Design of Digital Media Resource Management System Based on IOT Platform

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Abstract. Nowadays, the role of software systems is becoming more and more important in an increasingly developed information society. A powerful software system is crucial to the daily operation of schools, enterprises, etc. However, traditional digital media resource management systems have some problems, such as the system processing data slows down as the number of user accesses increases. This article studies the resource management analysis and verifies the scenario management system. By establishing a system processing speed for the resource environment, the proposed resource management scenarios were classified. The results show that the interface of this system is simple and clear, which can realize the efficient storage and fast retrieval of digital media resources, and the whole operation efficiency of this system has been improved through the unified interface style.

Keywords: Digital Media Resource Management System; Hardware Design; Embedded Microprocessor; Digital Resources; Database
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1 INTRODUCTION

Nowadays, digital resource management system, has been an irreplaceable part of people's life. Video, picture, and audio files in digital format have been generated, which are resources of certain value, and their implementation of comprehensive management is of great importance for social and economic development, which needs to consider many factors, such as the complexity of CAD software, the diversity of graphic data, the uncertainty of feature representation, etc. Digital media resource management, storing, organizing, distributing, and utilizing various media resources in the field of digital media. Akasiadis et al. [1] Digital media resources include digital images, digital audio, digital video, digital text, digital rights management and other forms. The purpose of Anwar [2] digital media resource management is to better protect, utilize, and improve the utilization rate and value. Bakkouri and Afdel [3] collected a large amount of CAD graphic data. And perform data preprocessing. The purpose of preprocessing is to remove noise, missing, and inconsistent features, and to divide the dataset into training and testing sets. Gao et al. [4] used the transfer learning algorithm to extract the feature representation from the trained CAD system, and used the multi-layer feature fusion network to fuse features to improve the robustness of features. Use CAD software to represent the extracted features for subsequent processing and analysis. The transfer learning algorithm is used to select suitable features from the test set to build the model, and the multi-layer feature fusion network is used to fuse the model to improve the robustness of the model. Evaluate the model using a test set to evaluate its performance and robustness. Optimize the model based on the evaluation results to improve its performance and robustness. Gao et al. [5] deployed the optimized model into practical applications to achieve robustness support for CAD software. Build a robust CAD system that can effectively handle the complexity of CAD software, the diversity of graphic data, and the uncertainty of feature expression, and achieve robustness support for CAD software.

This paper consists of four chapters, and the detailed structure of the chapters is as follows: Chapter 1: The introduction introduces the background of the system and the innovation points of this paper, based on which, the main research contents and the structure of the paper are described. Chapter 2: Mainly distributed as the current status of the application of the Internet of Things technology and the development tools, software development technology and system architecture technology used in the digital media resource management system. Chapter 3: On the basis of careful research and requirement analysis of the media asset management system, the functional and non-functional requirements to be achieved by this system are elaborated and the overall and detailed design of this system is described. Based on the requirement analysis and design, the system development strategy, system environment, and system configuration are discussed in detail. In the core function implementation part, the system login process, system search, data upload and download core functions are designed and implemented. Chapter 4: The interface of this system is simple and clear, which can realize the efficient storage and fast retrieval of digital media resources, and the whole operation efficiency of this system has been improved through the unified interface style.

The innovation of this paper is to point out a new direction in solving the above problems by introducing the IoT technology and the rapid popularity of Internet applications. Based on the browser/server architecture of IoT technology, the IoT browser can effectively support a variety of media through the interpretation and execution of hypertext markup language; through the combination of image and text hyperlink technology can provide a unified and friendly human-computer interaction interface for users. It can be said that the multimedia management information system based on IoT will replace the traditional management information system and become a new research and application direction in the field of information technology.

2 CURRENT STATUS OF RESEARCH

The monitoring system of the Social Internet of Things (SIoT) refers to a system that monitors and manages various devices in social scenarios through IoT technology. The monitoring system can monitor the status of devices in social scenes in real-time, including parameters such as temperature, humidity, voltage, current, power, as well as information on the operating status and abnormal situations of the devices. The monitoring system can transmit the status and information of these devices to the cloud through Internet of Things technology, achieving real-time monitoring and management of social scenes. Girau et al. [6] helped managers detect equipment malfunctions and anomalies in a timely manner, and took corresponding measures. Jong et al. [7] Internet of Things digital media management, storing, organizing, distributing, and utilizing various media resources in the field of digital media using Internet of Things technology. The purpose of digital media management in the Internet of Things is to better protect, utilize, and disseminate resources, and improve the utilization rate and value of digital media resources. Digital media resources include digital images, digital audio, digital video, digital text, digital rights management and other forms. The purpose of digital media resource management is to better protect, utilize. Kadhim et al. [8] utilized computer technology to assist in physical education teaching. Li et al. [9] include the function of sharing teaching resources, and both teachers and students can view physical education teaching syllabus, teaching plans, teaching courseware, teaching videos, teaching cases, and other resources at any time through the open teaching resource module. In addition, these systems can also provide online Q&A, learning discussions, and student self-directed learning functions, providing more convenient and effective support for physical education teaching. Li [10] The process of utilizing IoT technology to achieve intelligent campus management. These management systems can collect campus information through sensors, intelligent terminals, and other devices, such as classroom temperature, humidity, lighting intensity, as well as students' attendance, learning, and health status. Ma et al. [11] provide more accurate and efficient support for campus management through cloud management and analysis. In addition, these management systems can also provide intelligent security monitoring, intelligent campus greening management, and other functions, providing more intelligent and humanized services for the campus. Ma et al. [11] designed digital media resource management based on network architecture, first considering factors such as the type and quantity of digital media resources, as well as the transmission speed and reliability of the network. Generally speaking, digital media resources can be divided into various forms such as images, audio, video, text, copyright, etc. Each resource has a different format and quantity, and needs to be designed according to specific circumstances. Marion and Fixson [12] need to consider the storage and management of digital media resources. Digital media resources can be divided into two modes: local storage and cloud storage. It is necessary to select the appropriate storage mode according to the type and quantity of resources. Shi and Zhao [13] considered factors such as the transmission speed and reliability of digital media resources, as well as the load and security of the network. Tambe et al. [14] considered the transmission methods and protocols of digital media resources. Generally speaking, digital media resources can be transmitted through the network, and appropriate transmission protocols and communication methods need to be selected to ensure the transmission quality and efficiency of digital media resources. Zhang et al. [15] considered the security and privacy protection of digital media resources. Digital media resources involve issues such as personal privacy and copyright, and corresponding security and privacy protection measures need to be taken to ensure the security and privacy protection of digital media resources. In summary, designing digital media resource management based on network architecture requires comprehensive consideration of factors such as the type, storage and management methods, transmission speed and reliability, security and privacy protection of digital media resources, in order to achieve efficient management.

3 MANAGEMENT SYSTEM OVER ALL DESIGN

3.1 The Overall Architecture Design of Digital Media Resource Management System

The digital media resource management system refers to an overall solution for digital storage, management, and application of various media and content (such as video/audio materials, text files, charts, etc.) based on advanced technologies such as multimedia, network, database, and digital storage. This includes all aspects of digital media collection, cataloging, management, transmission, and encoding conversion. Its main purpose is to meet the requirements of media resource owners for collecting, saving, searching, editing, and publishing various information. Provide convenient methods for users of media resources to access content, achieve efficient management of media resources, and significantly increase the value of media resources. The maintenance and management of digital media resources, and the overall architecture of the system is shown in Figure 1. It illustrates the overall architecture of a digital media resource management system based on Internet of Things technology.

3.2 Hardware Design of Digital Media Resource Management System Based on IOT Technology

According to the overall designed, and its structure is shown in Figure 2.

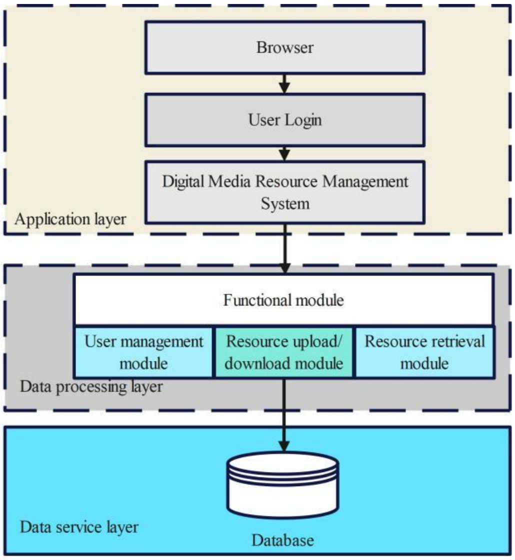

Figure 1: Overall architecture of digital media resource management system based on IoT technology.

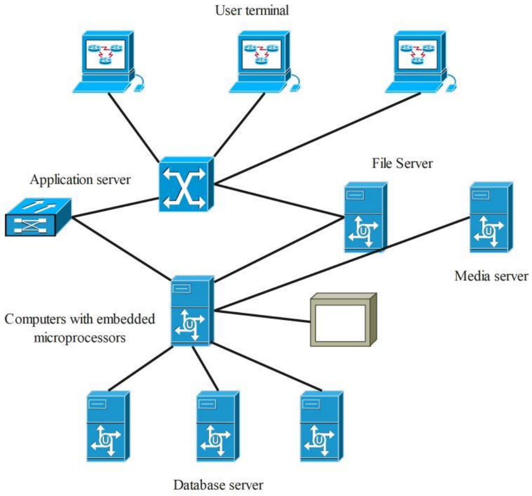

Figure 2: Hardware structure of digital media resource management system.

Figure 2 shows the hardware structure.

$$U = \{U_1, U_2, \cdots, U_n\} \quad (1)$$

$$p(U| \ \theta) = \sum_{k=1}^{K} \alpha G\left(U| \ u_k\right) \quad (2)$$

$$q(O| \ \theta) = \sum_{k=1}^{K} \beta G\left(O| \ u_k\right) \quad (3)$$

Where q represents the storage function; O represents the storage set; β represents the conversion factor. Through equation (3), it is stored into the database.

3.3 Typical Association Rule Mining Methods

The judgment matrix represents the comparison of the relative importance between all the criteria in this layer that are subordinate to it for a certain upper-level criterion. The representation of the judgment matrix is shown in equation (4).

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & \cdots & b_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ b_{n1} & b_{n2} & \cdots & \cdots & b_{nn} \end{bmatrix} \tag{4}$$

The matrix order n is the number of intercomparable elements in this layer, and the value of bij should be decided after careful deliberation based on professional opinion, past data and problem solving experience. It is worth noting that the value of n should not be greater than 9. If the number of elements is too large, it will make the judgment of the importance of the elements in the constructed matrix more prone to errors and bring great inconvenience to the later work.

$$\overline{b_{ij}} = \frac{b_{ij}}{\sum\limits_{i=1}^{n} b_{ij}}, i = (1, 2, \dots, \mathrm{n}) \tag{5}$$

After that, each column of the matrix B is summed by rows to obtain the vector W, where the calculation of the element of the j column, Wj, is obtained from Equation (6):

$$\overline{W_j} = \sum_{i=1}^{n} \overline{b_{ij}}, i = (1, 2, \dots, \mathrm{n}) \tag{6}$$

Then the vectors W=(W1,W2...Wn) are normalized, and the process is shown in equation (7):

$$W_i = \frac{\overline{W_i}}{\sum\limits_{i=1}^{n} \overline{W_i}}, i = (1, 2, \dots, \mathrm{n}) \tag{7}$$

The vector W is the approximate solution of the desired eigenvector. It reflects the weight of the elements involved in the comparison among the elements of the upper level to which they belong, i.e., the proportion of the weight of each element in the matrix among the elements of the upper level.

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(BW)_i}{nW_i}, i = (1, 2, \dots, n) \tag{8}$$

3.4 Implementation of Resource Query Module

All the resources, after the resource management module, the information properties of the file resources have been uploaded to the database. At this time, the resources need to be read out from the database and displayed with a unified interface for users to check. The digital resource management system provides a main page to display all resources categorized and provides resource navigation. Consistency refers to the logic and reasonableness of judging the importance between two two elements. Such a judgment is logical, otherwise, a logical contradiction will arise. When constructing the judgment matrix, the more elements involved in the comparison of importance, the higher the chance of possible human error, and the consistency verification of the matrix in the hierarchical single sort can effectively avoid the wrong results or deviations caused by human error. In the process of consistency verification, first we need to calculate the consistency index CI (Consistency Index) of the judgment matrix. the CI is calculated by equation (9).

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

The larger the calculation result of CI, the more the judgment matrix deviates from full consistency, and the smaller the calculation result of CI, the more the judgment matrix tends to be fully consistent. As the order n of the judgment matrix increases, the difference between the consistency and full consistency of the judgment matrix caused by human factors becomes larger and larger; conversely, the difference between the consistency and full consistency of the judgment matrix caused by human factors becomes smaller and smaller. The judgment matrix whose order does not reach 3 has perfect consistency. As shown in Equation (10), the consistency ratio CR (Consistency Ratio) is the ratio of CI to RI of the same order.

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

If CR<0.10, the consistency of the judgment matrix is considered to be within an acceptable range; if CR≥0.10, adjustments and modifications should be made to the judgment matrix to make it have acceptable consistency, i.e., the condition of CR<0.10 is satisfied. The total hierarchical ranking is the process of determining the weighting of all criteria to the total target, and this process is carried out sequentially from the highest to the lowest level. The weight of the lower-level criterion to the target level is the product of the weight of the criterion to the upper level criterion and the weight of the upper level criterion to the target level, and for the highest level criterion, the result of the single ranking of the hierarchy is the result of the total ranking. As an example, suppose the weight of criterion 11 on criterion 1 is a1 and the weight of criterion 1 on the target layer is b1, then the weight of criterion 11 on the target layer is b1 multiplied by a1.

The important idea of determining the attribute X1, X2, ... Xn weights $w = (w1, w2, \dots, wn)$ using the information entropy method is that the column vector of the normalized matrix R ($r1j, \dots, rmj$) as a distribution of information quantities. In this way, the entropy Ej of the attribute Xj can be defined by equation (11):

$$E_j = -\frac{1}{\ln m} \sum_{i=1}^{m} r_{ij} \ln r_{ij} \tag{11}$$

From the normalization of matrix R and equation (2-11), it is easy to know that 0 ≤ Ej ≤ 1 and Ej = 0 only when there is rij = 1 and Ej = 1 when (r1j, ..., rmj) = (1m, ..., 1m). it can be seen that the more consistent rj is, the more Ej converges to 1, the lower the differentiation of different data in that attribute, and the differentiation of attribute Xj for data Fj is shown in equation (12):

$$F_j = 1 - E_j \tag{12}$$

4 EXPERIMENTAL RESULTS AND ANALYSIS

4.1 Simulation Experiments and Results

First, the experimental environment is set up, and after setting up the experimental environment, the data processing speed of different digital media resource management systems is tested when different numbers of users (100, 200, 500, 1,000, 1,500, 3,000, 5,000, 8,000) access the digital media resource management system. The comparison results of data processing speed using this paper system, traditional digital media resource management system1 and 2 are shown in Figure 3.

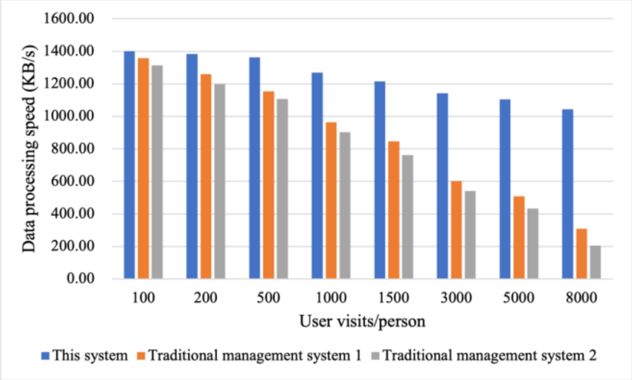

Figure 3: Data processing speed comparison results.

As can be seen from Figure 3, there is no significant difference in the data processing speed of the three digital media resource management systems when the number of user accesses is 100. However, for the system in this paper, the data processing speed does not decrease significantly with the increase of user access because it is based on IoT technology and uses embedded microprocessors to process data.

4.2 Analysis of Operation Time and Operation Results

The time complexity of both index evaluation criteria mentioned in this study is O(n), and it is not possible to compare the time consumption of the two solutions directly from the time complexity. The calculation time of single data is very small and cannot reflect the difference in time consumption of the two schemes, so it is necessary to judge their advantages and disadvantages in time consumption after calculating a large amount of data. Since the real data could not meet the demand of data volume, the experimental data used artificially generated random numbers whose format was kept consistent with the real data. In order to fully reflect the difference in running time between the two schemes, the amount of experimental data is set to [1000, 2000, 5000, 10000, 20000]. This is shown in Figure 4.

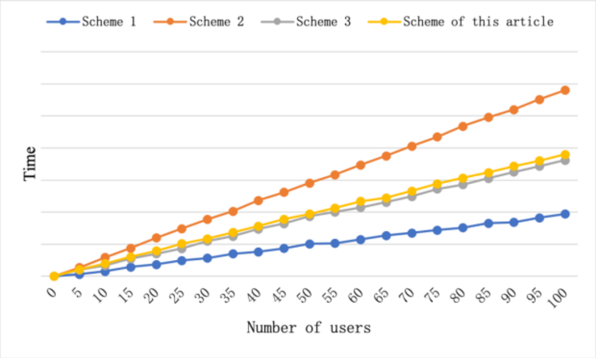

Figure 4: Comparison of total execution time of different schemes.

After repeated experiments to take the average value, the relationship between the running time of the two schemes and the amount of experimental data is shown in Figure 4. As can be seen, scenario 1 is significantly less time consuming than scenario 2, however, two points need to be noted here. First, when the integrated network management system is running, the operating data of network elements are collected every 15 minutes (or longer); and, at present, the actual amount of data will not be as huge as in the experiment. That is, both solutions actually take milliseconds to run in the system, and although there is a difference between the two, the impact on the overall system performance is minimal, and the difference is not strong enough to be a strong decision for solution selection.

The purpose of the quality assessment function is to reflect the operational quality profile of the subnet through the operational data of the network element devices in the subnet collected at each time interval. Therefore, in this paper, we verify whether the assessment of network operation quality is correct by the number of alarms generated by the subnets during one collection time, and it is obvious that the more alarms generated, the worse the operation quality of the subnets. Figure 5 shows the evaluation results of the two schemes. It can be seen that the results obtained in Scenario 2 are more evenly distributed than those in Scenario 1, especially the percentage of subnets evaluated as "poor" differs significantly. This is because in practice, the abnormal operation condition of subnets is usually for individual network elements, so the overall operation quality is evaluated by the average value of all network elements' operation indexes, while the evaluation result of Scheme 2 is based on the distance from the cluster center, and when the distance between the average value of indexes and the center corresponding to "poor" is smallest, the index evaluation result is "poor". The result is "poor".

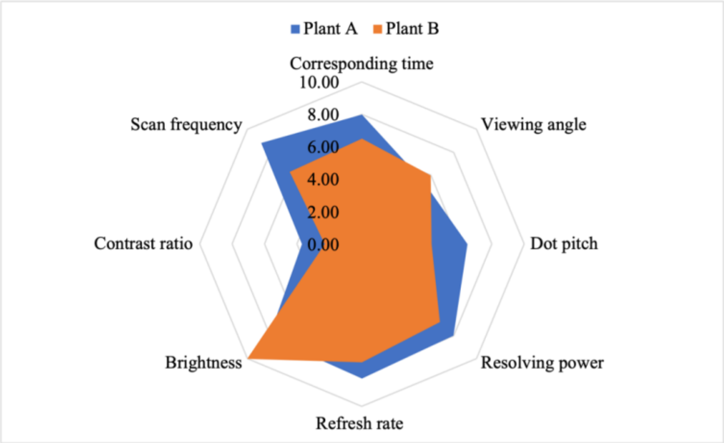

Figure 5: Operational results.

Figure 6 shows the number of subnets that generate alarms in each result when generating evaluation results for both scenarios. The proportion of alert-generating subnets in each result when generating evaluation results, i.e., the number of alert-generating subnets in an evaluation result divided by the total number of subnets in that result. The average number of alarms generated by subnets in each result. The combination shows that the number of subnets evaluated as "poor" in Scenario 1 is small, but 100% of the subnets evaluated as "poor" generate alarms, and the average number of alarms generated is high, while the subnets evaluated as "average" generate alarms. Only a very small number of alarms are generated by the subnets evaluated as "good", and there are no alarms in the subnets evaluated as "excellent"; the subnets evaluated as "poor" in Option 2 have more alarms. "There are more subnets with "poor" evaluation in Option 2, 93.2% of which generate alarms, and the average number of alarms generated is not as high as that of Option 1. No alarms were generated in the "good" and "excellent" subnets.

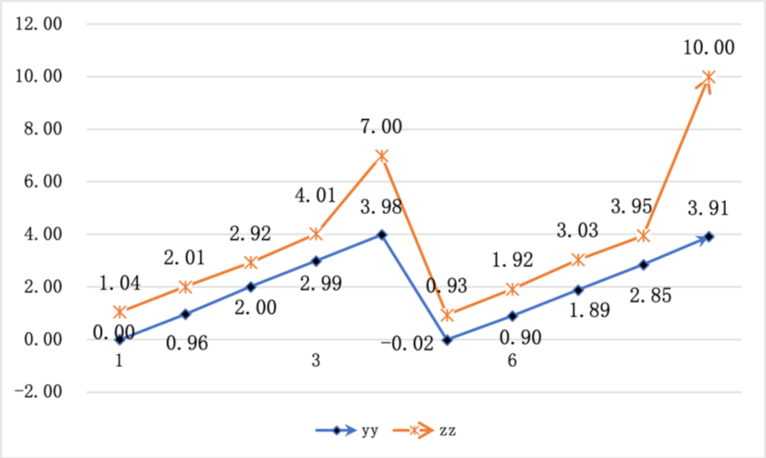

Figure 6: Number of subnets generating alarms by evaluation level.

It is clear from the comparison that the condition of "poor" in Scenario 1 is not easy to achieve, resulting in many subnets with more serious faults being classified as "average", which is best illustrated by the fact that most alarms in Scenario 1 are in subnets rated as "average" while most alarms in Scenario 2 are in subnets rated as "poor". "This is also the reason why the average number of alarms generated by the subnets in the "average" evaluation of Scenario 1 and the percentage of subnets generating alarms in Scenario 2 are not significant. This is the reason why the average number of alarms and the proportion of alarms generated by the subnets in the "general" evaluation of Scenario 1 are higher than those in Scenario 2. Combined with the development of evaluation criteria, the results obtained in Scenario 2 are basically consistent with the meaning of each level in the development of evaluation criteria, which indicates that the quality assessment results are correct and reasonable. Therefore, the system adopts Option 2 mentioned in Section 4.3 as the evaluation criteria of the operation index when implementing the network operation quality assessment. The final quality assessment process is that, according to the evaluation criteria obtained from the clustering division, the scoring of each indicator of the data to be evaluated is then combined with the indicator weights to calculate the total evaluation score and compare it with the final evaluation results.

4.3 Comparison of Ratios for Configuring Databases

The current database is dominated by relational databases. But in order to keep up with the fashion, major databases are also developing object-oriented relational database. Seamless connection between advanced programming languages and databases to leverage their respective strengths and weaknesses. Advanced programming languages are good at describing complex processes, while databases have powerful management functions and operability. Our current database is based on tables as the basic storage unit (describing an object), but with the rapid development, the complexity of data is also increasing. So, our two-dimensional database needs to shift towards the development of three-dimensional databases. OLEDB (Object Linking and Embedding, Database, also known as OLE DB or OLE-DB), a COM-based data storage object, provides access to all types of data, even offline. There are two ways to upload files by HTTP: componentless upload and component upload. Componentless uploads are slow, limited by memory size, file size, memory consuming, and write the file to the database in binary form. Component uploads are fast, consume less memory, and write the files to the server's hard drive as is.

Since IIS6 limits the file upload size to 200KB by default, this default setting needs to be changed. Solution: First check "Allow direct editing of configuration database" in IIS properties, as in Figure 7, then find the metabase.XML in XX:\Windows\System32\Inetsrv (XX stands for system disk) and modify Asp Max Request Entity Allowed=204800(200KB), change 204800 to the maximum upload file size, such as 204800000 (200MB). When the file upload limit has been changed to 200MB and the uploaded file is larger than 4MB, an error is reported: "Find the metabase. XML in XX:\Windows\System32\Inetsrv and modify Asp Buffering Limit="4194304"(4MB).

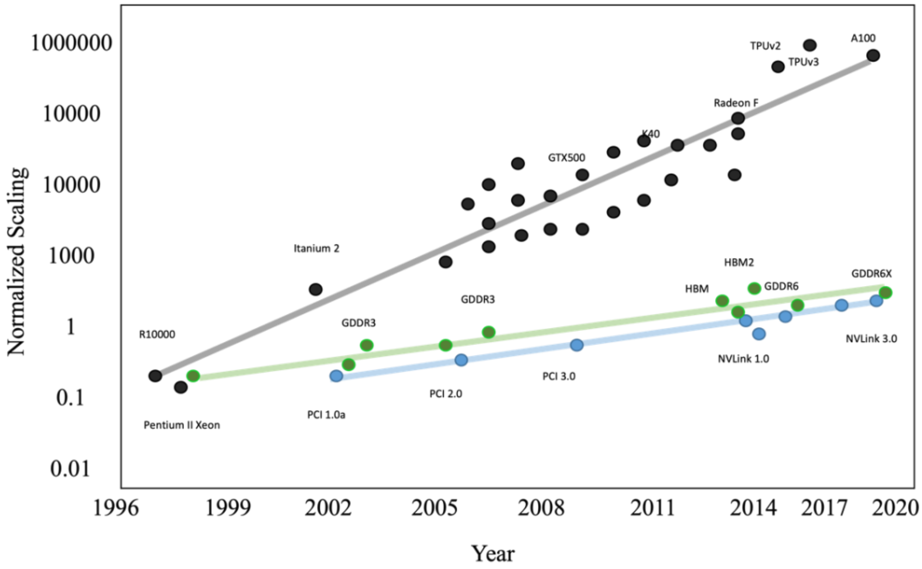

Figure 7: Comparison of the rate of editing configuration database in different times.

The actual application results in Figure 7 show that the component works stably and efficiently. The value of the parameter SizeThreshold is critical, as setting it too high will take up too much memory, and setting it too low will sacrifice performance by frequently using the hard disk as a buffer. Therefore, the value should be set according to the distribution of file sizes uploaded by users. The above is only for a single file upload, if there are multiple files you can call this upload process multiple times. From the above two methods we can see that uploading multiple files using ftp protocol is relatively simple and easy to implement. Uploading files by ftp protocol is usually a client-side program with complicated security settings on the server side, while uploading files by http protocol is a server-side application with relatively simple security settings. And through testing, we found that the ftp upload method is dozens or even hundreds of times faster than the http upload method when transferring large files, but slightly slower than the http upload method when transferring files smaller than 1MB.

5 CONCLUSION

When the number of user visits increases, there is a problem of slow data processing speed. For this reason, we designed a digital media resource management system based on IoT technology, applied data mining technology to evaluate the indicators of network operation, combined with hierarchical analysis and other related knowledge to build a network operation quality assessment system, and verified the rationality of the quality assessment system through experiments .How to discover the relationship between various interface data and network operation quality and apply it to the construction of the quality assessment system is the key to further improve the correctness of the assessment results.

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REFERENCES

[1] Akasiadis, C.; Pitsilis, V.; Spyropoulos, C.-D.: A multi-protocol IoT platform based on open-source frameworks, Sensors, 19(19), 2019, 4217. https://doi.org/10.3390/s19194217
[2] Anwar, K.: The perception of using technology canva application as a media for english teacher creating media virtual teaching and english learning in loei thailand, Journal of English Teaching, Literature, and Applied Linguistics, 5(1), 2021, 62-69. http://dx.doi.org/10.30587/jetlal.v5i1.2253
[3] Bakkouri, I.; Afdel, K.: Computer-aided diagnosis (CAD) system based on multi-layer feature fusion network for skin lesion recognition in dermoscopy images, Multimedia Tools and Applications, 79(29-30), 2020, 20483-20518. https://doi.org/10.1007/s11042-019-07988-1
[4] Gao, J.; Jiang, Q.; Zhou, B.; Chen, D.: Convolutional neural networks for computer-aided detection or diagnosis in medical image analysis: An overview, Mathematical Biosciences and Engineering, 16(6), 2019, 6536-6561. https://doi.org/10.3934/mbe.2019326
[5] Gao, Q.; Guo, S.; Liu, X.; Manogaran, G.; Chilamkurti, N.; Kadry, S.: Simulation analysis of supply chain risk management system based on IoT information platform, Enterprise Information Systems, 14(9-10), 2020, 1354-1378. https://doi.org/10.1080/17517575.2019.1644671
[6] Girau, R.; Anedda, M.; Fadda, M.; Farina, M.; Floris, A.; Sole, M.; Giusto, D.: Coastal monitoring system based on social Internet of Things platform, IEEE Internet of Things Journal, 7(2), 2020, 1260-1272. https://doi.org/10.1109/JIOT.2019.2954202
[7] Jong, W.-R.; Huang, Y.-M.; Lin, Y.-Z.; Chen, S.-C.; Chen, Y.-W.: Integrating Taguchi method and artificial neural network to explore machine learning of computer aided engineering, Journal of the Chinese Institute of Engineers, 43(4), 2020, 346-356. https://doi.org/10.1080/02533839.2019.1708804
[8] Kadhim, K.-T.; Alsahlany, A.-M.; Wadi, S.-M.; Kadhum, H.-T.: An overview of patient's health status monitoring system based on internet of things (IoT), Wireless Personal Communications, 114(3), 2020, 2235-2262. https://doi.org/10.1007/s11277-020-07474-0
[9] Li, H.; Zhang, H.; Zhao, Y.: Design of computer-aided teaching network management system for college physical education, Computer-Aided Design and Applications, 18(S4), 2021, 152-162. https://doi.org/10.14733/cadaps.2021.S4.152-162
[10] Li, W.: Design of smart campus management system based on internet of things technology, Journal of Intelligent & Fuzzy Systems, 40(2), 2021, 3159-3168. https://doi.org/10.3233/JIFS-189354
[11] Ma, K.; Mao, Z.; He, D.; Zhang, Y.: Design a network architectural teaching system by auto CAD, Computer-Aided Design and Applications, 17(S2), 2020, 1-10. https://doi.org/10.14733/cadaps.2020.S2.1-10
[12] Marion, T.-J.; Fixson, S.-K.: The transformation of the innovation process: How digital tools are changing work, collaboration, and organizations in new product development, Journal of Product Innovation Management, 38(1), 2021, 192-215. https://doi.org/10.1111/jpim.12547
[13] Shi, Y.; Zhao, Z.: Computer-aided software development and application in physical education in colleges and universities, Computer-Aided Design & Applications, 19(6), 2021, 59-69. https://doi.org/10.14733/cadaps.2022.S1.59-69

[14] Tambe, P.; Cappelli, P.; Yakubovich, V.: Artificial intelligence in human resources management: Challenges and a path forward, California Management Review, 61(4), 2019, 15-42. https://doi.org/10.1177/00081256198679

[15] Zhang, C.; Yao, W.; Yang, Y.; Huang, R.; Mostafavi, A.: Semiautomated social media analytics for sensing societal impacts due to community disruptions during disasters, Computer-Aided Civil and Infrastructure Engineering, 35(12), 2020, 1331-1348. https://doi.org/10.1111/mice.12576