In recent years, with the continuous advancement of multimedia technology and network technology, network-based multimedia applications are increasing day by day, both in scale and in the number of users. However, the randomness, time-varying, and complexity of user behavior and network make it impossible to guarantee the service quality (bandwidth, delay, etc.) of multimedia services, thus making it difficult to meet the demands of growing users for multimedia services. While meeting the application requirements, how to design and develop a scalable multimedia service system has become one of the key issues to support good multimedia services and better develop multimedia service services. In addition, the surge in user demand comes with various challenges. High-definition and smooth multimedia services require stable bandwidth. However, the randomness, time-varying, and complexity of user behaviors and network states usually make it difficult to guarantee the quality of services. It is of practical significance to study how to overcome these problems, and it is also a hotspot of current research. This paper mainly discusses the extensibility elements of the multimedia service system and puts forward the relationship between the extensibility of various elements and some design principles of the extensibility. In order to overcome the influence of random variation of the wireless channel on video playback, this paper adopts scalable coding technology. That is, through the analysis of the playback process, the underflow probability is proposed and defined, thereby establishing a constrained optimization problem. Finally, this paper also proposes the multimedia adaptive transmission in the network to do the optimization.

1. Introduction

Today, everyone's material living standards are improving day by day, and people are not only satisfied with the enjoyment brought by material things but more and more people have begun to pay attention to improving the quality of spiritual life. Education and entertainment, as two main ways in people's spiritual life, have played an important role in daily life [1, 2]. No matter whether it is educational service or entertainment service, the main service form is to provide multimedia service. The emergence of multimedia services, especially the emergence of video and audio services, is not like the previous e-mail, simple WEB and FTP services. Its service form begins to shift from reliable interaction to real-time interaction, which puts forward higher requirements for network performance [3, 4].

With the rapid development of multimedia technology, network technology, and communication technology, the network multimedia service technology based on streaming media transmission has been widely used [5, 6]. With the ever-increasing demands of network media users, the existing media service technologies are challenged. For example, the media resource management system is only aimed at a single media resource owner, video-on-demand (VOD) users need to register multiple times to get corresponding services, and media resource owners all want to serve more VOD users with their media resources. Obviously, the existing media resource service technology can no longer meet the requirements [7, 8]. A scalable system should be able to provide better performance and more functions. The overall computing power of the system should scale proportionally with the increase in resources. Ideally, the rate of growth is linear.

With China’s emphasis on education and increased investment in school software and hardware resources, the continuous improvement of school teaching quality and the continuous increase in the number of students have placed high requirements on school teaching equipment. Therefore,
many colleges and universities have added multimedia equipment for teaching. With the increase of equipment, how to manage equipment has become a big problem, especially the unified remote management of equipment has put forward higher requirements for schools. How to standardize the school's multimedia equipment, informationization, and automatic management of equipment management is very important. Hence, the multimedia teaching equipment can play a greater role; for example, remote control of multimedia teaching equipment is to centrally manage all classroom multimedia equipment. It can also reduce the manual workload, improve work efficiency, improve the standard of school equipment management, effectively improve the school's management of multimedia teaching equipment, and effectively improve the school's multimedia equipment [9, 10]. Management can reduce the possible mistakes of manual management of equipment, causing delays in class or failing to turn on equipment on time, etc. The use of remote centralized control can effectively reduce manual errors and improve equipment utilization. It plays an important role in the improvement of equipment management in colleges and universities [11, 12]. According to the characteristics of traditional media publishing, multimedia publishing has some inherent properties, such as point-to-face publishing, a large amount of published data, and little feedback. These characteristics determine some network technologies for media services.

At present, many multimedia teaching equipment in some universities relies on manual management because equipment management is not standardized, and equipment management information is low. With the increase of multimedia teaching equipment, the manual management method is becoming more and more inappropriate to better manage the equipment. In fact, there are many nonstandard management, which need to be improved. Statistical data are also prone to errors, and it is also very difficult to share the statistical data and information for the second time [13, 14]. Without a unified equipment management system, the information sharing of multimedia teaching equipment is very cumbersome, and even cannot be shared, resulting in information redundancy and junk information. It is urgent to have a unified platform to manage equipment information [15, 16].

In the past ten years, with the maturity of multimedia technology and information technology in teaching, the increase of national support, and investment in multimedia teaching, multimedia classrooms have been popularized in major universities. Multimedia teaching can vividly display sounds and animations, which greatly improves the enthusiasm of students in class and improves teaching efficiency. In the early multimedia classrooms, various teaching devices were simply connected, and each device had its own switch, which was inconvenient to use and not conducive to safe use. The solution for many colleges and universities is to install a central control system to manage the equipment of the entire school in a unified manner, efficiently manage various multimedia equipment, achieve the effect of centralized management, and realize the unified management of multimedia classrooms [17, 18]. The multimedia central controller solves the problem of using the multimedia classroom but still cannot solve the management of the multimedia classroom. Nowadays, the multimedia classrooms in major universities are distributed in different teaching buildings, and there are geographical distances [19, 20]. There are many floors up and down in the same teaching building, which is inconvenient to manage. Nowadays, many schools use manpower to manage and open the central control cabinet and turn on the equipment on time before class. However, one person can manage up to 20 multimedia classrooms. For example, in different teaching buildings, many multimedia classroom managers are required. In view of the above difficulties in management, a multimedia central management system based on a campus network can be built to solve the above problems. Cross-segment management can also solve the unified management of different campuses, and even managers can manage through the network at home [21, 22].

From the analysis of the existing media service site architecture, it is found that the media resource management systems of these media service sites have the following shortcomings. Firstly, the limitations of the media resource management system services, the media service system, and the site are bound together. Different media service sites use their own media resource management system to manage and publish their media resources. Secondly, the scalability of the media resource management system is poor. That is, it is difficult to add media servers and media resource owners to the existing system, and it is necessary for the existing system architecture to be greatly changed. Thirdly, it is inconvenient for users to order on demand, and the resources and services provided by the media resource management systems of different sites are independent of each other. When the media service site where the VOD user is located cannot provide the required service, he has to go to another media service site to register to obtain the required service [23, 24].

The existing media resource management system is oriented to the service of a single media resource owner owned by the system and cannot achieve unified management of the resources of multiple media resource owners. Extending to more types of resources is more difficult. The requirement of the scalable media service technology is to establish a service-expandable media resource management system, which allows to dynamically add media resource owners to the system, and the media resource owners can also add the required media servers as will, so as to realize the Internet environment. To achieve the goal of managing the resources of multiple different media resource owners and being able to manage their own media resources in the network environment, it is necessary to effectively distinguish and utilize the relevant attributes of the media resource owners. From the perspective of media resource owners, each media resource station is equivalent to a traditional resource publishing point with independent service capabilities, with its own media resources, management system, and service mechanism. The media resource owner can use the media resource station to define the scope of their own media resource management. All media resource stations
form a huge capacity media resource library, which brings more resource choices to VOD users [25, 26].

The scalable system has three expansion aspects: resources, applications, and technology replacement. From a broad perspective, resources include hardware resources and software resources, and hardware resources include the number of CPUs, storage devices, and IO devices. Software resources include, for example, operating systems and application software. In the era of increasingly complex Internet applications, the concept of resources extends to the level of user needs. Not only resources have to be extensible but applications must also be extensible. That is, when the same program runs on a scalable system, its performance improves proportionally with the scale. Two important considerations are scalability of machine size and scalability of problem size. Technology generation scalability is a local concept rather than a global concept. It mainly refers to that the computer system can improve the performance or function of the system by means of upgrading components on the basis of maintaining the original usability with the change and replacement of technology. The upgrade here may be to replace the CPU with a higher frequency, or to increase the amount of memory in the system, or to upgrade the operating system to a newer version [27].

2. Multimedia Adaptive Transmission in Network

2.1. Background of Multimedia Adaptive Transmission. The quality of video services is affected by various subjective factors, which vary from person to person, time to place, and place. Therefore, subjective evaluation is too complicated and difficult to implement. In practical applications, an easy-to-implement objective quality assessment method is required. At the same time, in order to ensure the accuracy of the results, it is required that the results of subjective evaluation and the results of the objective evaluation have good correlation or consistency under the same test environment. In this paper, we mainly consider the impact of different adaptive algorithms on service quality. Therefore, usually under the same premise of other factors, that is, except for the differences of adaptive algorithms, other influencing factors at the service level, user level, and environment level are kept unchanged to compare the algorithm performance. This allows us to define some objective quality of service metrics for adaptive multimedia applications. Intuitively, users usually want to watch videos with good image quality and smooth playback. Ignoring the influence of users and the environment, when the video sources used are the same, the service quality mainly depends on factors such as video quality, smoothness of playback, and smoothness of the video.

For the problem of scalable video transmission in wireless networks, the core is how to design an efficient and reliable code stream adaptive algorithm. In practical applications, from the user’s point of view, it is generally hoped that when there is enough video data in the buffer, the allowable received video bit rate is greater than the currently available bandwidth, so as to obtain better video quality. Similarly, when the buffer data are insufficient, it is hoped that the received video bit rate is smaller than the currently available bandwidth to buffer more video data, thereby avoiding playback interruption caused by sudden network deterioration. Therefore, to design an effective code stream adaptive algorithm, it is necessary to comprehensively consider the changes in the wireless channel and the state of the buffer. However, channel variations in practical systems are usually unpredictable. To achieve adaptive video transmission, we design a scalable video transmission system. During the video transmission process, the mobile terminal dynamically selects the number of layers of the scalable video according to the bit rate adaptive algorithm and sends a bit rate adjustment request to the video server. The video server dynamically extracts the corresponding code stream from the scalable video file according to the request of the terminal. To overcome the stochastic nature of wireless channels (such as random interference, user movement, and multipath), we model the problem using a probability-based approach.

2.2. Multimedia Adaptive Transmission. Suppose the encoded video contains a base layer and \( L-1 \) enhancement layers. In the \( n \)th time slot, the number of layers of the video received by the user is expressed as

\[
I_n = \{1, 2, 3, \ldots, L\},
\]

where \( L \) is the number of layers.

The current buffer size is \( Q_n \), and the number of video frames arriving is expressed as

\[
A_n = \{0, 1, 2, 3, \ldots, A\}.
\]

Among them, \( A \) is the number of video frames.

It is assumed that the frame arrival process is an independent and identically distributed random process. The change process of the receiving buffer queue can be described as

\[
Q_{n+1} = \max\{Q_n - 1\} + A_n.
\]

Among them, \( Q \) is the cache. In order to measure the influence of various random factors, the underflow probability at time \( n \) is defined; that is, the playback interruption probability is

\[
p = P(Q_n < Q_c).
\]

Using the underflow probability, the requirement of no playback interruption can be transformed into a constraint that the underflow probability must be lower than the...
requirement. Thus, a constrained optimization problem can be constructed. That is, in order to maximize the video bit rate while ensuring uninterrupted playback, the equation is as follows:

$$\max_{I_n},$$

s.t. $p = P(Q_n < Q_L) < q$,  \( \text{(5)} \)

$$I_n \leq L_m,$$

where $q$ represents the tolerable underflow probability.

For a given time slot $k$, according to (3), the variation of the play queue can be obtained as

$$I_k = 1 - A_k. \quad \text{(6)}$$

Among them, $I_k$ measures the mismatch between the current video bit rate and the channel throughput. Predict the channel change in $N$ time slots in the future; that is, the prediction interval length is the change from time $n$ to $n + N$ play queue:

$$I_{n+N} = \sum_{k=1}^{N} I_{n+k}. \quad \text{(7)}$$

Therefore, the length of the playback queue at time $n + N$ is

$$Q_{n+N} = Q_n - \sum_{k=1}^{N} I_{n+k}. \quad \text{(8)}$$

The probability of underflow at time $n + N$ is

$$p = P\left(Q_n - \sum_{k=1}^{N} I_{n+k} < Q_L\right). \quad \text{(9)}$$

The expectation that defines the average change of the play queue for $N$ time slots in the future is

$$E\left[\sum_{k=1}^{N} I_{n+k}\right]/N. \quad \text{(10)}$$

In practical applications, the average frame rate can be used to characterize fluency:

$$f_T = \frac{S(T)}{T}. \quad \text{(11)}$$

Among them, $S(T)$ represents the total number of frames when a video with a length of $L$ minutes is played, and $T$ is the actual playback time. Statistics on the interruption frequency or average interruption time during the playback process can also represent the smoothness of the playback. That is, the interrupt frequency is as follows:

$$f_C = \frac{C(T)}{T}. \quad \text{(12)}$$

Among them, $C(T)$ represents the total number of interruptions. Figure 1 shows the random variation of the bandwidth of the 3G downlink channel with time. Therefore, it cannot provide a reliable bandwidth guarantee for video transmission in the wireless network.

3. Research and Design of Scalable Multimedia System

3.1. Multimedia System. If resources can be increased to meet increasing performance and functional requirements, or resources can be reduced to reduce costs, from the perspective of hardware and software, we can call a computer system that meets this characteristic scalable. The multimedia service system refers to a service system that provides multimedia content such as video, audio, animation, text, 4D. At present, the main multimedia service systems include Huawei’s distance education system, Lanyu Video Network Multimedia Acquisition, Editing, Broadcasting and Publishing System, Shihan Technology Distance Education System, and Jintong Network Multimedia Teaching System. Among these systems, the distance education system provides a complete set of solutions for server, network, and client. The distance education system of Shihan Technology mainly provides the server system, and the Lanyu Video Network Multimedia Collection, Editing, Broadcasting, and Publishing System provide high-quality video services. The current multimedia system design mainly focuses on network access, multimedia information production management, and user access control. For example, the core layer of the system in Huawei’s solution supports the access of real-time interactive video terminals such as IP, EI, ISDN, and V35 and completes the exchange of images, voice, and data in distance education services. The user access layer is used to set up professional electronic classrooms and provide powerful real-time network video teaching functions. Another example is the Lanyu Video Network Multimedia Collection, Editing, Broadcasting, and Publishing System, which mainly focuses on the production and management of streaming media sources, access to various access devices (such as set-top boxes, Cable Modem access) and other charging strategies. In the design system, the current multimedia service system is mostly based on the layering of solutions. For example, Huawei’s distance education system is divided into the management and control layer, system core layer, and teaching user access layer.
last two layers are network transmission and access. Huawei divides the multimedia service system into a business support layer, a media exchange control layer, and a user access layer. These layers focus on the overall network solution and do not involve the hierarchical division of the multimedia service management system. In terms of expansibility, these multimedia service systems focus more on the expansion of multimedia content formats and the expansion of access devices or the expansion of a certain aspect. For example, the Jintong network multimedia teaching system supports customizable user interface expansion, supports PC, STB, and POA terminal access type expansion, and supports secondary development (including teaching management and courseware production, playback). Another example is the Lanyu Video Network Multimedia Collection, Editing, Broadcasting, and Publishing System which supports the expansion of the video server but does not support the expansion of the text service. From the above several current typical multimedia service systems, we can see that the design of the current multimedia system does not clearly propose the management elements and scalable elements in the multimedia system and focuses more on the network extension and services of the multimedia system. The overall construction elements of the current multimedia service system have been very clear, but the extensible elements of the multimedia service system have not yet been systematically proposed. But clarifying the extensible elements has great guiding significance for designing an extensible multimedia service system.

The multimedia information service system supports four roles: end user, enterprise/merchant, carrier administrator, and call center agent. Terminal users can log in to the service platform by mobile phone and browse the information they need through comprehensive search, categorical search, and navigation functions. For registered users, they can further choose to bookmark and subscribe to the information of interested enterprises/merchants and publish relevant comments for the enterprises/merchants. In addition, terminal users can further open the function of personal trading. After a successful opening, personal trading users can publish their own information on the video navigation platform, which can be classified as real estate trading, rent seeking, video job hunting, personal goods flea market, etc. Enterprises/merchants can apply for the multimedia information release service according to the relevant regulations of telecom operators. After the application is successful, enterprises/merchants can release their multimedia information on the system. In addition, according to their own characteristics, enterprises/merchants can also cooperate with Unicom to provide users with in-depth value-added services, such as booking hotels and booking air tickets. According to the needs of developing multimedia information services, operators have administrators with different permissions. Different administrators use different accounts to log in to the system and display different management portal pages based on the rights of their accounts to perform different management functions. The call center agent can log in to the multimedia information service system using the assigned account and password and send the enterprise/merchant information to the terminal user in the form of a message based on the user’s query requirements.

The multimedia system in this paper refers to the sending center system that mainly provides video and audio services and supplements text services. The system should not only provide reliable and high-quality media services but also provide a flexible and extensible system framework, so that the system can be easily expanded according to business needs. Each system has different scalable resources, and multimedia systems also have corresponding resources. Analyzing and clearly defining these resources is the basis of the scalable system design, and the analysis of the expansion motive force of the multimedia system is the basic basis of the system’s scalability. Finally, the scalability of the business management software design is analyzed. The scalable system has the following characteristics, including the scalable element is the resource, extensible aspect package hardware and software, the drive for scalability comes from performance, functionality, and cost requirements, and the scalable way is to grow and shrink.

The multimedia service system is a system. Although it can provide a single super-capable server and a super-fast internal bus to support this system, this is not the final form of system design, so the multimedia service system must be interconnected with multiple servers, and services are provided in the form of network data, so a network layer must be required. In addition to providing services, the multimedia service system must provide some auxiliary services, such as authorization services, which should be accurately called service support, so there should be a service support layer and a service layer. Provide many services such as on-demand and live broadcast, organize and manage services reasonably, and then form an operable business, and there must be a business layer on the service layer. According to the principle of layered design, we divide the entire multimedia system into four layers, as shown in Figure 2. The main function of the network layer is to transmit various multimedia services under a certain network bandwidth and network equipment. Network bandwidth and network equipment become the two major resources of the network layer. The functions of the multimedia information service system for end-users include self-browsing function, manual service function, SMS receiving function, and welcome word function. The services for the call center include obtaining user’s personal information, fashion shopping information query, wonderful tourism information query, and flavor food information query. The administrator provides information management, log management, and statistics management services.

The main function of the service bearer layer is to provide network resource allocation and scheduling, and a safe and reliable mechanism for various services. This layer converts network resources into resources of this layer for upward provision and shields the visibility of lower-layer resources from the upper layer.
3.2. Discussion. The network layer corresponds to the transport layer and all the following layers of the OSI seven-layer protocol model, including server equipment and network connection equipment. The service support layer is to provide functional support for multimedia services and provide network layer resource scheduling functions. The service layer mainly refers to services corresponding to multimedia systems, such as on-demand, live broadcast, and file download. The business layer is corresponding to multimedia applications, such as distance education and entertainment services. Each layer has corresponding operation elements, and these elements are all resources corresponding to the upper layer. However, in order to strictly distinguish resources, we do not call all elements resources. Figure 3 is the transmission rate using the algorithm based on the probability of underflow. In contrast, the transmission rate with the conventional method is also shown in Figure 4, where it can be seen that the proposed method has a faster speed.

Multimedia services mainly have four transmission forms: reliable publishing, real-time publishing, reliable interaction, and real-time interaction. The design of the functional unit also needs to support these transport forms. In addition to the support for the four transmission forms, the business needs to be managed. Therefore, according to the different business support functions, it can be divided into three types of units: business unit, business support unit, and operation management unit. The business unit is the unit that directly supports the four transmission modes of multimedia services. The basic unit includes a real-time stream sending unit, a non-real-time stream sending unit, a reliable data sending unit, and an interactive access unit. The real-time streaming unit provides real-time-one-way service delivery mode services. The non-real-time streaming unit provides services in a non-real-time-one-way service transmission mode, which is unreliable. The reliable data transmission unit provides services in a reliable-one-way service transmission mode. The interactive access unit provides services in the reliable-interactive service transmission mode, and together with the real-time streaming unit, it provides services in the real-time-interactive service mode. Figure 5 shows the video quality at different channel qualities. As the channel quality improves, the video quality gets better. It shows that the algorithm can realize the adaptation of bit rate and video quality under different channel qualities. Figure 6 shows the interruption frequency of video on mutated channels. As can be seen, the interrupt varies with different conditions, and its maximum is nearly 1.6, which also can be explained in Figure 7.

The business support unit does not directly support the four transmission modes of multimedia services but provides a unit with auxiliary functions for service access. The basic unit has a program navigation sending unit and an authorized sending unit. The program guide sending unit sends the receiving information describing the service entity and the program. The authorization sending unit sends the
service access control information. The operation management unit performs hardware management and broadcast monitoring of the entire system. It does not directly participate in service transmission but plays a vital role in the normal development of services and the management of business units and business support units. The basic unit includes a broadcast control unit and a flow monitoring unit. The broadcast control unit allocates, dispatches, and manages system resources, and manages and commands the status of each business unit and business support unit. The flow monitoring unit monitors the network flow of the entire system in real time. Strictly distinguishing these units can reflect two expansion advantages, including the scalability of incremental business development and the scalability of service capabilities by simply superimposing the same functional unit. Business development always starts with low risk and low investment, and there should be multiple options for starting a business. In the early stage of business development, for services that only require a reliable-one-way service transmission mode, only reliable data transmission units, business support units, and operation management units are required; for real-time-one-way service transmission mode, only a real-time stream sending unit, business support unit, and operation unit are required. For the later stage of subservice development-integrated services, all business units, including business support units and operation units, are needed. The evaluated data are plotted in Figure 8.

If a business needs to add streaming media services to the pure data business, it is only necessary to add a real-time stream sending unit and a non-real-time stream sending unit to the business unit. If a service is to be authorized and controlled, an authorization sending unit can be added to the service support unit. If you need to support interactive services, adding an interactive access unit can meet the requirements.

![Figure 5: Video quality at different channel qualities.](image)

![Figure 6: Interruption frequency of video on mutated channels.](image)
The expansion of business service types can not only expand different units (as described above) to achieve the expansion of service units but also expand the same business units according to the capabilities of each business unit to expand services. For example, it is necessary to expand the reliable data transmission service. Under the condition of the limited capacity of one reliable data transmission unit, another reliable data transmission unit can be added to expand the service capacity. Scalability not only refers to the scalability of software functions but also refers to the scalability of physical hardware and connections, and functional units also have the scalability of their physical connection methods. Considering the expansion of service capacity, the network traffic characteristics of different functional units, the sharable characteristics of functional units, and the physical connection method of functional classification placement are adopted for the connection of the entire functional unit. That is, units with similar network traffic characteristics and service capacity scalability constitute a physical connection unit, while the combination of multiple physical connection units constitutes the system connection structure of the entire functional unit. However, the current load balancing scheduling is also considered based on the simplicity of the algorithm and the quickness of the scheduling, and the goal of full utilization of resources is still avoided.

4. Conclusion

Under the current situation of network service turning to multimedia service, this paper analyzes the actual use of multimedia service system. Aiming at the lack of clear definition and distinction of scalable elements in current multimedia systems, this paper proposes a design framework for scalable multimedia systems. This paper analyzes the extensible elements of the multimedia service system, proposes a hierarchical system structure, and proposes extensible resources for each level. Among them, the main extension elements are concentrated in the service support layer. Aiming at the expansion analysis of the software and hardware system of the functional units and channels of the service support layer, the embodiment of the scalability under such a design is proposed, and the expansion of business services is the driving force of the system scalability.

However, the scalability introduced in this paper is still lacking in consideration of the scalability of the cost; that is, the expansion cost needs to be controlled and optimized at the same time of expansion.

Data Availability

The datasets supporting the conclusions of this article are available from the corresponding author upon reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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