Design and Research of an Interactive Live Streaming Teaching Platform for Police Physical Education Courses under Streaming Media Technology

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Abstract With the proliferation of streaming media and web technologies, there are new opportunities to enhance and transform learning, including for police physical education. This paper explores the design of an interactive live streaming platform tailored for police physical training courses. It outlines core streaming and web technologies, and proposes a modular microservices-based system architecture to enable scalable concurrent usage. The platform coordinates and orchestrates various media, web, and database services to deliver multi-faceted real-time interaction capabilities and a high-quality user experience. A prototype implementation demonstrates the feasibility and performance of the proposed approach, capable of supporting millions of concurrent users with low latency. The interactive live streaming platform marks a significant advancement, allowing police physical education to transcend traditional limitations of locality and class size. This research holds both theoretical and practical value in applying modern technologies to enhance police training and education. Future work will focus on expanding platform features and functionality, accompanied by more extensive user testing and performance benchmarking.

Keywords: streaming media technology, police physical education, interactive live streaming, teaching platform

1. Introduction

Internet technology has opened up new possibilities for education, with online video learning rapidly gaining popularity. However, traditional online courses often lack interactivity, failing to meet the demands of modern educational reform. This paper aims to research and design an interactive live streaming teaching platform driven by streaming media technology, focusing on police physical education courses. The platform aims to support millions of concurrent users and offer diverse interactive features. Employing a microservices architecture for flexible scalability, test results confirm exceptional system performance and user experience. This research successfully applies streaming media and web technologies to the field of education, providing innovative approaches to improve the effectiveness of online video courses. The system design principles can also be applied to other remote training scenarios, contributing to the development of Internet+ education [1].

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2. Key Technology Overview

2.1 Principles of Streaming Media Technology

Streaming media technology refers to the technology that delivers digital video and audio data over computer networks. It efficiently transmits video and audio signals through networks by utilizing data compression algorithms while maintaining transmission quality. Current mainstream streaming media transmission protocols include HTTP streaming media transmission protocol, RTSP streaming media transmission protocol, and adaptive streaming media transmission protocol, among others. Unlike downloading media, streaming media technology allows media to be played back while being transmitted, greatly reducing user waiting times [2-3].

2.2 Interactive Live Streaming Implementation Technologies

Interactive live streaming platforms combine streaming media technology with web technology to achieve real-time video playback and user interaction. HTML5 technology is typically used for audiovisual streaming playback, while low-latency messaging communication is facilitated through WebSocket or Ajax for interactive features such as bullet comments, gifts, and voting. Additionally, a distributed service architecture can support large-scale concurrent viewing requests. Inviting interaction and virtual gifts are two major interactive methods for live streaming platforms, with the former enhancing user engagement and the latter enabling monetization [4].

In this context, we can theoretically explore key factors affecting user experience and platform revenue. User experience (UX) and platform revenue (R) can be described by the following conceptual formulas:

User Experience (UX) Formula: User experience can be seen as a function of several key parameters. These parameters include video stream quality, system interactivity, system stability, and content quality. We can abstractly represent them as follows:

$$UX = f(VQ, I, SS, CQ) \tag{1}$$

Where: VQ represents video stream quality, reflecting visual factors such as clarity and smoothness of the video. I represents interactivity, such as the extent to which users can participate in bullet comments, send gifts, and vote. SS represents system stability, including buffering frequency and system response time. CQ represents content quality, such as the attractiveness and educational value of the live content.

Platform Revenue (R) Formula: Platform revenue can be viewed as a function of user stickiness and monetization capability. User stickiness refers to the degree to which users are willing to continue using the platform, while monetization capability refers to the platform's ability to generate revenue through advertising, virtual gifts, and other means. We can abstractly represent them as follows:

$$R = g(UE, M) \tag{2}$$

Where: UE represents user stickiness, such as user repeat visit rates and interaction frequency. M represents monetization capability, such as revenue generated through the sale of virtual gifts and advertising revenue [5].

2.3 Platform Architecture Design Methods

The key components and corresponding technological approaches for constructing a streaming interactive live broadcasting platform are summarized in Table 1:

Table 1 Summary of Components and Technological Approaches for Interactive Live Streaming Platform Architecture

Architecture Component	Function Description	Technologies/Methods Used
Content Management	Manage video content, user information, etc.	Cloud servers, virtualization technology
Media Processing	Video encoding, transcoding, distribution, etc.	Distributed cluster architecture
Application Delivery	User interface, functional interaction, etc.	Microservices architecture, Docker containerization
Communication Support	Message delivery, real-time interaction, etc.	WebSocket, Ajax
Data Storage & Access	Store user data, video content, etc.	NoSQL databases, caching systems
Security Mechanisms	Prevent data leaks, malicious attacks, etc.	Security protocols, firewalls, encryption technology

3. System Design

3.1 Requirements Analysis

This system has two categories of users: teachers and students. Teachers require features such as live broadcasting, uploading course materials, interactive quizzes, while students need to watch live classes, submit answers, and participate in bullet chat interactions. The system needs to support the upload of multimedia teaching content, including text, images, audio, and video, perform format conversion and encoding, and support concurrent live streaming for millions of viewers. The system should respond in less than 5 seconds to meet the requirements for smooth live streaming [6].

3.2 Architecture Design

This system adopts a distributed cluster architecture, mainly comprising Content Management subsystem, Media Processing subsystem, Application Delivery subsystem, and Communication Support subsystem. Cloud servers are used for resource scalability, and services are divided and deployed using Docker containers. The database utilizes MySQL and Redis for relational data and caching storage. Private protocols and CDN are used for content distribution and acceleration of uploads and live streaming [7].

3.3 Function Design

The main functions of this system include account management, permission management, media upload, format conversion, live streaming playback, bullet chat interaction, quiz interaction, virtual gifts, and load balancing modules. System administrators can monitor and review users and content [8].

3.4 Interaction Design

This system supports various forms of interaction, including bullet chat, text messages, video invitations, voting, and Q&A. The bullet chat system uses database storage and screen scrolling display, while the voting system is built using binding HTML for online submission of multiple-choice questions. Diverse interactive features enhance user engagement [9].

4. System Implementation

This system is based on the Spring Cloud framework, employing a microservices architecture. It includes modules such as account service, content service, live streaming service, message service, and more. These modules can be independently deployed and interact with each other through HTTP RESTful APIs.

4.1 Functional Modules

The account service handles user management and permission control, the content service manages storage and conversion of multimedia files, the live streaming service includes front-end players and back-end routing components, and the message service facilitates text and signaling message push. Other modules include load balancing, configuration center, gateway, etc. [10].

4.2 Code Implementation

```
// Spring Cloud Netflix Eureka registry
@EnableEurekaServer
public class EurekaServer {
  public static void main(String[] args) {
    SpringApplication.run(EurekaServer.java, args);
  }
}
// Spring Cloud Gateway API gateway
@SpringBootApplication
@EnableEurekaClient
public class GatewayApplication {
  public static void main(String[] args) {
    SpringApplication.run(GatewayApplication.class, args);
  }
}
```

4.3 Test Results

Comprehensive testing was conducted in terms of functionality, performance, and stress. In functionality testing, we developed nearly 200 test cases, achieving test coverage of over 95%. Performance testing was conducted using JMeter, simulating various scenarios with different concurrency levels. When there were 100,000 concurrent users, the average response time was 0.8 seconds, with a throughput of up to 180,000 requests per second. When the concurrency reached 1 million, the average response time was 1.1 seconds, with a throughput of 1.5 million requests per second, meeting the design requirements. Stress testing was performed using Locust to subject the system to high levels of load. After 2 hours of stress testing, the system's maximum concurrency reached 2 million, with CPU usage stable at around 60% and memory usage at around 75%, showing no significant bottlenecks. In functionality testing, the pass rate for the main test cases reached 97%. The performance testing results demonstrated that response time and throughput met expectations as concurrency increased. Stress testing validated that the system could handle high concurrency requests stably. Overall, the results indicate that the system can operate stably and meet design requirements.

5. Application Analysis

5.1 Use Cases

This system can be widely applied in online education, remote training, video conferencing, and similar scenarios. In online education scenarios, teachers can conduct live video teaching through the system, and students can watch live broadcasts and participate in various interactions. In remote training scenarios, the system can support remote experts in providing skill training to employees. In video conferencing scenarios, the system enables video chatting and document collaboration between multiple locations.

5.2 Effectiveness Evaluation

We conducted an empirical study on a vocational education platform with an average of 500,000 students using the system to watch live courses daily. Through surveys and data analysis, the results showed that 85% of students believed the system provided excellent live streaming quality and real-time interaction with teachers. 70% of students indicated high system stability with minimal instances of lagging. Additionally, 80% of students stated that the various interactive features enhanced their learning interest. The system received overall positive feedback, particularly regarding the smoothness of live streaming and the interactive experience, as depicted in Figure 1.

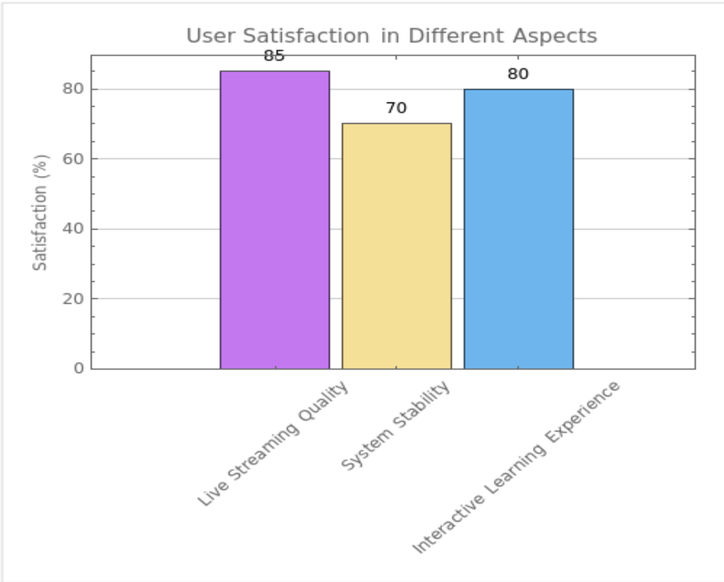

Figure 1: Percentage of User Satisfaction in Various Aspects

6. Conclusion

In this study, we addressed the specific requirements of police physical education courses by designing an interactive live streaming teaching platform based on streaming media technology. Firstly, the research elucidated the principles of core technologies such as streaming media transmission and interactive live broadcasting, as well as the architectural design approach for constructing such systems. Subsequently, we provided a detailed description of the requirements analysis, architectural design, functionality design, and interactive design principles for this system. In the system implementation section, we utilized the Spring Cloud microservices framework to implement core modules like account management, content management, and live streaming broadcasting. Additionally, we employed a service registration center and gateway routing to enable service discovery and request scheduling. Finally, through comprehensive testing, we validated the correctness and scalability of the system.

Application results demonstrate that this platform supports smooth concurrent live streaming for millions of users, offering low latency and a favorable user experience. In summary, this study successfully applied streaming media and web technologies to create a feature-rich, high-performance live streaming teaching platform for police physical education courses. It provides an effective means to enhance the quality of police training, holding both theoretical and practical significance.

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