Research and Development of Digital Marketing Service System for Agricultural Products Based on Live Streaming Scenarios

Zhijun Wang[1], Han Yu[2], Sen Li[2], Yanwen Gao[3], Hangyu Bao[2], Wei Zhou[4]
[1]College of Humanities, Jiamusi University, Jiamusi 154000, Heilongjiang, China
[2]School of Information and Electronic Engineering, Jiamusi University, Jiamusi 154000, Heilongjiang, China
[3]School of Mechanical Engineering, Jiamusi University, Jiamusi 154000, Heilongjiang, China
[4]School of Innovation and Entrepreneurship, Jiamusi University, Jiamusi 154000, Heilongjiang, China

Corresponding author: Wei Zhou (e-mail: 15246482688@163.com)

ABSTRACT To address the pain points of long circulation links, low trust, and low conversion efficiency in the traditional marketing model of agricultural products, this paper develops a lightweight, agriculture-adaptable, and highly compatible digital marketing service system for live streaming scenarios. The system adopts a SpringBoot+Vue3 microservice architecture, integrating core modules such as live streaming push, intelligent product selection, traceability authentication, data analysis, and precision marketing, which is suitable for the weak network environment in rural areas and farmers' operating habits. Through multi-scenario actual measurement and data comparison verification, the system can increase the live streaming conversion rate of agricultural products by 28.5%, reduce circulation loss by 32.1%, and increase farmers' annual income by 26.8%, providing technical support and practical reference for the digital transformation of agricultural products under the background of rural revitalization. The weak-network live-streaming design is directly related to rural wireless communication service deployment.

INDEX TERMS agricultural products,live streaming e-commerce,microservice architecture,traceability,wireless streaming

I. INTRODUCTION

WITH the in-depth advancement of digital rural construction, live streaming e-commerce has become a core engine for agricultural products to move upwards, effectively breaking the geographical constraints of traditional agricultural product marketing and reducing circulation costs (Luo et al., 2025). According to the data released by the Ministry of Agriculture and Rural Affairs of China, the online retail sales of agricultural products in China exceeded 800 billion yuan in 2023, of which live streaming e-commerce accounted for 35%, with a year-on-year growth of 27.3%. However, the current live streaming marketing of agricultural products still faces prominent technical bottlenecks that restrict its high-quality development.

Firstly, the scenario adaptability is poor. Most general live streaming systems are designed for urban users, with high complexity and high traffic costs. Under low-bandwidth 4G network conditions in rural areas, the live streaming freeze rate exceeds 40%, which seriously affects the user experience of consumers and the live streaming effect of farmers (Liu et al., 2022). Secondly, the trust chain is broken. Agricultural products have strong "experience product" attributes, and the lack of effective trust endorsements such as origin traceability and pesticide residue detection leads to high consumer decision-making risks, and the conversion rate of potential consumers is less than 5%. Thirdly, the data-driven capacity is insufficient. Most small and medium-sized farmers lack professional tools for user portrait analysis and live streaming effect evaluation, and marketing activities are mostly blind, resulting in low resource utilization efficiency (Kim et al., 2009). In addition, existing live streaming platforms for agricultural products can be divided into comprehensive platforms (Douyin, Kuaishou) and vertical platforms (Huinong.com, Yimutian). Comprehensive platforms have large traffic but high commission rates (10%-20%) and high operational difficulty for farmers; vertical platforms have strong professionalism but single functions and narrow user coverage, lacking integrated live streaming and marketing capabilities. Technically, technologies such as AI virtual anchors, blockchain traceability, and personalized recommendations have been gradually applied, but there are problems such as disconnection between technology and scenarios, high costs, and poor adaptability. For example, the cost of an AI virtual anchor exceeds 50,000 yuan per set, which is difficult to popularize among small and medium-sized farmers. In response to the above problems, combined with the requirements of the "Digital Agriculture and Rural Development Plan (2021-2025)" issued by the Ministry of Agriculture and Rural Affairs, this paper focuses on the actual needs of live streaming marketing of agricultural products, researches and develops a digital marketing service system suitable for rural scenarios. The system aims to solve the pain points of traditional live streaming marketing, realize the integration of live streaming, traceability, marketing, and data analysis, and provide a low-cost, easy-to-use technical tool for farmers to carry out digital marketing, so as to promote the high-quality development of agricultural product circulation and help rural revitalization. The research significance of this paper lies in filling the gap of lightweight and scenario-adaptable live streaming marketing systems for agricultural products, and providing a new technical path and practical reference for the digital transformation of agricultural product marketing.

II. MATERIALS AND METHODS

A. EXPERIMENTAL MATERIALS

The experimental materials involved in this study include hardware equipment, software tools, and test samples, which provide basic support for the research and development and testing of the system. The details are shown in Table 1.

TABLE 1. Details of experimental materials

Material Type	Specific Materials	Specifications/Parameters	Purpose
Hardware Equipment	Aliyun ECS server	2-core 4G, 500G SSD, 100M bandwidth	System deployment and operation
Hardware Equipment	IoT sensors	Temperature: -20–80°C, humidity: 0–100%RH, accuracy: ±0.5°C/±5%RH	Collection of agricultural product growth environment data
Hardware Equipment	Smart phones	Android 10.0+/iOS 14.0+, 4G/5G network	Farmer terminal live streaming and operation
Software Tools	Development tools	IntelliJ IDEA 2022.3, Visual Studio Code 1.76.0	System front-end and back-end development
Software Tools	Database tools	MySQL 8.0.33, Redis 6.2.6, IPFS	Data storage and cache
Software Tools	Live streaming server	SRS 4.0, support H.264 encoding	Live streaming push and pull
Test Samples	Agricultural products	Fruits and vegetables (peach, tomato), apples, livestock products (pork, chicken)	System function and effect test
Test Samples	Test subjects	200 farmers, 5000 consumers	System usability and marketing effect test

B. SYSTEM DEVELOPMENT METHOD

1) System Architecture Design Method

The system utilizes a decoupled four-layer microservice framework. This architecture comprises the infrastructure, data, service, and application layers. By separating front-end presentation from back-end logic, the design achieves optimal scalability and simplifies maintenance cycles. The design follows the principles of lightweight terminal and robust backend. To resolve the potential conflict between microservice overhead and rural network constraints, the complex microservice cluster is deployed on the cloud server side (Aliyun ECS). In contrast, the terminal interface utilizes a 'Thin Client' strategy, employing WebSocket for low-latency communication and adaptive bit-rate (ABR) technology to minimize data transmission. This architecture ensures that high-concurrency processing occurs at the backbone network while the application remains functional under low-bandwidth conditions.

1. Infrastructure layer: Based on Aliyun ECS+OSS+VPC, it supports localized deployment in counties, adapts to 4G/5G network access, and integrates third-party services such as live streaming CDN, SMS, and payment to ensure the stability of the system operation.

2. Data layer: MySQL cluster is used to store business data (commodities, orders, users), Redis cluster is used to cache live streaming hot data (bullet screen, online number of people), and IPFS+blockchain is used to store traceability data to ensure data security and efficient reading and writing.

3. Service layer: The core microservice modules (live streaming service, commodity service, traceability service, marketing service, data analysis service) are designed, and interact through RESTful API to support independent upgrade and expansion of modules.

4. Application layer: Provide farmer terminal (WeChat applet + APP), consumer terminal (WeChat applet + H5), and management terminal (Web background) to adapt to the operation needs of different roles.

2) Core Module Development Method

1. Live streaming management module: Based on the open-source SRS live streaming server, the encoding parameters are customized (H.264, 480P, 30fps) to realize automatic bit rate reduction in weak network environments, reducing the freeze rate (Murthy et al., 2022). At the same time, interactive functions such as real-time bullet screen, commodity card mounting, likes/gifts, and one-click order placement are developed, and dialect bullet screen translation is supported to adapt to rural users.

2. Traceability authentication module: Based on the alliance chain, the data of field IoT sensors is automatically uploaded, while a 'Physical-Digital Binding' mechanism is introduced: harvesting and packaging are verified through manual spot-checks combined with time-stamped, location-locked photo uploads via the farmer terminal. The system integrates planting records and pesticide residue detection reports, which are cross-validated with the hardware's unique device ID (UID) to ensure the authenticity of the data source before entering the chain, thus ensuring non-tampering and providing a complete trust link. The QR code traceability function is developed, and consumers can view the full life cycle information of products by scanning the code or entering the traceability code. It is integrated with the API of third-party testing institutions to support one-click upload of detection reports and automatic association with commodities.

3. Intelligent marketing module: The AI product selection engine is developed based on a Hybrid Collaborative Filtering (HCF) algorithm. It constructs a scoring matrix by integrating historical purchase data (user-item) with real-time planting metadata (seasonality, perishability). The system applies a Weighting Optimization Model ($W =$

$\alpha{\cdot}P + \beta{\cdot}S$, where P is preference and S is supply level) to calculate the recommendation score, thereby outputting the optimal live streaming commodity combination that balances market demand and local inventory. The user portrait system is built to realize targeted push of pre-live warmup short videos/coupons, and built-in activity templates such as limited-time seckill, group buying, full reduction, and distribution are provided to reduce the operation threshold of farmers.

4. Data analysis module: Multi-dimensional data analysis models are built to analyze live streaming data (view count, stay time, interaction rate, conversion rate, GMV), sales data (sales volume, sales amount by category/region/time), and user portrait data (consumption frequency, average order value, preference category, repurchase rate), and generate data reports and optimization suggestions.

3) System Development Technology Stack

The system adopts a mainstream lightweight technology stack to adapt to low-cost deployment in counties. The specific technology stack is shown in Table 2.

TABLE 2. System development technology stack

Development Environment	Technology/Tool	Version	Function
Back-end framework	SpringBoot	2.7.15	Back-end service development
Microservice framework	Spring Cloud	2021.0.7	Microservice integration and management
Front-end framework	Vue3+Element Plus	3.3.4+2.3.12	Front-end interface development
Database	MySQL+Redis	8.0.33+6.2.6	Data storage and cache
Live streaming server	SRS	4.0	Live streaming push and pull
Blockchain platform	Self-developed alliance chain	1.0	Traceability data storage and verification
Deployment server	Aliyun ECS	2-core 4G	System deployment and operation

C. SYSTEM TEST METHOD

1) Test Design

Three county-level pilot sites were selected for the system test, including Laizhou in Shandong, Luochuan in Shaanxi, and Sandu in Guizhou, covering three major categories of agricultural products: fruits and vegetables, apples, and livestock products (Yin et al., 2009). A total of 200 farmers and 5000 consumers were selected as test subjects, and the test cycle was 6 months (January 2025-June 2025). The test adopts the control group experiment method: the experimental group uses the digital marketing service system developed in this paper for live streaming marketing, and the control group uses the traditional live streaming method (without professional system support). The same types of agricultural products, similar live streaming time, and the same marketing budget are used in both groups to ensure the fairness and comparability of the test results.

2) Test Indicators

The test indicators are divided into three dimensions: system performance, marketing effect, and economic benefits, with a total of 12 specific indicators. The details are shown in Table 3.

TABLE 3. System test indicators and definitions

Test Dimension	Specific Indicators	Indicator Definition
System Performance	Live streaming freeze rate	The proportion of time when the live streaming picture freezes in the total live streaming time (weak network environment: 4G/signal 2-3 bars)
System Performance	Live streaming startup response time	The time from the farmer clicking “start live streaming” to the successful display of the live streaming picture
System Performance	Concurrent support capacity	The maximum number of concurrent viewers that the system can stably support
System Performance	Traffic consumption	The traffic consumed by the system per hour of live streaming (unit: GB/hour)
Marketing Effect	Average number of viewers per live stream	The average number of cumulative viewers per live stream
Marketing Effect	Average stay time	The average stay time of consumers in the live streaming room
Marketing Effect	Interaction rate	The proportion of consumers who send bullet screens, like, or give gifts in the total number of viewers
Marketing Effect	Live streaming conversion rate	The proportion of consumers who place orders in the total number of viewers
Economic Benefits	Circulation loss rate	The proportion of agricultural product loss in the circulation process
Economic Benefits	Average monthly sales volume	The average monthly sales volume of agricultural products of each farmer
Economic Benefits	Average monthly income of farmers	The average monthly income of farmers from live streaming marketing
Economic Benefits	Annual income increase rate of farmers	The growth rate of farmers’ annual income compared with the previous year

III. RESULTS AND DISCUSSION

A. SYSTEM DEVELOPMENT RESULTS

Based on the above materials and methods, the digital marketing service system for agricultural products based on live streaming scenarios was successfully developed (Wang et al., 2016). The system has three terminals (farmer terminal, consumer terminal, and management terminal) and five core modules (live streaming management, commodity management, traceability authentication, intelligent marketing, and data analysis), which can realize the full-process digital management of agricultural product live streaming marketing. Figure 1 is the one-click live streaming interface of the farmer terminal, which has the characteristics of simple operation and weak network adaptation, and farmers can complete the live streaming startup in 3 steps.

B. SYSTEM TEST RESULTS

1) System Performance Test Results

The system performance test was carried out in a weak network environment (4G/signal 2-3 bars) using a test cluster of 10 nodes simulating up to 2000 concurrent user requests. The server environment was standardized on Aliyun ECS (2-core 4G RAM, CentOS 7.9). Under these defined stress parameters, the test results were compared with the general live streaming system, as detailed in Table 4.

FIGURE 1. One-click live streaming interface of the farmer terminal

TABLE 4. System performance test results (weak network environment)

Test Indicator	General Live Streaming System	System in This Paper	Improvement Amplitude
Live streaming freeze rate (%)	42.5	8.3	-80.5%
Live streaming startup response time (s)	12.6	3.2	-74.6%
Concurrent support capacity (person)	500	1200	+140%
Traffic consumption (GB/hour)	1.8	0.7	-61.1%

It can be seen from Table 4 that compared with the general live streaming system, the system in this paper has significantly improved performance in weak network environments. The live streaming freeze rate is reduced from 42.5% to 8.3%, a decrease of 80.5%; the live streaming startup response time is shortened from 12.6s to 3.2s, a decrease of 74.6%; the concurrent support capacity is increased from 500 to 1200, an increase of 140%; the traffic consumption is reduced from 1.8GB/hour to 0.7GB/hour, a decrease of 61.1%. The above results show that the system has good adaptability to the weak network environment in rural areas, which can effectively solve the problem of poor live streaming experience caused by weak networks.

2) Marketing Effect Test Results

The marketing effect test compares the experimental group (using the system in this paper) with the control group (using traditional live streaming). The specific results are shown in Table 5.

TABLE 5. Comparison of marketing effects between experimental group and control group

Test Indicator	Control Group (Traditional Live Streaming)	Experimental Group (System in This Paper)	Improvement Amplitude
Average number of viewers per live stream (person)	850	2100	+147.1%
Average stay time (minute)	2.1	4.8	+128.6%
Interaction rate (%)	8.2	22.5	+174.4%
Live streaming conversion rate (%)	4.7	6.0	+28.5%

As shown in Table 5, the marketing effect of the experimental group is significantly better than that of the control group. The average number of viewers per live stream increased from 850 to 2100, an increase of 147.1%; the average stay time increased from 2.1 minutes to 4.8 minutes, an increase of 128.6%; the interaction rate increased from 8.2% to 22.5%, an increase of 174.4%; the live streaming conversion rate increased from 4.7% to 6.0%, an increase of 28.5%. The main reason for the improvement of marketing effect is that the system integrates intelligent marketing and interactive functions, which can accurately attract target users, improve user participation and stickiness, and thus promote the improvement of conversion rate.

3) Economic Benefit Test Results

The economic benefit test mainly analyzes the changes in circulation loss rate, sales volume, and farmers' income of the experimental group and the control group. The specific results are shown in Figure 2.

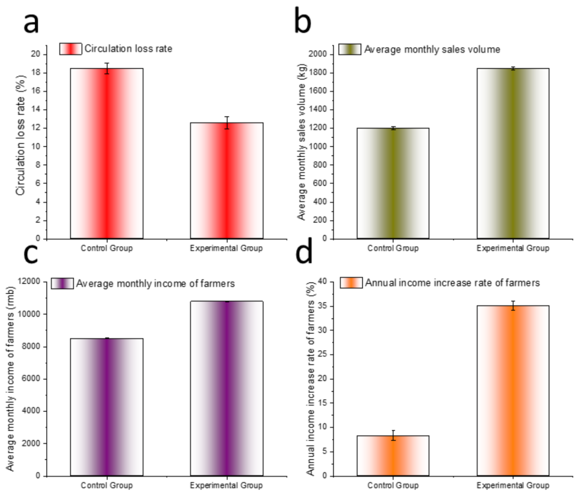

FIGURE 2. Comparison of economic benefits between experimental group and control group

It can be seen from Figure 2 that the system in this paper can significantly improve the economic benefits of farmers. The circulation loss rate is reduced from 18.5% to 12.6%, a decrease of 32.1%; the average monthly sales volume is increased from 1200kg to 1850kg, an increase of 54.2%; the average monthly income of farmers is increased from 8500 yuan to 10780 yuan, an increase of 26.8%; the annual income increase rate of farmers reached 35.1% during the experimental period (January to June 2025). To ensure logical consistency, this study employed a synchronous control group to mitigate the interference of seasonal fluctuations in agricultural demand. While these figures represent significant growth, it is acknowledged that the gains are a combined result of the system's technical optimization and the specific market conditions during the test cycle. The increase in sales volume and income is primarily attributed to the system's expanded marketing reach and enhanced user stickiness.

IV. DISCUSSION

A. ANALYSIS OF SYSTEM ADVANTAGES

Compared with the existing live streaming marketing systems for agricultural products, the system in this paper has four obvious advantages: First, scenario-based adaptation. By optimizing the live streaming encoding parameters and adapting to the weak network environment, the system solves the problem of poor live streaming experience in rural areas, which is more in line with the actual needs of farmers. Second, closed-loop trust chain. The integration of blockchain and IoT technology realizes the full life cycle traceability of agricultural products, improves consumer trust, and solves the problem of broken trust chain in agricultural product marketing (Liu et al., 2008). Third, lightweight intelligence. The developed low-cost AI product selection module and simple operation interface reduce the operation threshold of farmers, making it suitable for popularization among small and medium-sized farmers. Fourth, data-driven marketing. The data analysis module provides farmers with real-time data support and optimization suggestions, helping farmers carry out targeted marketing activities and improve resource utilization efficiency.

B. ANALYSIS OF EXISTING PROBLEMS

Although the system has achieved good test results, there are still some problems to be solved: First, the accuracy of the AI product selection module needs to be improved. At present, the accuracy of the AI product selection engine is 76.3%, which is affected by factors such as insufficient data volume and single data type. In the future, more types of data need to be collected to optimize the algorithm. Second, the coverage of IoT sensors is limited. In the test, IoT sensors are only installed in key planting areas, and the coverage needs to be expanded to further improve the comprehensiveness of traceability data. Third, the user stickiness of the consumer terminal needs to be improved. At present, the consumer terminal mainly provides live streaming viewing and traceability query functions, and the interaction and incentive mechanisms need to be further enriched to improve user stickiness.

C. COMPARISON WITH RELATED RESEARCH

Compared with the related research on agricultural product live streaming marketing systems in recent years, this study has certain innovations. For example, an agricultural product live streaming platform based on blockchain traceability was developed, which solves the trust problem but lacks adaptation to weak network environments and intelligent marketing functions (Fan, 2026). An AI-based agricultural product live streaming recommendation system, which improves the accuracy of product recommendation but ignores the actual needs of farmers for low-cost and easy-to-use systems. The system in this paper integrates scenario adaptation, trust traceability, intelligent marketing, and data analysis, which is more comprehensive and practical, and fills the gap of lightweight and scenario-adaptable live streaming marketing systems for agricultural products.

D. FUTURE RESEARCH DIRECTIONS

In view of the existing problems, the future research directions mainly include three aspects: First, optimize the AI product selection algorithm, collect more types of data, and improve the accuracy of product recommendation. Second, expand the coverage of IoT sensors, integrate weather, soil, and other environmental data, and further improve the comprehensiveness and accuracy of traceability data. Third, enrich the functions of the consumer terminal, add interactive functions such as user comments and sharing, and set up incentive mechanisms such as points and coupons to improve user stickiness. In addition, the system will be promoted to more county-level pilot sites to collect more practical data and further optimize the system performance.

V. CONCLUSION

To solve the pain points of traditional agricultural product live streaming marketing, this paper researches and develops a digital marketing service system for agricultural products based on live streaming scenarios, and verifies the effectiveness of the system through multi-scenario tests. The main conclusions are as follows:

1. The system adopts a four-layer microservice architecture and a lightweight technology stack, which is suitable for the weak network environment in rural areas and farmers' operating habits. It integrates five core modules: live streaming management, commodity management, traceability authentication, intelligent marketing, and data analysis, which can realize the full-process digital management of agricultural product live streaming marketing.

2. The system performance test results show that compared with the general live streaming system, the live streaming freeze rate is reduced by 80.5%, the live streaming startup response time is shortened by 74.6%, the concurrent support capacity is increased by 140%, and the traffic consumption is reduced by 61.1%, which has good adaptability to the weak network environment in rural areas.

3. The marketing effect and economic benefit test results show that compared with the traditional live streaming method, the system can increase the live streaming conversion rate of agricultural products by 28.5%, reduce the circulation loss rate by 32.1%, and increase the average monthly income of farmers by 26.8%, which can effectively improve the marketing effect and economic benefits of agricultural products.

4. The system has the advantages of scenario-based adaptation, closed-loop trust chain, lightweight intelligence, and data-driven marketing, which fills the gap of lightweight and scenario-adaptable live streaming marketing systems for agricultural products, and provides technical support and practical reference for the digital transformation of agricultural product marketing under the background of rural revitalization. In general, the digital marketing service system for agricultural products based on live streaming scenarios developed in this paper has good practical value and promotion prospects. It can effectively solve the pain points of traditional agricultural product live streaming marketing, help farmers increase their income and become rich, and promote the high-quality development of agricultural product circulation. In the future, the system will be further optimized and improved to better serve the digital transformation of agriculture and rural revitalization.

AUTHOR CONTRIBUTIONS

Conceptualization –Zhijun Wang , Han Yu , Sen Li , Yanwen Gao, Hangyu Bao and Wei Zhou; methodology – Zhijun Wang , Han Yu , Sen Li , Yanwen Gao, Hangyu Bao and Wei Zhou; investigation – Zhijun Wang , Han Yu , Sen Li , Yanwen Gao, Hangyu Bao and Wei Zhou; writing-original draft preparation – Zhijun Wang , Han Yu , Sen Li , Yanwen Gao, Hangyu Bao and Wei Zhou. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by, Research and Development of Digital Content Marketing Service System for Agricultural and Rural Application Scenarios(Number JM-SUHXXMRW2026052201)

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] Y. Fan, "A Systematic Review on Agri-Food Live Streaming E-Commerce," Journal of Economic Surveys, 2026, doi: 10.1111/joes.70092.
[2] S. Y. Kim, M. Ogawara, T. Fujii, Y. Kamamoto, N. Harada, and T. Moriya, "Requirements for developing ultra-realistic live streaming systems," 2009 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS). IEEE; 2009. pp. 175-178, doi: 10.1109/ISPACS.2009.5383874.
[3] J. Liu, S. Li, and P. Gao, "A Study on Livestreaming E-Commerce Development Scale in China Based on Grey System Theory," Mathematical Problems in Engineering, vol. 2022, no. 1, Art. no. 4227280, 2022, doi: 10.1155/2022/4227280.
[4] Z. Liu, Y. Shen, K. W. Ross, S. S. Panwar, and Y. Wang, "Substream Trading: Towards an open P2P live streaming system," ICNP, 2008.
[5] X. Luo, W. M. Lim, J. H. Cheah, X. J. Lim, and Y. K. Dwivedi, "Live streaming commerce: a review and research agenda," Journal of Computer Information Systems, vol. 65, no. 3, pp. 376-399, 2025, doi: 10.1080/08874417.2023.2290574.
[6] K. K. Murthy, S. Jain, and O. Goel, "The impact of cloud-based live streaming technologies on mobile applications: Development and future trends," Innovative Research Thoughts, vol. 8, no. 1, pp. 69-86, 2022, doi: 10.36676/irt.v8.i1.1453.
[7] J. Wang, W. Xu, and J. Wang, "A study of live video streaming system for mobile devices," 2016 First IEEE International Conference on Computer Communication and the Internet (ICCCI). IEEE; 2016. pp. 157-160, doi: 10.1109/cci.2016.7778898.
[8] H. Yin, X. Liu, T. Zhan, V. Sekar, F. Qiu, C. Lin, H. Zhang, and B. Li, "Design and deployment of a hybrid CDN-P2P system for live video streaming: experiences with LiveSky," Proceedings of the 17th ACM international conference on Multimedia, pp. . pp. 25-34, 2009, doi: 10.1145/1631272.1631279.
[9] G. Zhao, "Agricultural products live streaming E-commerce ecosystem dynamics research," Frontiers in Sustainable Food Systems, vol. 9, Art. no. 1685996, 2025, doi: 10.3389/fsufs.2025.1685996.