the necessary information can be obtained easily and quickly.

B. Web Application

A web application applies browser technology to run applications and is accessed via a computer network. It is a program that is stored on a server and sent over the internet to be accessed via a browser interface. It is accessed using a web browser via the internet or intranet network. It is also a computer software coded in a programming language that supports web-based software [5].

It can be said that Web Applications are usually built using a combination of programming languages for a variety of different purposes such as to manage information data in the internet network. Web applications have very light acceleration as well as use minimal resources.

The **Figure 1** below illustrates the details of web application in the web desktop application and web mobile

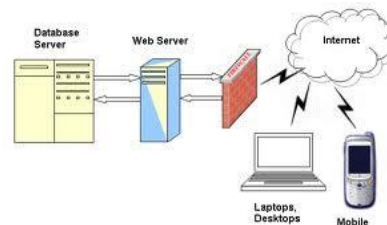


Figure 1. Details of Web Application

C. QUIC (Quick UDP Internet Connection)

Quentin De Coninck and Olivier Bonaventure [6] stated that Quick UDP Internet Connection (QUIC) is the latest protocol initiated by Google that combines HTTP/2, TLS, and TCP functions directly over UDP with the aim of reducing client-server communication latency. QUIC encrypts all data and most protocol headers to prevent interference from middleboxes.

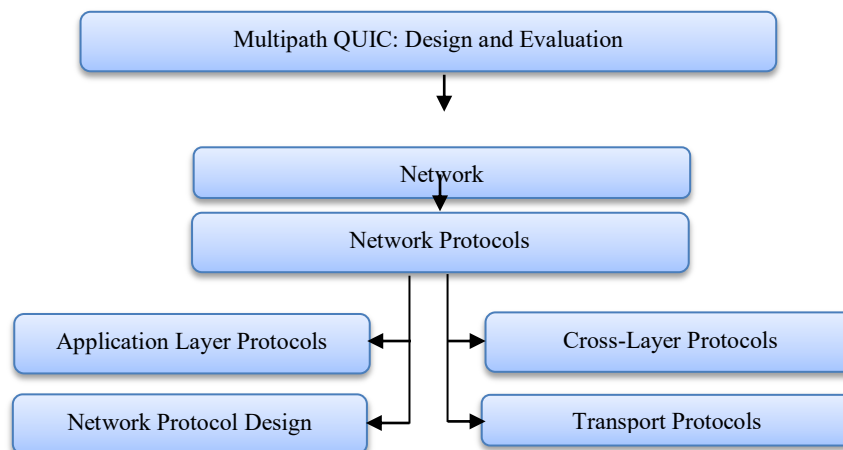


Figure 2. QUIC Design and Evaluation

Based on **Figure 2** in Multipath QUIC (MPQUIC) allows QUIC connections to be used in WiFi and LTE networks on smartphones, or IPv4 and IPv6 on dual-stack hosts. MPQUIC maintains the function of Multipath TCP without losing packets.

QUIC is a new multiplex transport built using the User Datagram Protocol (UDP) and applying HTTP/3 to avoid head-of-line blocking between data streams.

Chromium.org suggested that the QUIC is an alternative to TCP+TLS+HTTP/2, with the goal of improving user experience, particularly page load times. The QUIC working group at the IETF defined a clear boundary between the transport QUIC and application HTTP/3.

D. Hypertext Transfer Protocol (HTTP/3)

HTTP is part of a Uniform Resource Locator (URL) which acts as a scheme or specific instructions regarding the use of a website. In other words, HTTP is used as the basis for data communication needed on the World Wide Web in the form of a series of structured text and using links.

Based on **Figure 3** is HTTP/3 is the third version development of HTTP that offers several capabilities as follows.

- 1) Better early data support that allows faster website access
- 2) Faster handshakes to avoid delay in file downloading
- 3) Able to avoid unnecessary query security that allows transfer data to be processed once only

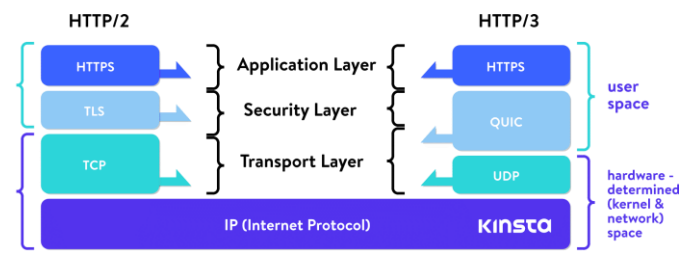


Figure 3. Differences between HTTP/2 and HTTP/3

E. User Experience (UX)

According to ISO 9241-210, the definition of user experience is a person's perception and response from using a product, system, or service. According to Mendiola [7], User Experience (UX) assesses a person's satisfaction and comfort with a product, system, and service. A principle in building UX is that users have the power to determine their level of satisfaction (customer rule). No matter how good the features of a product, system, or service are, if the intended users do not feel satisfaction, rules, and comfort, then the UX level will be low. The development of the digital and mobile has made UX more complicated and multidimensional.

F. Developer Experience (DX)

Developer Experience (DX) is similar to User Experience, but the main users of the DX application are the developer team (Developers) who are very concerned about the implementation of application products, documentation, frameworks, open-source solutions, general tools, APIs, and matters related to application development. DX will provide technical recommendations to support application performance such as the application of technology, functions, and user interfaces.

Results and Discussion

A. Requirement Specification

The result of this study is implemented using both hardware and software specifications such as:

1. Server hardware of Processor 1.8 GHz , Memory 2 GB
2. Server software of Operating System ubuntu server 20.04, RDBMS PostgreSQL 13, dan HTTP/3
3. Programming language of php 7
4. Client software of Browser Latest Chrome 88.

Operational variables in the moodle learning management system are used as features of the xSIA sub-system, where the client consists of Manager and User actors. The types of transaction data accessed are in the form of text and audio visual (AVI) as measuring tools, where the master data running on the system are: lecturers, students, institutions, authentication, courses, lecture_activities.

The xSIA simulation on the moodle learning management system (LMS) is carried out to see the performance of the system in carrying out data communication service transactions that are capable of sending documentation of lecture activities. As illustrated in **Figure 4**, User actors interact in carrying out activities to fill in learning topics in the form of text or avi.

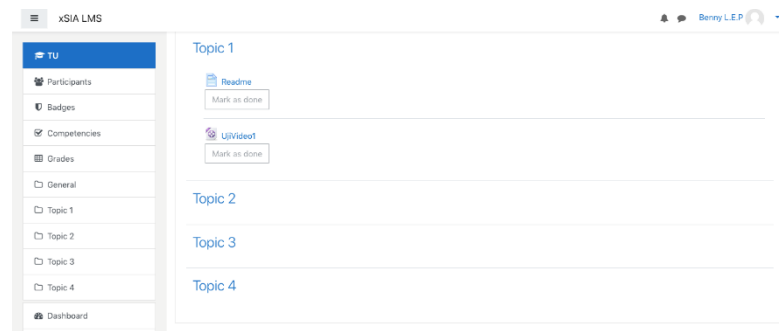


Figure 4. Prototype of xSIA LMS Moodle Interface

The condition of implementing Moodle LMS xSIA which tends to carry a lot of audio-visual data transactions in real time is an important reason that an application system needs to be built using the Quick UDP Internet Connection (QUIC) and the http/3 protocol.

The User Data Protocol (UDP) is a simpler internet protocol where error checking and recovery services are not required. Complete files are processed from server to client so that transaction times are more stable. **Figure 5** shows that in the condition when an error or corrupt data transaction occurs, the use of UDP causes no overhead to open a connection, maintain a connection, or terminate a connection. Data continues to be sent intact from the server to the receiving client.

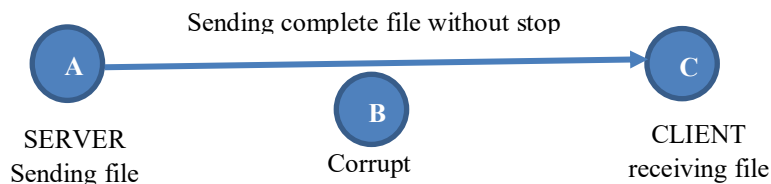


Figure 5. QUIC flow on server transaction to client

The application of UDP allows for more flexibility and enables QUIC implementations to run completely in user space. Updates to protocol implementations are unrelated to operating system updates. **Figure 6** explains that with QUIC, HTTP level streams can be more easily mapped to get all the benefits without experiencing head-of-line blocking when corruption occurs.

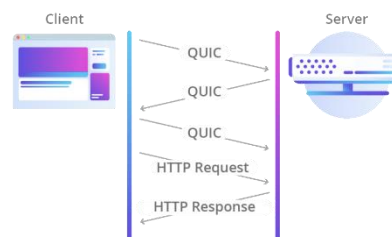


Figure 6. HTTP request over QUIC

QUIC provides encryption and authentication by default, enabling faster connection establishment, even when a new QUIC connection is initiated for the initial request in the HTTP session.

Figure 7 illustrates the design of the Moodle LMS system that is integrated with SIACA through the xSIA web as a media for reporting academic results, where user actors interact via the http/3 protocol.

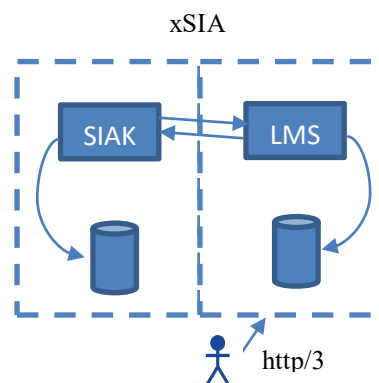


Figure 7. xSIA system integration dan user actors

When many users carry out audio visual (avi) data transactions such as uploading and sending data simultaneously, the QUIC flow makes it possible to share the same connection for all users because the QUIC flow occurs independently. That is, if a system error occurs in carrying out a data transmission transaction from one user, it does not affect the flow of data used by other users.

B. Implementation and testing

The prototype implementation of the moodle LMS xSIA website interface shown in **Figure 8** was built using the php7 programming language. The Latest Chrome 88 browser is used as a medium to open web pages via http/3 while the latest canary build installation was to enable http/3 so that the listing code can be read by browsers.

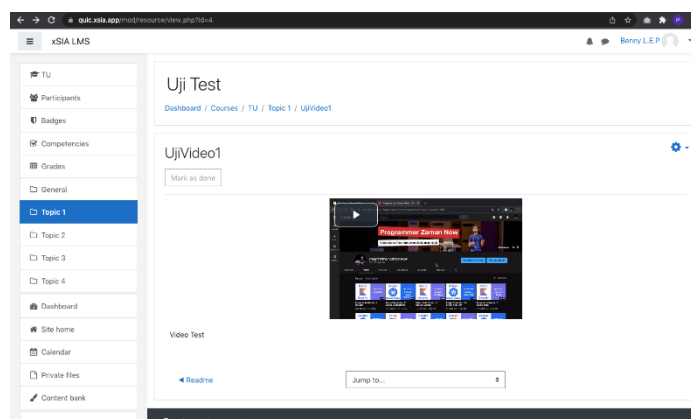


Figure 8. Implementation of *moodle* LMS xSIA with audio visual interaction

Latency is used to measure the delay that occurs. Multiplex is sending signals simultaneously from several messages over a communication line. User Data Protocol (UDP) is a communication protocol used for low latency and tolerant of data loss, in connections between applications on the internet. QUIC is a new multiplex transport built using the UDP protocol. HTTP/3 is a protocol designed to take advantage of the QUIC feature.

The implementation of the xSIA Moodle LMS web system on a webserver that applies HTTP/3 protocol must meet the following conditions:

- 1) The selected webserver is an open source nginx webserver
- 2) To obtain a nginx webserver with the HTTP/3 protocol, nginx is compiled by adding several additional modules besides the standard modules commonly used, namely the boringssl module and the Quic module.

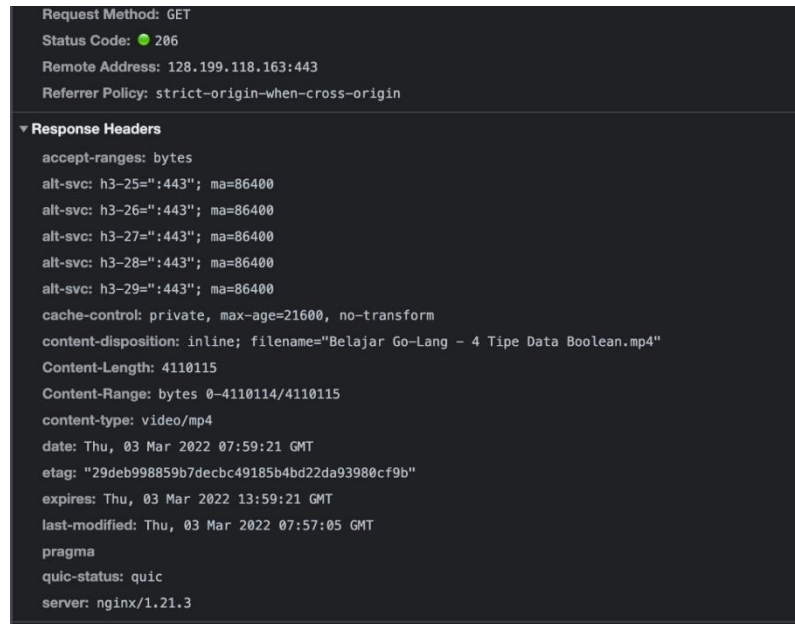


Figure 9. QUIC protocol testing

Figure 9 is the result of the back-end test of the LMS xSIA moodle web page, showing that there is a data transaction with the content type in the form of audio video. The h3 protocol indicates that http/3 is running and receives a response to a data transaction request by looking at the quick status.

Quick UDP Internet Connection (QUIC) is suitable for real-time communication that does not require conditions to open, maintain, or terminate a connection as in streaming video conferencing. It is also optimal to use because the UDP data transfer method is sent individually and checked for its integrity upon arrival. As shown in Figure 10, when a video streaming transaction lasting 02:36 seconds with a file size of 4.1mb, there is a significant difference of 100.98ms in the waiting time to first byte (ttfb). When an error occurs in the process of sending data from the server to the client using the UDP protocol, the basic error checking mechanism uses checksums, namely checking data errors in the order of letters and numbers. Errors in the process of sending data by the server to the client as the recipient can occur due to internet network problems or hard drive problems that cause files to be corrupted.

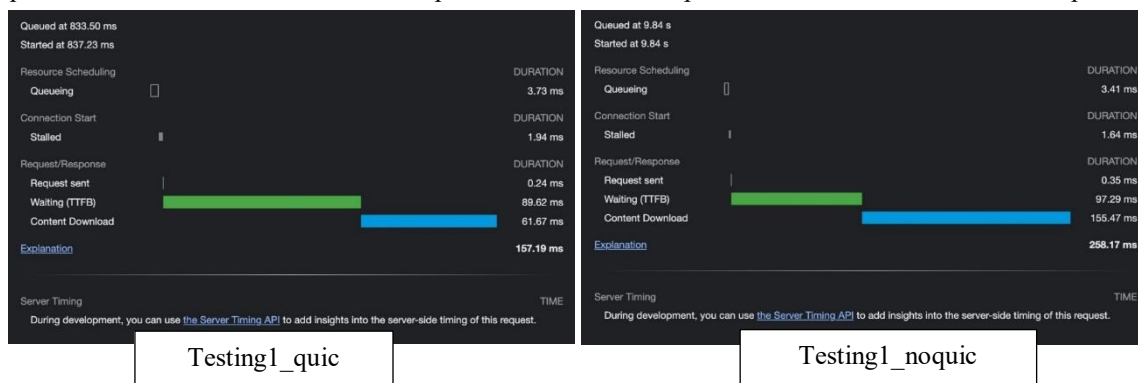


Figure 10. Performance of protocol transaction speed using QUIC

Figure 10 shows xSIA without QUIC was implemented with Transmission Transfer Protocol (TCP) which means that once the connection has been established data can still be transmitted in both directions. TCP checks for errors and guarantees data is delivered in order. Consequently, xSIA without QUIC requires a longer waiting time to send information from the server to the client. The feedback mechanism on TCP produces greater overhead and requires a large bandwidth for each activity.

Test simulations were carried out with different data transaction models in the form of text, images, and videos, as shown in Figure 11. Figure 12 shows the performance difference between xSIA using quic and without quic and the result is a difference in response time of 0.32 seconds between no_quic response and quic response to 25 file requests.

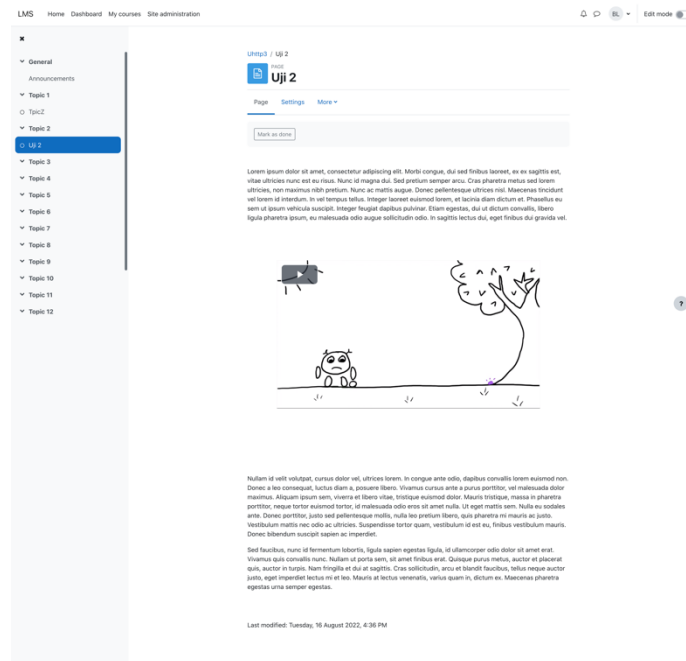


Figure 11. The first simulation of text-image-video data transactions

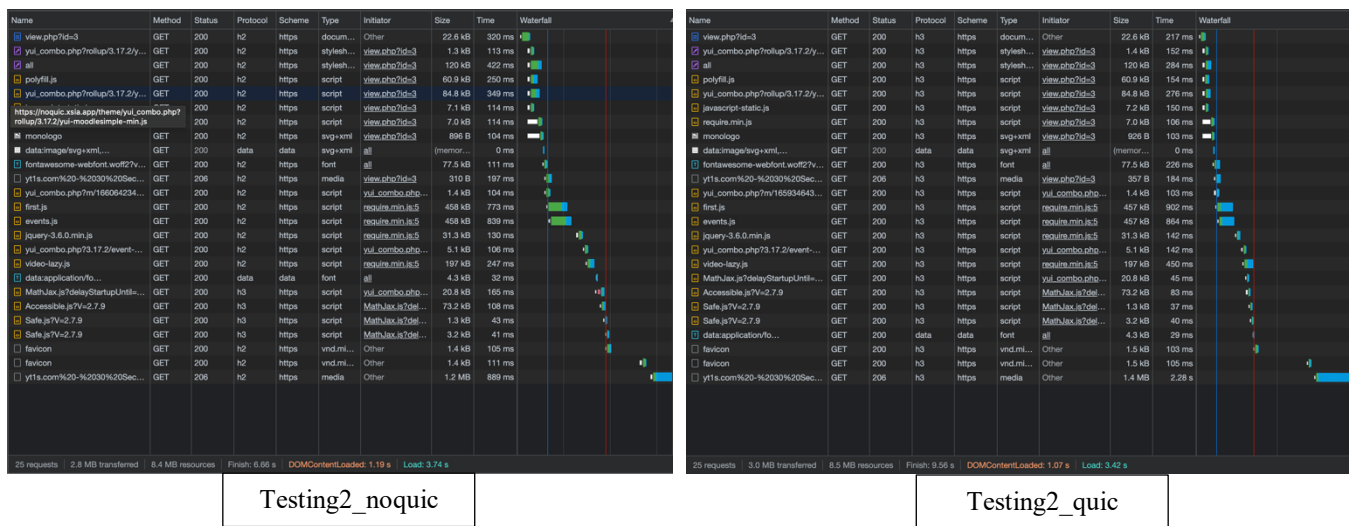


Figure 12. Second back-end test result

Figure 13 shows the backend system testing was carried out repeatedly with a higher resolution video file load than the video streaming in Figure 11. As a result, the response time performance of the xSIA_quic implementation is still better in conducting data transactions with a difference in response time of 0.53 seconds from xSIA_no_quic like in Figure 14

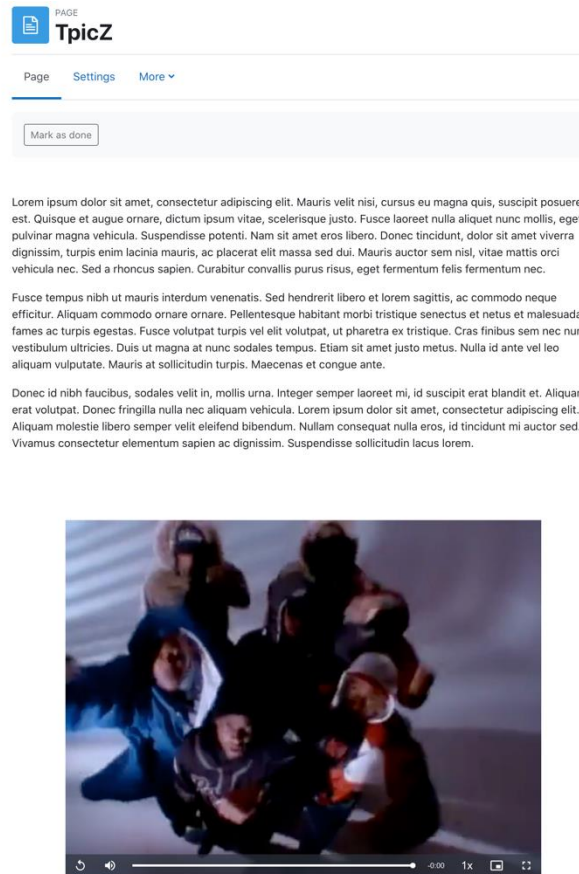


Figure 13. The second simulation of text-image-video data transaction

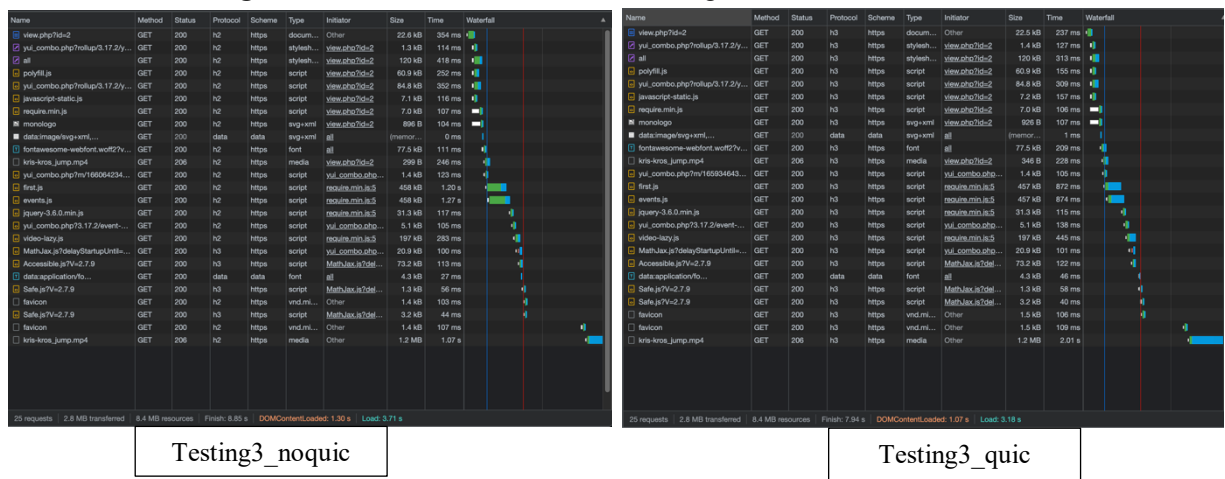


Figure 14. Third back-end test result

Conclusion

The conclusion of the development of a web-based information system using QUICK UDP Internet Connection are as follows: (1) xSIA as a web-based information system has been developed using HTTP/3, especially in Moodle LSM as a learning medium that carries out a lot of video streaming activities. (2) The application of UDP in web application development can avoid transportation and network problems when accessing video streaming in real time on web pages on the client side. (3) Protocol transaction speed performance on the xSIA academic information system using QUIC technology is faster because there is no error checking and recovery for each transaction activity so that excessive overhead does not occur which causes data to continue to be sent to the client from the server.

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