Hindawi
Scientific Programming
Volume 2022, Article ID 7997773, 9 pages
https://doi.org/10.1155/2022/7997773

Research Article

Multimedia Application and Network Architecture Design Based on Multiterminal Collaboration

Lian Wu [1] and Lee Jong Han [2]

[1] *School of Digital Arts, Suzhou Art&Design Technology Institute, Suzhou 215009, China*
[2] *General Graduate Schools, Hoseo University, Asan 31499, Republic of Korea*

Correspondence should be addressed to Lian Wu; wulian@sgmart.edu.cn

Received 1 March 2022; Revised 20 April 2022; Accepted 27 April 2022; Published 2 June 2022

Academic Editor: Hangjun Che

Copyright © 2022 Lian Wu and Lee Jong Han. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

In the rapid development of network technology, most users can simultaneously or alternately use multiple communication terminals. At this time, how to build a control platform of integrated network to help users manage multiple terminals has become the focus of mobile network technology research and development. On the basis of understanding the design content of the network control platform and according to the three types of network selection algorithm, this paper analyzes how to build the architecture of the multiterminal collaborative network control platform based on the open source Mobicents design and conducts test research on its system implementation.

1. Introduction

In the development of the information era, both the Internet and the telecommunications industry are in a state of competitive innovation, especially under the background of the extensive promotion of optical communication technology, digital technology, and other content, all kinds of wireless networks blend with each other and gradually break through a business development mode built by a single network. From the practical point of view, the ultimate purpose of the integrated development of Guangzhou Power Grid, computer network, and telecommunications network is to meet the continuously rising business needs of users and rationally use various business resources to improve the development level of China's information industry. This research topic proposal has attracted the attention of relevant scientific research scholars at home and abroad. At this stage, two terminal collaborative architecture designs have been built for this content, one refers to overlay, and the other refers to the business agent model. Meanwhile, Shaoyong Guo, Lanlan Rui, XuesongQiu, and others [1] in the business-based multiterminal dynamic collaborative framework mechanism research concluded that, combined with the heuristic multiterminal cooperative construction mechanism, in simulation analysis, the built system can not only support differential business, but also reduce business restart. Thus, it proves that this mechanism has application advantages; Hui Tian, Zheng Hu, and Ping Zhang [2] found when studying the business flow control content based on multiterminal collaboration that the future network will be a network with integrated operation and terminals providing users with cross-heterogeneous communication services, it must be deeply explored based on multiterminal collaborative applications and related technologies, and it not only provides new options for the business, but can also provide a basic guarantee for the coordinated application of the business environment; for example, Niemegeers and Groot S [3, 4] proposed to design networking Fednets in the research and development exploration, and based on the construction of personal networks, different types of personal networks share the terminal facilities and services of users. Zhang, Chen, Li [5], and others studied the personal mobility of the application layer combined with the SIP protocol and thus concluded that the SIP protocol has the basic guarantee for personal mobility in the application layer, which can effectively solve the problems caused by mobility by the underlying mobile protocol and provide a supplement to the actual missing environment. Therefore, it can be seen that when the future mobile communication network innovates towards the direction of diversified and digital development, the most important thing is to rationally use all the network resources to provide high-quality services for users. Therefore, it is crucial to strengthen the multimedia application and network architecture design and analysis based on the multiterminal pedigree.

2. Architecture and Algorithm Design

2.1. Design and Analysis of the Network Control Platform. Combination of the following is shown in Figure 1; architecture diagram analysis shows that the converged network control platform must be able to meet the requirements of various network resource transmission interfaces, service control-oriented service interfaces, and support the requirements of multi-service coordinated trigger control, resource scheduling management, mobility management, etc. Only in this way can the end users in the system be guaranteed to experience the same service no matter what network or application they are in [6, 7].

From the perspective of hierarchy analysis, the network control platform is mainly divided into three aspects: first, the business layer, which is mainly used to control business and design business logic; second, the control layer, which is mainly responsible for optimal connection management, with network control environment; third, the bearer layer and the terminal layer, which include the ubiquitous network and all kinds of terminals and refer to the bearer of the network and the actual receiver and initiator of the application [7, 8]. As shown in Figure 2, the network architecture is mainly composed of terminal application and server network architecture. Terminal application refers to mobile intelligent terminal, which can be used on intelligent terminals of Android and iOS systems and computers. The server network architecture mainly includes the operation system, the core application, the operation and maintenance system, the network architecture components, and the basic parts. The network architecture is a mobile multimedia intelligent terminal to achieve enterprise communication. The integration experience of cloud office network architecture effectively improves the efficiency of information sharing and use between multimedia, and reduces the communication cost within the enterprise. The problem of internal management coordination has been effectively solved, and the precise connection between enterprises and external resources multimedia applications has been realized, which lays a foundation for the healthy and stable development of enterprises. The network architecture supports a variety of forms of information transmission, mainly including text, voice, pictures, and files. Enterprise multimedia can be the most convenient to choose their own needs. The most intuitive way to communicate with each other is to create groups for discussion.

In this paper, a data processing center network architecture is designed, which includes four subnets including input, operation, output, and monitoring, and the first three subnets have a redundant structure, as shown in Figure 3.

2.2. Network Selection Algorithm. Combined with the analysis of multiterminal and multinetwork collaboration scheme, the network selection algorithm is mainly divided into the following categories.

First is the network selection algorithm based on multiple attribute decision making (MADM). Generally, the factors that influence network selection are divided into four categories, which relate to network performance, terminal performance, business requirements, and user preferences. In order to reduce the dimensional effect of each factor, normalization treatment must be implemented because of the large gap between different influencing factors. By integrating all factors into a study, and weighting each decision factor, the absolute importance contained in it was clarified by representation, and then the specific weight value was studied by combining the analytic hierarchy process (AHP). Taking simple weighting method (SAW) and exponential weight multiplication method (MEW) as examples, the former requires linear weighting calculation using various attributes in order to obtain the best network decision. The latter is to use exponential multiplication to access the best network, and the specific formula is as follows:

$$G_{\text{SAW}} = \sum_{j=1}^{M}\left(w_j * v_{i,j}\right),$$
$$G_{\text{MEW}} = \prod_{j=1}^{M} {v_{i,j}}^{w_j}. \tag{1}$$

In formula (1), w_j represents the weight value of the j attribute and v_{ij} represents the normalized value of the j attribute of the i network. The MEW algorithm is more computationally difficult than the SAW algorithm, but the final simulation is not much different.

The distance method needs to be closer as the best evaluation scheme when calculating and analyzing the relative distance between all the evaluation schemes and the positive and negative ideal schemes. The specific formula is shown as follows:

$$G_{\text{TOPSIS}} = \frac{D_{w,j}}{D_{b,j} + D_{w,j}},$$
$$D_{w,j/b,j} = \sqrt{\sum_{j=1}^{M} w_j^2\left(v_{i,j} - r_{w,j/b,j}\right)}. \tag{2}$$

In the above formula, $D_{w,j}$ represents the distance difference between a candidate network and the reference optimal (worst) network, wj represents the weight value of the property j, and r_w, j/b, j represents the worst value and the optimal value of the property j. This algorithm is more scientific than the previous two, but it is extremely sensitive to handling user preference weights.

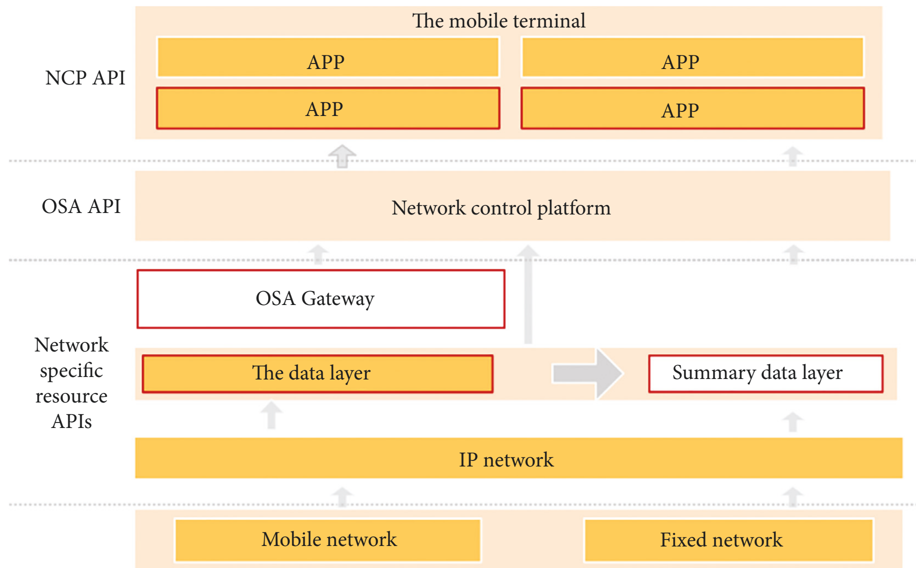

FIGURE 1: Structure diagram of network control platform design.

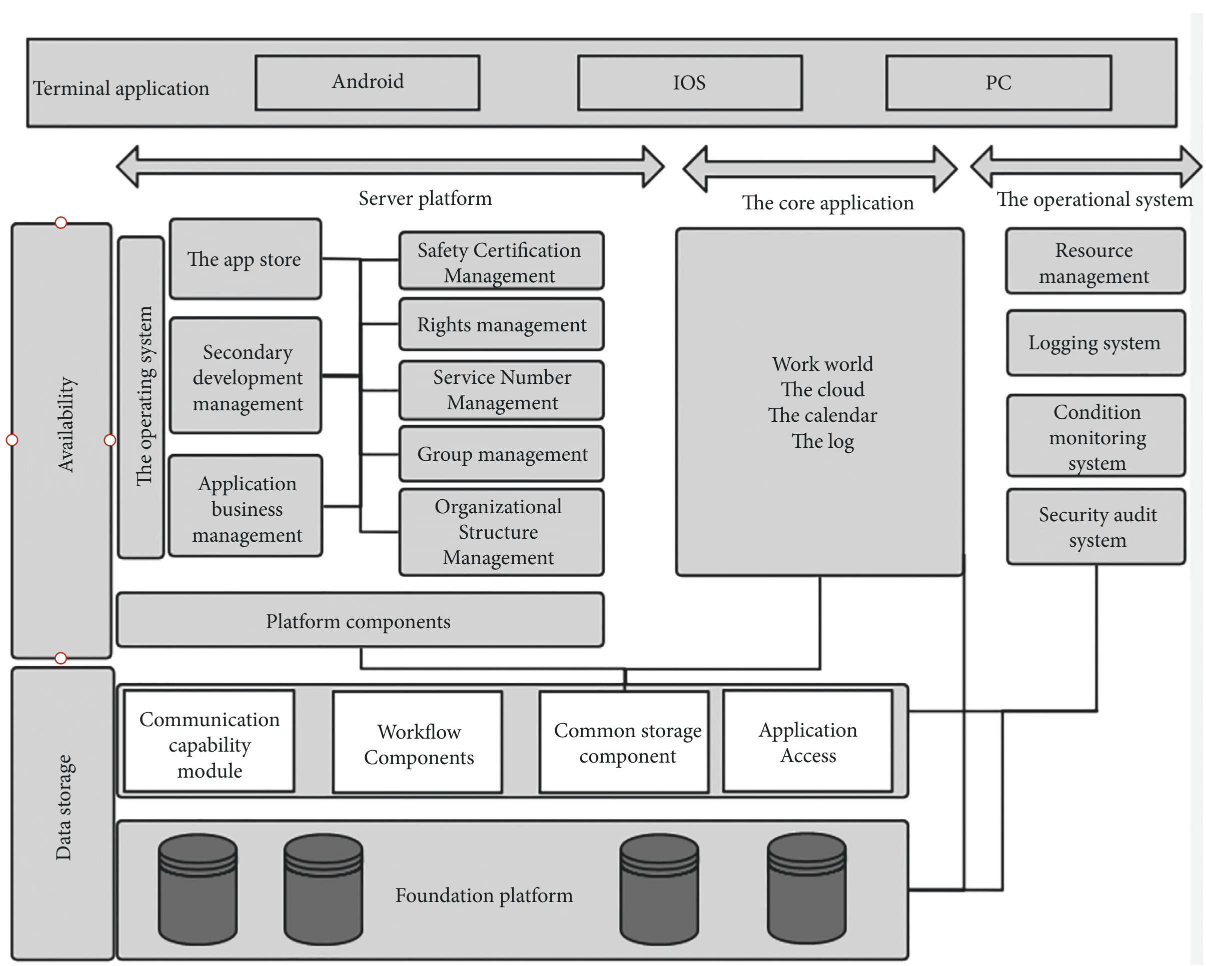

FIGURE 2: A schematic diagram of the overall network architecture for multimedia applications.

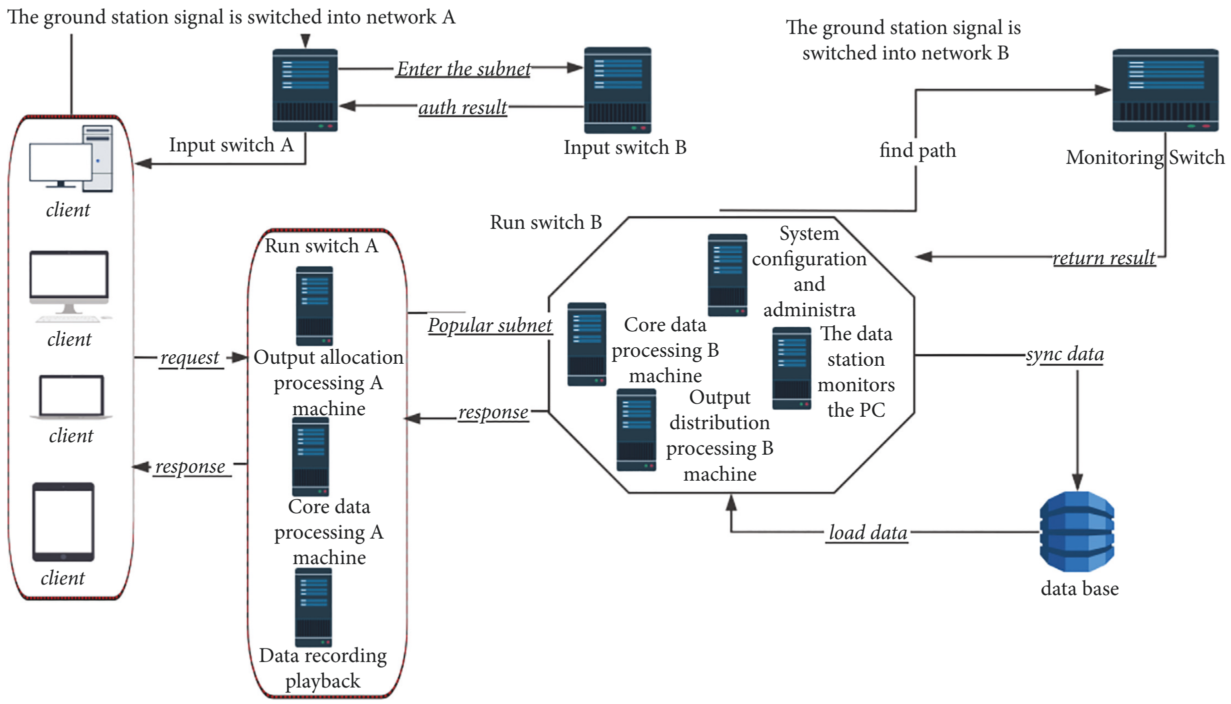

Figure 3: Multimedia application network infrastructure.

Using the grey relation analysis (GRA) method to the network selection algorithm, a grey relation coefficient (GRC) is generally defined to show the proximity of each candidate network and the ideal reference network, which needs to be obtained by the best value of a certain property. The specific formula is as follows:

$$G_{\mathrm{GRA}} = \frac{1}{\sum_{j=1}^{M} w_j \left| v_{i,j} - R_j \right| + 1}. \quad (3)$$

In the above formula, R_j represents the best value of the j attribute.

The network selection algorithm is based on user preferences. From a practical point of view, this algorithm is mainly divided into two aspects. On the one hand, it refers to the calculation of the index weight value, and on the other hand, the network preference weight value.

According to the above picture analysis, the network selection process is mainly divided into three steps: First step is collection of data. This work is mainly used to obtain business demand, network status, service price, and other information indicators, which are mainly the main factors affecting the network selection decision, but also the core object of data processing; second is processing the data. Level through to build network selection model, the paper puts forward the AHP judgment matrix and the network parameter matrix and then uses the AHP method to calculate the subjective weight of the clear network parameters, the application position method to get the objective weights of network parameters, and then according to the needs of the business and scientific adjustment of the correlation coefficient between the two user preferences, and synthesis weights of the network parameters. At the same time, the distance analysis method should be used to clarify the objective weight data of network preferences, and the subjective and objective weight data of network preferences should be used to clarify the comprehensive weight data of network preferences, and finally, the comprehensive effect data of candidate networks should be determined through planning and processing. Finally comes the decision part. According to the comprehensive effect value of the candidate network, the target access network is defined, and the executive network is connected.

In this study, network bandwidth is a benefit parameter, while time-continuance muscle jitter and service price are cost parameters. Normalization is carried out for these parameters, and the specific formula is as follows:

$$x_{ij}' = 1 - \frac{\left| x_{ij} - x_{j\_\max} \right|}{x_{j\_\max} - x_{j\_\min}},$$
$$x_{ij}' = 1 - \frac{\left| x_{ij} - x_{j\_\min} \right|}{x_{j\_\max} - x_{j\_\min}}. \quad (4)$$

In the above formula, *Xij* represents the current value of the *j* parameter of the *i* network; the numerical size is directly related to the specific parameters of the current network; *Xij'* represents the current value of the *j* parameter of the *i* network; *Xj-max* represents the maximum value of the *j* parameter in each candidate network; and *Xj-min* represents the minimum value of the *j* parameter in each candidate network.

When calculating the network parameter weight, a hierarchical analysis model is constructed to clearly judge that the matrix is $C_x = (c_{ij})_{3\times 3}(x = B, D, J, L, C.i, j = n1, n2, n3)$.

And the product of each row of elements of the corresponding matrix is as follows:

$$V_i = \prod_{j=1}^{n} a_{ij}\,(i = 1, 2, \ldots, n). \tag{5}$$

The n secondary root of the V_i is

$$\overline{V_i} = \sqrt[n]{V_i}. \tag{6}$$

After normalization treatment is

$$u_i = \frac{\overline{v_i}}{\sum_{i=1}^{n} \overline{v_i}}. \tag{7}$$

Therefore, the evaluation parameter weight of the criterion layer is

$$\{u_B, u_D, u_J, u_L, u_C\}. \tag{8}$$

In order to avoid inconsistency, consistency detection is generally performed on the constructed judgment matrix, and the specific process is as follows.

The indicator *CI* for consistency is defined as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1}. \tag{9}$$

In the above formula, λmax represents the maximum eigenvalue of the judgment matrix and n represents the order of the judgment matrix.

Secondly, the need is to find the corresponding average random consistency index *RI* where $n = 1$, 2,.., 9, and the specific values of *RI* are shown in Table 1.

Finally, the proportional *CR*, formula for the analysis consistency, is as follows:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}. \tag{10}$$

When *CR* is less than 0.10, the consistency of the judgment matrix is considered acceptable; otherwise, appropriate adjustments are needed.

In the process of calculating the objective weight value, the information entropy of network parameters should be studied first. The specific formula is as follows:

$$X(j) = -k \sum_{i=1}^{n} a_{ij} \ln a_{ij}. \tag{11}$$

In the above formula, a_{ij} represents the normalized value of j parameter of i network, n represents the number of candidate networks, and k represents specific elaboration. Generally, it can be regarded as 1 after simplification.

Then calculate the analysis difference degree, and the specific formula is as follows:

$$Y(j) = 1 - X(j). \tag{12}$$

Finally, calculate the analysis weight vector, and the specific formula is

$$u_j' = \frac{Y(j)}{\sum_j Y(j).} \tag{13}$$

Table 1: Numerical analysis of the *RI*.

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

It makes it clear that the weights of the network parameters are

$$\{u_B', u_D', u_J', u_L', u_C'\}. \tag{14}$$

The comprehensive weight calculation formula of the network parameters is

$$w_i = \alpha * u_i + (1 - \alpha) * u_i'(i = B, D, J, L, C). \tag{15}$$

In the above formula, α represents the adjustment coefficient and conforms to the condition of $0 < \alpha < 1$, which directly proves the user's subjective preference and the difference of decision value in the decision indicator and makes clear the user's preference demand for service QoS. Generally speaking, $\alpha = 0.5$.

Assume that the number of evaluation parameters is i and the network preference weight is j, then the subjective weight *UI* can be used to clarify the subjective preference weight of all users for each candidate network. The specific formula is

$$p_k = \sum_i C_i(k) * u_i\,(i = B, D, J, L, C.k = n1, n2, n3). \tag{16}$$

The corresponding consistency ratio *RI*(j) calculation formula is

$$\mathrm{CR} = \frac{\sum_j \mathrm{CI}(j) * u_j}{\sum_j \mathrm{RI}(j) * u_j} \tag{17}$$

Under $CR < 0.10$, the acquired preference weights meet the consistency requirements.

Using objective weight to be preference, the information network parameter matrix is assumed to be X', and x represents the j parameter value of the i network, then it can be obtained after standardized processing

$$X' = \left(x_{ij}'\right)_{3\times 5}. \tag{18}$$

The ideal values X^+ and negative ideal values X^- are calculated:

$$\begin{aligned} X^+ &= \left(x_B'^+, x_D'^+, x_J'^+, x_L'^+, x_C'^+\right) \\ X^- &= \left(x_B'^-, x_D'^-, x_J'^-, x_L'^-, x_C'^-\right). \end{aligned} \tag{19}$$

In the above formula, the following conditions are met:

$$\begin{aligned} x_l'^+ &= \max\left(x_{1l}'^-, x_{2l}'^-, x_{3l}'^-\right), x_l'^{--} \\ &= \min\left(x_{1l}'^-, x_{2l}'^-, x_{3l}'^-\right), l = B, D, J, L, C. \end{aligned} \tag{20}$$

The European distance between the two is

$$D_k^+ = \sqrt{\sum_{l=1}^{5}\left(x_{kl} - x_l^{'+}\right)^2}$$
$$D_k^- = \sqrt{\sum_{l=1}^{5}\left(x_{kl} - x_l^{'-}\right)^2}. \tag{21}$$

The relative proximity between the network and the ideal network is

$$C_k = \frac{D_k^-}{\left(D_k^+ + D_k^-\right)}. \tag{22}$$

The normalization treatment of the above formula is obtained as follows:

$$p_k' = \frac{C_k}{\sum_{k=1}^{3} C_k, k = 1, 2, 3}. \tag{23}$$

In the above formula, $p_k' pk'$ represents objective preference weight values for the weight of each candidate network obtained.

The corresponding comprehensive weight formula is

$$W_k = \beta * p_k + (1 - \beta) * p_k'(k = n1, n2, n3). \tag{24}$$

In the above formula, β represents the coefficients of the user policy, which represents a linear weighted proportion of the user's network subjective and objective preferences and meets the conditions of $0 < \beta < 1$.

It can be seen that the optimal access network selection formula is

$$U(i) = \left[\sum_j \left(x_{ij}' * w_j\right)\right] * W_i (i = n1, n2, n3; j = B, D, J, L, C). \tag{25}$$

3. Result Analysis

3.1. Algorithm Implementation. According to the existing multiterminal collaborative selection mechanism, the corresponding selection algorithm is analyzed and designed, and the terminal and the connected network are regarded as a virtual terminal unit (VTU), and the algorithm of the terminal and network collaborative selection (NCS) algorithm is clarified. The experiment explores the selection process of the cooperative terminal set (CTS). There are three cases of subjective weights as follows: First, Case 1 means that all parameters are consistent; Case 2 means that the parameters available bandwidth (AB) and packet loss rate (L) together occupy 70% of the weight, and other parameters occupy 30% of the weight, in other words, that is, for the environment of data services; Case 3 means that parameters AB, time delay (DE) jitter (L), etc., occupy 70% of the total, while other parameters account for 30%, in other words, for the environment of voice services.

Combined with the parameter design conditions shown in Table 2, the corresponding network access options are shown in Figure 4. Starting from this, comparing and analyzing the throughput of different algorithms, it can be seen that under the condition that the number of cooperative working terminals continues to increase, the business throughput will also increase. When in Case 1, the number of terminals is less than or equal to 2, and the SAW is greater than or equal to MEW. When the number of terminals is 3, 4, and 5, the throughputs of the two are the same; when in the sum, the number of terminals is less than or equal to 2, and the throughput of the two algorithms is the same. But when the number of terminals reaches 3, the MEW is larger than the SAW, and when the number exceeds 3, the throughput of the two is the same. The details are shown in Figure 5.

3.2. Verification Analysis of Environmental Testing. Test as a system development the key link; only through the test, we can accurately detect a system function integrity and accuracy, and we can control the business environment which involves the function of the terminal group registration, terminal status updates, more terminal voice calls, media flow guide control function, the short message function business logic control, etc. So, the actual test starts with the above content.

First, the terminal needs to register. This functional test requires registration in conjunction with the web page. The web page is configured in the Apache server, and it can be verified whether it meets the expected functional requirements by entering the full information of the terminal registered by the user through the web page. After filling out the information, click Submit to complete the registration. After successful registration, the newly registered terminal group information can be queried in the data system.

Second is terminal status updates. At this stage, the dynamic innovation of SIP terminals has been completed. In other words, SIP terminals can be automatically acquired and updated in offline SCE. After the successful registration of the terminal, the default ONLINE status of the SIP terminal is Offline, and the default status of the mobile phone is Online. After the SIP terminal goes online, the Proxy Server will use the SIP register packet that can be intercepted, and the relevant Register information will be first sent to the SIP Proxy component in the SCE. These components will send the SIP number, message, and other information in the message to the Terminal Group Management component. It is then forwarded to the SIP server. At this point, if we check the terminal state in the SCE database again, we can find that it has changed from Offline to Online, which proves that the dynamic innovation of terminal state has been successful [9, 10].

Third is multiterminal voice calls. There are multiple terminals in the user terminal group. If you want to select the optimal terminal, you need to follow the following rules for analysis and processing. If the SIP terminal is assumed to be online, call the SIP terminal. Assuming that there are multiple SIP terminals online, it is necessary to select the SIP terminal with the latest online time. If the SIP terminal is not online, it is necessary to return the newly registered mobile terminal number again. If there is no mobile terminal number at this time, it is an error that has returned [11].

Table 2: Parameter design based on network selection.

	AB(Mbit/s)	TB(Mbit/s)	SS(%)	u(%)	DE(ms)	J(ms)	L(/10)	C(%)
$AN1$	1	2	100	20	50	10	50	60
$AN2$	1.2	2	100	25	50	10	20	80
$AN3$	6	11	100	40	150	20	30	10
$AN4$	30	54	90	60	150	20	80	12
$AN5$	20	60	90	80	90	10	40	70
$AN6$	40	60	90	30	100	10	30	100

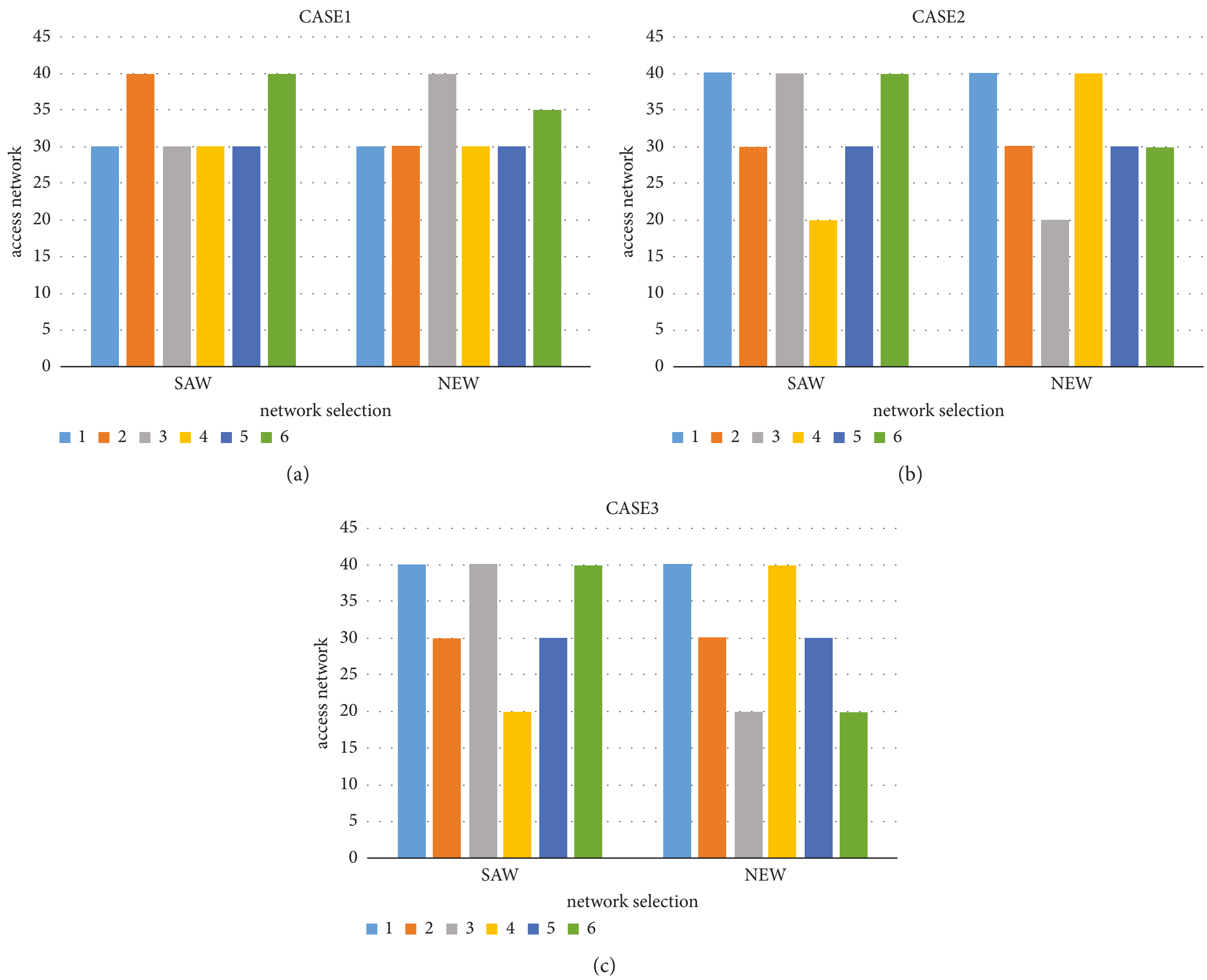

Figure 4: Network selection results.

Fourth is media stream guidance and control. This function is demonstrated in the remote control program developed by the platform. First, click the update button at the terminal to obtain the corresponding terminal group information. The message returned by the SCE will be displayed in the Debugging Information section below. At this time, it can be clear how many terminals have been returned, and the specific IP address will also be displayed directly. Combined with the status information bar of terminal equipment, the above presentation terminal can be studied to determine whether it is available or not. Secondly, select the desired terminal and click the Play button. Then, you can see that the lower right corner of the first terminal icon in the interface will mark the playback symbol, which proves that the current terminal is in the playback state. Finally, the video is played on the selected terminal [12].

Fifth is short message function business logic control. This functional test mainly verifies the business logic function of short message sending. The actual interface design contains three contents: first is the mandatory parameters, which involve the number of the sender, the number of the receiver, and the message content; next is optional parameters, which involve the text message need to copy well and logo and other content; finally, there is the service endpoint information, which refers to the information data on the server side, such as the user name and password. The key parameter is the mandatory parameters.

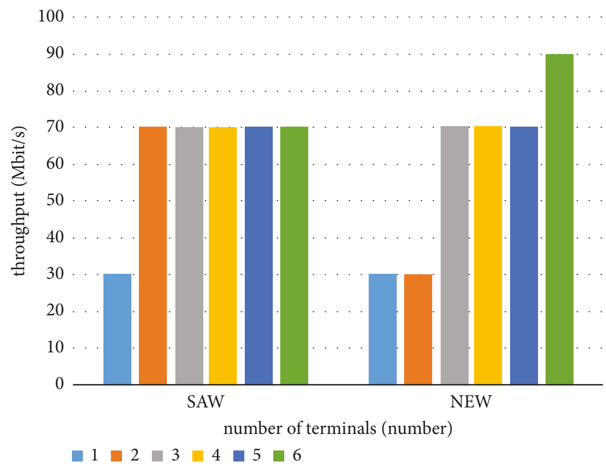

Figure 5: Comparison results of the algorithm throughput.

After completing information filling, click “Submit” below, and then the network platform can obtain the web page to submit the application. The specific code is as follows [13].

```
("deliveryInfoNotifl cation" :["senderAddress" :"tel:+1890000991" , "nessage":"Message
fron SCE." , "deliveryInfo":[{" deliveryStatus" : "DeliveredToTerninal"," address":"tel
:+13500000991"] 。 [" deliverystatus" : "DeliveredToTerninal" 。 "address" : tel:+1350000099
2"],["dellverys tatus": "DellveredToTerninal" , " address":"tel: +13500000993"}, {" dellve
rystatus":"DeltveredToTerninal" ， " address":"tel:+13500000994"] ,[" deltverystatus" :"0
eilver edToTerntnal"， ”address":"tel:+13500000995"}]}}
18:05:22,195 INFO [CPEHttpResourceAdapto r] POST /oneapiserver /snsdeltverynottftca
tton HTTP/1.1
```

This component then converts the message form into a pattern recognized by the SMS Gateway and passes it to and through the SMS Gateway [14].

Combined with the content analysis of multiterminal collaborative multimedia application and network architecture design outlined above, it can be seen that the overall system design applies the idea of layering, including the business control layer, the network control layer, and the bearing layer from top to bottom, and the interface is needed to communicate with each other. From the perspective of business control environment, it is necessary to use the componentized design idea to divide larger functions into multiple components, so that the components can complete the task in cooperative operation and facilitate subsequent business expansion and development. In the design of terminal group business logic, the ultimate purpose of business environment control is to control the terminal group business logic, such as how to store and update the terminal group information and how to make full use of all terminal business capabilities to provide users with quality services. Combined with the analysis of the network control environment, in order to build a flexible and modifiable system software platform, it is necessary to select an appropriate network selection algorithm and implement differentiated queue control rules according to different business requirements.

4. Conclusion

To sum up, in the comprehensive promotion of information network technology, most users can skillfully use or alternately use multiple communication terminals, and these terminals can be connected to different or heterogeneous networks. At this time, in order to guarantee the quality and safety of system operation, it is necessary to build a control platform of fusion network based on practical development requirements, which can not only help users comprehensively control multiple terminals, but also make reasonable use of the business capabilities of each terminal. Combined with the research and analysis of the design form of network control platform and network selection algorithm in this paper, the overall design is mainly divided into three layers, and the selected algorithm mainly has three kinds, including FAHP-GRA algorithm, based on the AHP and entropy method, and based on AHP and TOPSIS algorithm. According to the overall system design form, the comparison and analysis of the three alternative algorithms show that the application performance of the algorithm based on AHP and TOPSIS is better, showing a strong application advantage in both unnecessary conversion rate and user satisfaction. And test validation analysis was carried out on the overall system design, which mainly includes the function of the terminal groups registered, terminal status updates, more terminal voice calls, media flow guide control function, the short message function business logic control, and other functions, and through the test and analysis, we found that various functions can be fully present in the development of practice [15–17].

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

References

[1] S. Guo, L. Rui, X. Qiu, and L. M. Meng, "Business-oriented mechanism," *Journal of Electronics and Information*, vol. 34, no. 7, pp. 1703–1708, 2012.

[2] P. Zhang, J. Miao, Z. Hu, and T. Hui, "A review of general network research," *Journal of Beijing University of Posts and Telecommunications*, vol. 033, no. 005, pp. 1–6, 2010.

[3] C. Zhang, M. Chen, and B. Li, "Analysis of application layer personal mobility under SIP protocol," *Computer Technology and Development*, vol. 020, no. 007, pp. 109–113, 2010.

[4] I. G. Niemegeers and S. M. H. De Groot, "FEDNETS: context-aware ad-hoc network federations," *Wireless Personal Communications*, vol. 33, no. 3-4, pp. 305–318, 2005.

[5] H. Tian, Z. Hu, and P. Zhang, "Business flow control based on multi-terminal collaborative," *ZTE Technology*, vol. 18, no. 3, pp. 16–19, 2012.

[6] S. Yang, B. Yang, H. S. Wong, and K. Zhongfeng, *Cooperative Traffic Signal Control Using Multi-step Return and Off-Policy Asynchronous Advantage Actor-Critic Graph algorithm*, Knowledge-Based Systems, College Station, TX, USA, 2019.

[7] A. I. Delis, I. K. Nikolos, and M. Papageorgiou, "Macroscopic traffic flow modeling with adaptive cruise control: development and numerical solution," *Computers & Mathematics with Applications*, vol. 70, no. 8, pp. 1921–1947, 2015.

[8] R. Chandrasekaran and K. P. K. Y. P. S. N. Nair, "Multi-terminal multipath flows: synthesis," *Discrete Applied Mathematics*, vol. 143, no. 1-3, pp. 182–193, 2004.

[9] Z. Li, Y. Liu, S. Xu, and Y. Qian, "Analytical studies on an optimized adaptive cruise control model of traffic flow based on self-stabilizing strategy," *International Journal of Modern Physics C*, vol. 31, no. 4, 2020.

[10] Y. Zhang, Y. Yang, W. Zhou, and O. Xiaocao, *Multi-city Traffic Flow Forecasting via Multi-Task learning*, pp. 1–19, Applied Intelligence, Surrey, LN, UK, 2021.

[11] Y. Liu, R. J. Cheng, Y. Q. Ma, and H.X Ge, "The control method for the multi-phase traffic model," *International Journal of Modern Physics C*, vol. 27, no. 10, Article ID 1650111, 2016.

[12] S. I. Roumeliotis and I. M. Rekleitis, "Propagation of uncertainty in cooperative multirobot localization: analysis and experimental results," *Autonomous Robots*, vol. 17, no. 1, pp. 41–54, 2004.

[13] S. Erhart and S. Hirche, "Internal force analysis and load distribution for cooperative multi-robot manipulation," *IEEE Transactions on Robotics*, vol. 31, no. 5, pp. 1238–1243, 2015.

[14] Z. Zhen, D. Zhao, J. Gao, D. Wang, and Y. Dai, "FMRQ-A multiagent reinforcement learning algorithm for fully cooperative tasks[J]," *IEEE Transactions on Cybernetics*, vol. 47, no. 6, pp. 1367–1379, 2016.

[15] I. F. Akyildiz, J. Liebeherr, and I. Nikolaidis, "Multi-level rate-based flow control for ABR traffic," *Performance Evaluation*, vol. 31, no. 1-2, pp. 107–131, 1997.

[16] S. Lakshmanan and R. Sivakumar, "Proteus: multiflow diversity routing for wireless networks with cooperative transmissions," *IEEE Transactions on Mobile Computing*, vol. 12, no. 6, pp. 1146–1159, 2013.

[17] A. Torreño, E. Onaindia, and A. Komenda, "Cooperative multi-agent planning: a survey[J]," *ACM Computing Surveys*, vol. 50, no. 6, pp. 1–32, 2017.