A balanced allocation method of English MOOC teaching resources based on QoS constraints

Xiaodong Yuan

Department of Foreign Language and International Education,
Henan Polytechnic Institute,
Nanyang 473000, China
Email: xiaodong7@mls.sinanet.com

Abstract: In order to overcome the problems of long allocation time and high bandwidth consumption in traditional resource allocation methods, this paper proposes a new balanced allocation method of English MOOC teaching resources based on QoS constraints. With the support of big data and cloud computing technology, MOOC English teaching resources are mined and collected, and the resource balanced allocation model is constructed by using MMPs algorithm. The resource balanced allocation of virtual machine is realised through the selection of QoS constraint parameters, physical resource mapping and QESA resource allocation system. On the basis of experiments, the proposed method has the advantages of balanced resource allocation and execution time.

Keywords: QoS constraints; MOOC resources; MMPS algorithm; QESA system.

Reference to this paper should be made as follows: Yuan, X. (2023) 'A balanced allocation method of English MOOC teaching resources based on QoS constraints', *Int. J. Continuing Engineering Education and Life-Long Learning*, Vol. 33, No. 1, pp.84–98.

Biographical notes: Xiaodong Yuan received his BA in English from Henan Normal University in 2010. He is a Lecturer in the Department of Foreign Language and International Education of Henan Polytechnic Institute. His research interests include vocational English education and Linguistics.

1 Introduction

Promoting the balance of educational resources is an important task for my country's education. It is conducive to solving the problems of imbalances in educational resources, contradictions in educational levels, and educational equity issues in my country, and promotes the scientific development of China's educational undertakings for building China. The characteristic socialist education and cultural power of the country makes contributions. With the rapid development of modern network technology and information technology, the internet has provided social education institutions with a support platform for online education work. Online education has gradually risen and received widespread attention. In recent years, it has developed well, and there are more and more online education resources. The scale is gradually expanding, and the distribution of information resources is gradually socialised. Among them, the MOOC teaching career has developed rapidly, its teaching resources are huge, and the uneven distribution of teaching resources is serious. Therefore, how to promote the reasonable and balanced distribution of educational resources in the rapidly developing and huge dynamic network environment has become the current research focus in the field of online education.

With the development and maturity of network information technology, the balanced distribution of network teaching resources can be achieved through high technology such as network big data and cloud computing. There are currently many more effective research results. For example, literature Gao (2019) proposes a method based on multiple the agent node's mobile network education resource balanced allocation method, by calculating the adaptation factor of the resource node performance index and the resource consumption index, according to the calculation result, the network teaching resources are balanced allocated; this method is mainly aimed at the allocation method of mobile network teaching resources Research has certain limitations. Literature Wang (2019) proposed a method of GIS-based educational resource balance, using GIS to spatialise and dynamically update educational resources, and establish a balanced evaluation index covering multiple dimensions of educational opportunities, resource allocation, education quality, etc. System, and through a variety of spatial analysis methods, balanced distribution of educational resources. Literature Zhang (2018) proposed a method of balanced distribution of mobile network teaching resources based on sequential games. This method first calculates the Nash equilibrium solution of each resource sequential game, and on this basis predicts the current network resource load capacity, gives the computing capacity of the proportional distribution of resources, and completes the balanced distribution of network teaching resources. However, this method is less robust and cannot meet the requirements of balanced distribution of educational resources under certain circumstances.

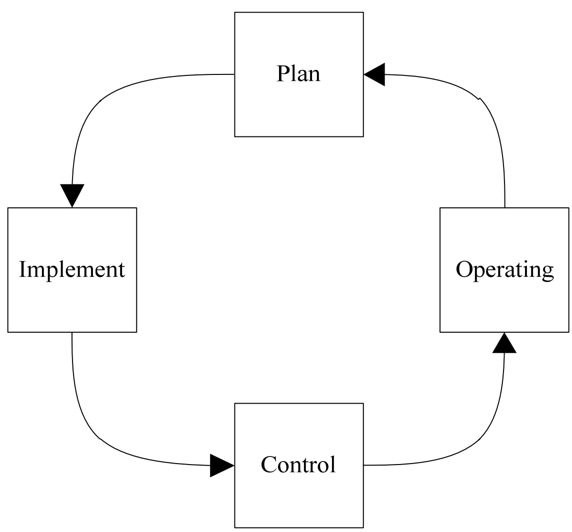
The above methods have certain effects in promoting the allocation of teaching resources, but they all have certain pertinence, poor applicability and cannot be widely popularised. Therefore, a balanced allocation method of English MOOC teaching resources based on QoS constraints is proposed. The overall research scheme of this method is as follows:

1. According to the target information requirements of English MOOC teaching resources, the collection process of English MOOC teaching resources is formulated to complete the full collection of English MOOC teaching resources.
2. Based on the collected information of English MOOC teaching resources, this paper selects the QoS constraint parameters, and constructs the balanced allocation system of English MOOC teaching resources according to the MMPs resource balanced allocation algorithm in the QoS constraint, so as to effectively complete the balanced allocation of English MOOC teaching resources.
3. Compared with the traditional bandwidth allocation method, this paper takes the experimental time as the verification index.

2 Collection of English MOOC resources

English MOOC teaching resources are mainly collected through the internet data resource database. According to the user's search requirements, the computer system searches resources within the scope of the internet and accesses other information platforms or resource databases. The access interface of the platform generally needs certain access rights to obtain the target information resources, and then transmits the resources to the main computer system through network communication to complete the collection and storage of resource information (Wu, 2019; Fang, 2018; Shen, 2018; Kang and He, 2018). MOOC teaching system platform has its own resource information database, which stores a large number of teaching resources of the platform itself or introduced. Therefore, the collection of teaching resources first collects the resources of MOOC teaching platform, and then searches and collects the English MOOC teaching resources of the whole network. The obtained teaching resources will be stored in the system resource database to complete the storage and arrangement, so that the subsequent system can construct the allocation model and experiment. The collection process of English MOOC resources is shown in Figure 1.

Figure 1 Acquisition process



Through the above process, sufficient data of English MOOC teaching resources are collected to lay the foundation for the following balanced allocation of resources.

3 Resource balanced allocation algorithm based on QoS Constraints

3.1 QoS constraint parameter selection

Due to the different service objects of network teaching resource allocation, the requirements for resources are also different. Taking into account the dynamics, openness and complexity of the network, selecting QoS constraints as the relevant measurement standard for resource allocation can more effectively evaluate the objects. Therefore, it is necessary to select the relevant parameters of QoS constraints, and analyse the needs of general users for online English MOOC teaching resources, extract the key points of the requirements, and then form a representative QoS constraint standard. The user can perform resources according to the measurement standard. Selection and evaluation (Tao et al., 2018: Mercado Varela et al., 2018; Zhang et al., 2018). According to some characteristics of online English teaching resources, this paper selects the following representative QoS constraint parameters:

1 Time. According to the total duration of the teaching resources, the teaching resources are divided and evaluated. This is mainly for some users who have strict time requirements. Many users will select suitable teaching resources for different time divisions for various reasons.

2 Network. Network status is an important aspect that affects users' access to teaching resources. The quality of the network, the speed of the network, and the openness of the network all affect the acquisition and sharing of resources, so the network is a constraint measurement standard.

3 Price. Many resources on the internet are paid, and online English teaching resources are also affected by factors such as the quality of teaching content, length of time, audience level and other factors, and resource prices also have different standards. But now most people still pursue low-cost prices, so price can become a constraint measure (Rahmna et al., 2018; Gonzales et al., 2019; Brinton et al., 2018; Manathunga et al., 2018; Kabtane et al., 2019).

3.2 Construction of resource allocation model

The balanced allocation model of resources based on QoS constraints first needs to optimise the allocation of resources based on the task requirements of resources and the mutual mapping of resources and constraint parameters. With the technical support of Internet big data and cloud computing, the process of network English teaching resource allocation can be described as: After a resource request task is issued, it reaches the relevant network computing node through network communication. Within its overall duration, the task demand Indexes such as type, time length, network status, and execution speed must meet the parameter standards of QoS constraints. δ_d represents the standard deviation of the model. The following table is the statistical table of the information of the model constructed by Internet of Things technology in different distance ranges. DAF can effectively remove pulse interference noise and mixed pixel interference.

After the resources are mapped to the virtual machine, adjust the parameter configuration of the virtual machine, normalise the parameter interval to the [0, 1] interval according to the MMPS algorithm, and then quantify the parameters according to formula (1):

$$\begin{cases} \pi(\Delta) = \dfrac{\Delta - \dfrac{1}{M} \times \sum_{k=1}^{M} \Delta}{\max(\Delta) - \min(\Delta)} \\ \Delta \in (f_k, w_k, \varepsilon_k, \delta_k) \end{cases} \tag{1}$$

Among them, π (Δ) represents the specific quantitative values of physical resources, f_k, w_k, ε_k, δ_k respectively represents the parameter values of the CPU processing speed, memory capacity, external memory capacity, and network bandwidth of the virtual machine, and max (Δ) and min max (Δ) respectively represents the maximum and minimum values of the virtual machine parameters in the data set participating in the quantisation operation. The physical resources of the virtual machine are quantified by the above formula, and the quantised parameter values and corresponding QoS constraint parameters are obtained for standard evaluation.

3.2.1 Time

According to the parameter standards of QoS constraints, the partial time nodes of the task request are used as reference coefficients, and the corresponding physical resource parameter quantisation values in the mapping relationship are calculated by the time weighting formula to obtain the overall duration of the task completion under the influence of the physical equipment factors at the time:

$$H_t = \frac{1}{3} \times \left[\pi f_k + \pi w_k + \pi \delta_k\right] \tag{2}$$

3.2.2 Network

Network status is an important factor that affects resource mapping and communication transmission. For resource allocation and transmission with high complexity or a large number of resources, a faster network speed and stable network status should be used for resource allocation and mapping. According to the resource mapping relationship, the virtual machine network performance parameters can be calculated, and the virtual machine performance parameters can be adjusted according to the calculation results:

$$V_t = \pi \delta_k \tag{3}$$

3.2.3 Price

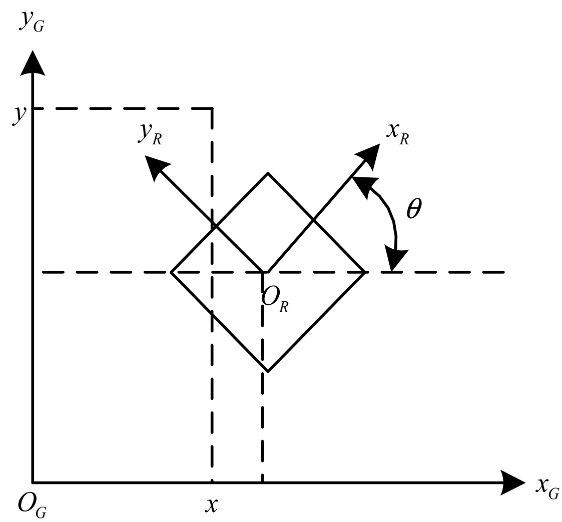
Price calculation mainly includes all expenditures in the overall process of resource allocation and transmission. The cost calculation involves the consumption of the total cost. According to the mapping relationship between QoS parameters and physical resources, the weighting formula of the price is calculated as follows:

$$P_t = \frac{1}{4} \times \left(\pi f_k + \pi w_k + \pi \varepsilon_k + \pi \delta_k\right) \tag{4}$$

When detecting price interest, setting the fluctuation coordinate system is divided into the following three types: The first is the global coordinate system of the environment in which it is located, described as (X_G, Y_G, Z_G), it can show the changes in the position of the system in the environment. The second is a fixed internal local coordinate system, which is described as (X_R, Y_R, Z_R), the third type is the polar coordinate system formed by the data information fed back by the ranging sensor under normal circumstances, which is described as (ρ, θ).

The global coordinate diagram is shown in Figure 2.

Figure 2 Schematic diagram of global coordinates



Set mapping location $[x, y, \theta]^T$, the mathematical model can be described as:

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix} \tag{5}$$

In formula (5), ω is the angular velocity starting from the centre point, v is the linear velocity, then the above formula must meet the constraint condition of non-integrity:

$$\dot{x}\sin\theta - \dot{y}\cos\theta = 0 \tag{6}$$

In the actual detection process, the parameters of the radio frequency collector are restricted as follows:

$$|v| \le v_{\max}; |\omega| \le \omega_{\max} \tag{7}$$

According to the above calculation, the weighted calculation result of the quantised physical resource data can be obtained, and the vector and the expected vector can be expressed as follows:

$$J = [H_t, V_t, P_t] \tag{8}$$

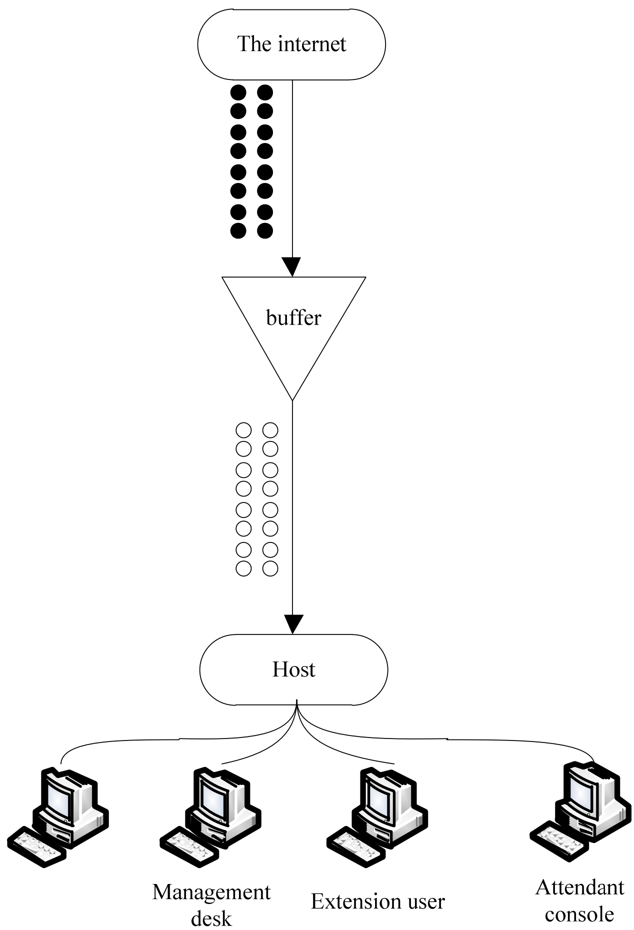
$$E = [e_H, e_V, e_P] \tag{9}$$

According to the quantified vector representation and expected vector representation of physical resources, the evaluation operation is based on QoS constraints, as shown in formula (10):

$$Cost_k = \sqrt{\left[\sum_{k=1}^{k} (J - E)^2\right]} \tag{10}$$

According to the calculation result of the above formula, the smaller the value $Cost_k$, the higher the matching degree between the resource allocation task requirements and the virtual machine parameter configuration, the better the mapping effect, the more reasonable the parameter configuration, and the better the applicability on the virtual machine. The lower the matching degree, the less ideal the mapping effect. Then, according to the matching effect, the resource allocation task is bound to the virtual machine, and the resource allocation task is unbound from the original host and added to the resource allocation processing space of the virtual machine. This process takes into account the load of the virtual machine, so it must pass the load detection before binding, and the task requirements that meet the virtual machine space load requirements can complete the binding (Wang, 2019; Gao, 2019; Shinha et al., 2020). The data classification process is shown in Figure 3.

Figure 3 Data classification process

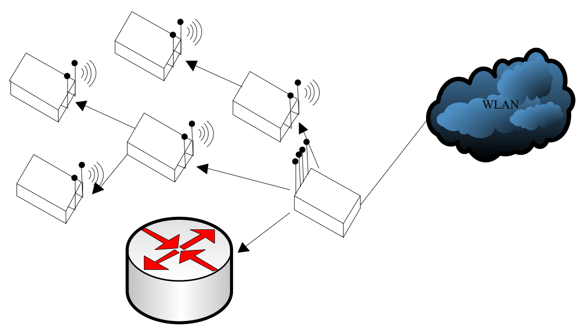


4 Construction of a balanced resource allocation system based on QoS constraints

4.1 QESA resource allocation system structure

The QESA resource allocation system is mainly responsible for resource information discovery, resource coordination and allocation, and resource information adjustment and scheduling for English MOOC teaching resources based on QoS constraints characteristics (Yan, 2018; Tawafak et al., 2018). When the QESA resource allocation system performs resource information coordination and task scheduling, it needs to start the reservation manager and resource allocator to adjust and manage the teaching resource information; and according to the resource demand tasks proposed by the application layer users, the teaching resources and QoS constraint services are coordinated and adjusted to meet user resource requirements. The resource allocation process is shown in Figure 4.

Figure 4 Resource allocation process (see online version for colours)



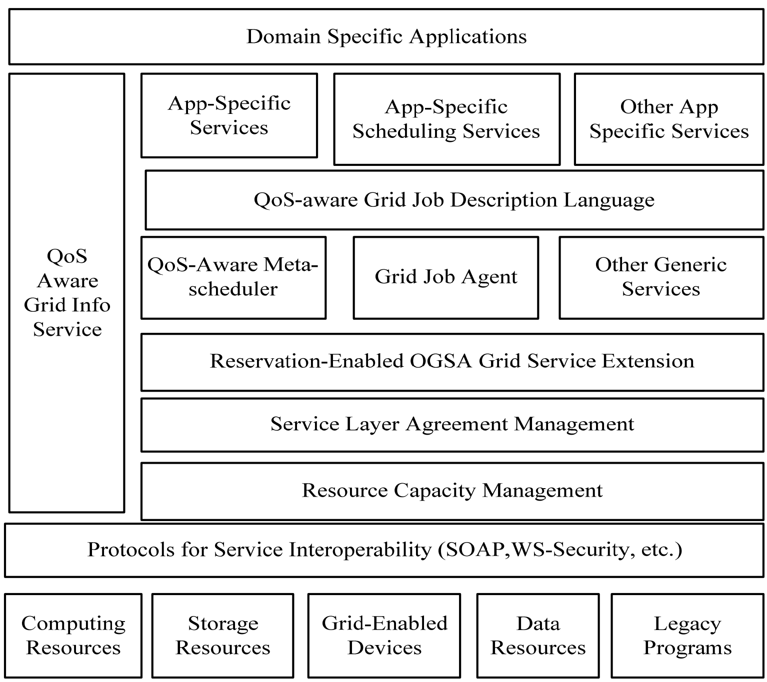
The QESA resource allocation system builds a network information resource data management and allocation system that conforms to English MOOC teaching resources on the basis of supporting QoS services. Its main structure has the following levels:

1. Resource information management service based on QoS. Including the management of the system's own resource information database and network information resource retrieval system. Through the information management mechanism and query service interface of the resource allocation system, it realises the orderly management of system resource classification management and external network resource information retrieval and search, and supports QoS on the basis of constrained services, it satisfies the resource exploration, collection and management of the teaching system,
2. Coordinated allocation of resource information based on QoS. The QESA resource allocation system starts the reservation manager and resource allocator based on the QoS constraints, and realises the reservation service of resource information through the reservation interface according to the information requirements of the resource request task; at the same time, according to the system evaluation procedure for teaching The multi-faceted performance evaluation results of resources can realise resource classification based on the performance of a certain resource, and adjust and

coordinate related resource tasks according to the classification results and the degree of performance matching.

3 Resource task scheduling based on QoS. The system performs application performance analysis and QoS capability evaluation on resource information according to the user needs of the application layer and the result of system resource matching, and according to the matching result of the QoS capability in the resource mapping model and the physical resource mapping, the QoS capability and resource task of the resource information The requirements are analysed and matched, and the system resource requirements tasks are coordinated and scheduled appropriately based on the analysis results. The resource allocation architecture of QESA is shown in Figure 5.

Figure 5 QESAA resource allocation system structure



The overall structure of QESA resource allocation system is shown in Figure 5. Its services include user demand analysis, resource information analysis and matching, and resource task adjustment and scheduling of the system (Chiu and Hew, 2018; Larionova et al., 2018; Wang et al., 2018). On the basis of supporting QoS services, it promotes the analysis and matching of teaching information resources in the system, which is conducive to ensuring the rationality and effectiveness of teaching information resource allocation. The resource allocation time is shown in Figure 6.

Figure 6 Resource allocation time

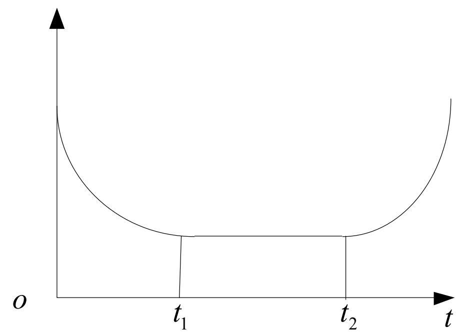
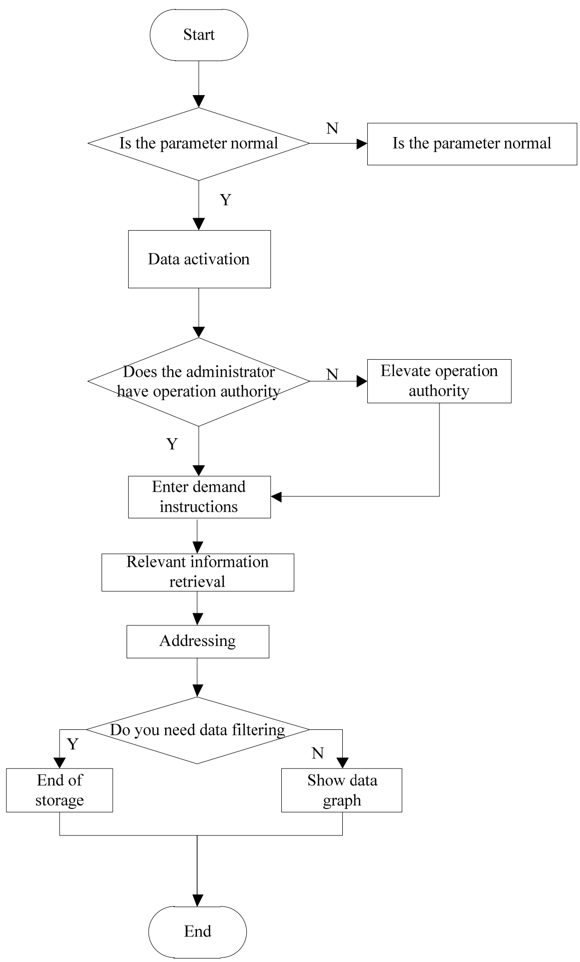


Figure 7 QESA system evaluation process



4.2 QESA system assessment

The QESA system evaluation process is shown in Figure 7.

Taking into account the relevant characteristics of QoS constraints, according to the evaluation results, this paper selects the QESA resource allocation system based on QoS. Compared with other resource allocation service systems, the QESA resource allocation system has the following advantages:

1. The QESA resource allocation system can directly communicate and process information between the system application layer client and the system data layer service processing end. The information processing process is relatively simple, and the processing efficiency is high. It has the ability to analyse and match information resources. A certain flexibility.
2. It has a certain degree of adaptability to QoS service characteristics. The mapping matching degree of QoS service capabilities is high, which is convenient for information resource matching and task scheduling based on QoS constraint characteristics. The work completion degree is high, and the matching degree with the system is good.
3. The QESA resource allocation system has the currently popular service grid technology. Based on the technical operation of big data and cloud computing, it has high data calculation and logic analysis capabilities; the performance analysis of teaching resources and task allocation capabilities are relatively high. High work efficiency can meet the current demand for balanced distribution of resource information, and can be updated with the further development of the distribution grid technology.

The QESA resource allocation system has high adaptability and openness, can meet the QoS service capabilities and characteristic requirements, and can further expand its service scope according to the information resources and task requirements, and meet the resource allocation requirements of the system. It has strong applicability and comprehensiveness. The performance is relatively good.

5 Experimental research

In order to verify the practical application effect of the MMPS resource balance allocation algorithm based on QoS constraints, this paper designs experimental research, and selects two other traditional resource balance allocation methods according to the resource allocation task and virtual machine parameter settings to conduct research experiments.

5.1 Experimental environment

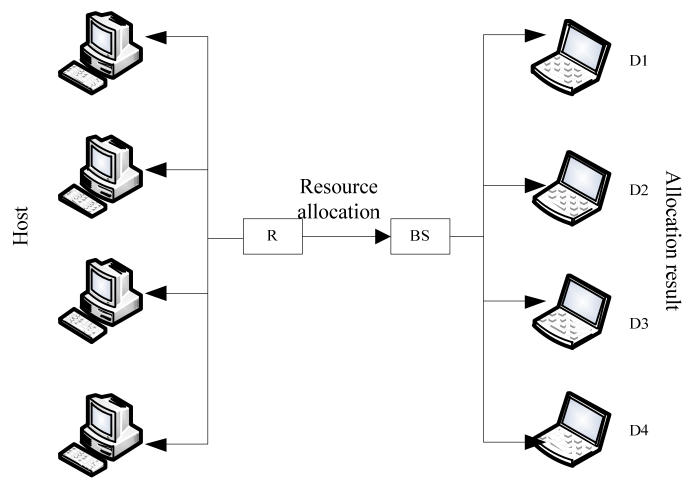
In this paper, three virtual machines are selected for experimental research. The virtual machine adopts unified device configuration, and the configuration is shown in Table 1.

Table 1 Experimental equipment configuration information table

Instrument configuration	*Lab environment*
AMDA88640K3.60GHZ	CPU
Windows 7	PC system
Java	Programming language
8 GB	Running memory
256 GB	Storage memory
Eclipse	Programming software

On the basis of the above experimental equipment configuration, MMPs resource balanced allocation algorithm, GYS algorithm and SES algorithm based on QoS constraints are used to carry out the same resource allocation task operation experiment on English MOOC teaching resources, and the QoS constraint parameters of the completion time, network state and operation cost of the resource allocation tasks of the three algorithms are studied and analysed. The experimental environment is shown in Figure 8.

Figure 8 Experimental environment



5.2 Experimental index

In order to fully verify the effectiveness of the proposed allocation method, this paper compares the proposed method with the traditional GYS method and SES method, taking the allocation time and the allocated bandwidth as the experimental comparison indexes.

1 Allocation time: allocation time refers to the time spent by different methods in the allocation of English MOOC teaching resources with the same data. The shorter the allocation time, the higher the allocation efficiency of the methods.

2 Bandwidth occupied by allocation: since the allocation is carried out through the internet, the network bandwidth will be occupied in the process of resource

allocation. The less the bandwidth occupied by allocation, the higher the performance of the method.

5.3 Comparison of resource allocation time

The resource allocation methods of the two cases are shown in Table 2.

Table 2 Resource allocation task execution time

Method	*Allocate time/s*
Method of this paper	174.6
GYS method	205.3
SES method	217.9

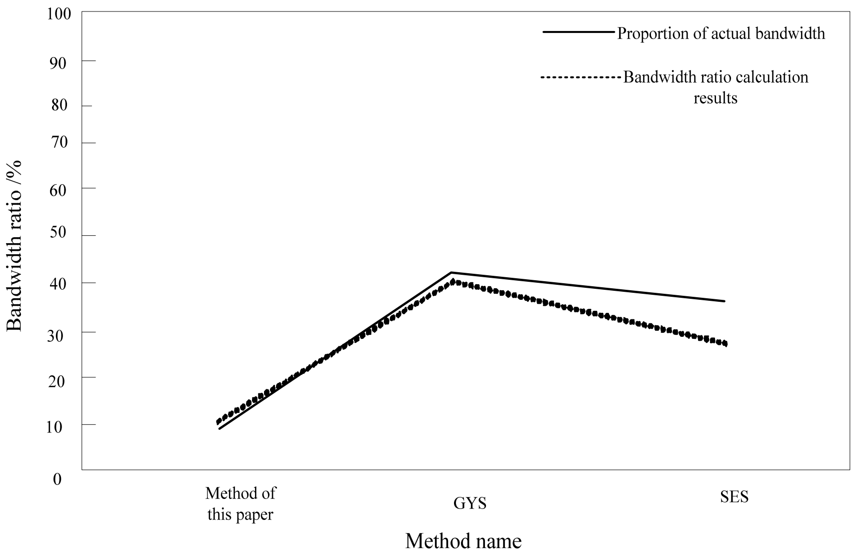
It can be seen from Table 2 that the resource allocation time of this method is the shortest, only 174.6 s, which saves nearly 12% of the time compared to the traditional allocation method. The resource allocation time of the GYS method is 205.3 s, which is about 30 s longer than the method in this paper. It shows that the allocation speed of the GYS method is slow, the overall efficiency is not high, and the completion effect of the resource allocation task is not very ideal. The overall allocation time of the SES method is the longest among the three methods, and the time consumed is more than 10s longer than that of the GYS method, indicating that its resource allocation efficiency is low, and the allocation efficiency is not as good as the previous two methods. It can be seen that the method in this paper is more conducive to the balanced distribution of resources, which makes it have certain advantages in task execution time.

5.4 Comparison of allocated bandwidth

The higher the broadband occupancy rate is, the slower the network speed is. For the same resource allocation task, more network energy is needed. The comparison results of bandwidth occupied by resource allocation of the three methods are shown in Figure 9.

As shown in Figure 9, the network bandwidth ratio of the method in this paper is the lowest, only about 10%, and it is lower than the actual network ratio, indicating that its network broadband belongs to the uplink network status, the network speed is faster, and the resource allocation speed is also faster. The proportion of the network bandwidth of the GYS method is significantly higher than that of the method in this article, reaching about 45%, which is higher than the expected network bandwidth proportion. The network occupancy rate of the SES method is relatively low, but it has reached 40%, which is 10% higher than the expected state. It can be seen that compared with the traditional method, the network status of the method in this paper is obviously much better, reflecting its relatively stable network status and faster network speed, which in turn makes resource allocation faster and more efficient, and is also conducive to maintaining the health and stability of the computer system.

Figure 9 Network bandwidth ratio results



6 Conclusions

In order to solve a series of problems existing in traditional teaching resource allocation methods, a balanced allocation method of English MOOC teaching resources based on QoS constraints is proposed. The performance of the method is verified from both theoretical and experimental aspects. This method is used to balance the allocation of English MOOC teaching resources. The process has a higher allocation efficiency and a lower bandwidth ratio. Specifically, compared with the GYS method, the allocation efficiency is greatly improved, and the allocation time is reduced by about 30 s; compared with the SES method, the proportion of the allocated bandwidth is significantly reduced, with the lowest proportion being only 9%. Therefore, it fully illustrates that the proposed resource allocation method based on QoS constraints can better meet the requirements of English MOOC teaching resource allocation.

References

Brinton, C.G., Buccapatnam, S., Zheng, L., Lan, S., Wong, F., Ha, S., Chiang, M. and Poor, H. (2018) 'On the Efficiency of Online Social Learning Networks', *IEEE/ACM Transactions on Networking*, Vol. 26, No. 5, pp.2076–2089.

Chiu, K. and Hew, K. (2018) 'Factors influencing peer learning and performance in MOOC asynchronous online discussion forum', *Australasian Journal of Educational Technology*, Vol. 34, No. 4, pp.16–28.

Fang, G. (2018) 'Japanese informatization teaching model based on MOOC', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 13, No. 7, pp.124–129.

Gao B. (2019) 'Highly efficient English MOOC teaching model based on frontline education analysis', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 14, No. 6, pp.138–146.

Gonzales, A., Paletta, F.C., Vaisman, C. and Giraud, A. (2019) 'MetroTeach: modelling of knowledge and skills in a MOOC with the visuo-cognitive metaphor of the metro map', *Education for Information*, Vol. 35, No. 3, pp.285–304.

Kabtane, H.E., Adnani, M.E., Sadgal, M. and Mourdi, Y. (2019) 'Augmented reality-based approach for interactivity in MOOCs', *International Journal of Web Information Systems*, Vol. 15, No. 2, pp.134–154.

Kang, Z. and He, L. (2018) 'Construction and practice of SPOC teaching mode based on MOOC', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 13, No. 12, pp.35–42.

Larionova, V., Brown, K., Bystrova, T. and Sinitsyn, E. (2018) 'Russian perspectives of online learning technologies in higher education: An empirical study of a MOOC', *Research in Comparative and International Education*, Vol. 31, No. 7, pp.174–178.

Manathunga, K. and Hernández-Leo, D. (2018) 'Authoring and enactment of mobile pyramid-based collaborative learning activities', *British Journal of Educational Technology*, Vol. 49, No. 2, pp.262–275.

Mercado Varela, M.A., Fernandez Morales, K., Lavigne, G. and Ramirez Montoya, M.S. (2018) 'Teaching and dissemination about the use of open educational resources with MOOC: a case study', *CPU-e Revista de Investigación Educativa*, Vol. 36, No. 26, pp.3–19.

Rahman, D., Mohsen, G. and Mohammad, D. (2018) 'Fault location in power distribution network with presence of distributed generation resources using impedance-based method and applying π line model', *Energy*, Vol. 159, No. 15, pp.344–360.

Shen, C. (2018) 'MOOC teaching mode of news transmission based on network audio data decoding technology', *International Journal of Emerging Technologies in Learning*, Vol. 13, No. 6, pp.125–129.

Shinha, K., Nihei, W., Ono, T., Nakazato, R. and Kimura, H. (2020) 'A pharmacokinetic-pharmacodynamic model based on multi-organ-on-a-chip for drug–drug interaction studies', *Biomicrofluidics*, Vol. 14, No. 4, pp.108–114.

Tao, S., Yanjun, L. and Ji, X. (2018) 'A graph-based power flow method for balanced distribution systems', *Energies*, Vol. 11, No. 3, pp.511–515.

Tawafak, R.M.T., Romli, A.B. and Arshah, R.B.A. (2018) 'Continued intention to use UCOM: four factors for integrating with a technology acceptance model to moderate the satisfaction of learning', *IEEE Access*, Vol. 25, No. 9, pp.157–162.

Wang, R. (2019) 'Massive open online course platform blended English teaching method based on model-view-controller framework', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 14, No. 16, pp.188–193.

Wang, Z., Anderson, T. and Chen, L. (2018) 'How learners participate in connectivism learning: an analysis of the interaction traces from a cMOOC', *International Review of Research in Open & Distance Learning,* Vol. 19, No. 1, pp.44–67.

Wu, Q. (2019) 'MOOC learning behavior analysis and teaching intelligent decision support method based on improved decision tree C4.5 algorithm', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 14, No. 12, pp.29–33.

Yan, Y. (2018) 'Design and implementation of english MOOC platform based on BP neural network algorithm', *Automation & Instrumentation*, Vol. 25, No. 8, pp.81–83.

Zhang N. (2018) 'Development and application of an english network teaching system based on MOOC', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 13, No. 7, pp.149–154.

Zhang, Y., Chen, J., Miao, D. and Chen, Z. (2018) 'Design and analysis of an interactive MOOC teaching system based on virtual reality', *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 13, No. 7, pp.111–116.