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Analysis of the Development Trend of Virtualization Technology Based on CiteSpace and VOSviewer

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Abstract: *The purpose of this paper is to comprehensively analyze the development trend of virtualization technology. By systematically combing 3202 relevant academic journal literatures published on CNKI from 2012 to now, this paper reveals the research trajectory, current situation and future trend of virtualization technology. It is found that virtualization technology has become the core support of cloud computing services, which promotes the support of cloud computing platform for a variety of operating systems, applications and development environments. The future virtualization operating system is expected to be highly distributed, enterprise-class direction.*

Keywords: *Virtualization Technology, Aituation Analysis, Data Visualization, Bibliometrics*

1. Introduction

With the rapid development of information technology, virtualization technology, as the cornerstone of cloud computing services, is gradually becoming a key force to promote digital transformation. Virtualization technology realizes the optimization and efficient utilization of computer resources by means of resource pooling and dynamic adjustment, and provides rich cloud service options for cloud computing platforms. In recent years, with the rapid rise of cloud computing technology, the demand for efficient use of computing resources is increasing. Virtualization technology has developed rapidly and has gradually developed into a comprehensive operating system.

This paper will make an in-depth analysis of the development trend of virtualization technology, and reveal the research trajectory, current situation and future trend of virtualization technology by systematically combing the relevant academic journal literature. Studying the development trend of virtualization technology not only helps us to better understand the current situation of this frontier technology field, but also provides a useful reference for future technology development and application scenarios. At the same time, this paper will also discuss the challenges faced by virtualization technology, such as security performance issues, and put forward suggestions to strengthen technological innovation and personnel training, with a view to contributing to the diversified development of virtualization technology.

2. Research Background and Significance

Virtualization technology is to virtualize a computer into multiple logical computers through virtualization technology, and run multiple logical computers on a computer at the same time. At the same time, each logical computer can run different operating systems, and applications can run in separate spaces without affecting each other, thereby improving the efficiency of the computer. Virtualization technology breaks through the limitation that physical resources cannot be cut, so as to realize the management of resources.

2.1. Study on the Background

In 1959, Christopher published an academic report called " Time Sharing in Large High-Speed Computers, " in which he proposed the basic concept of virtualization. The earliest implementation of virtualization on commercial systems is IBM 's IBM7044 released in 1965. It allows users to run multiple operating systems on a single host, allowing users to make full use of expensive mainframe resources as much as possible. In 1999, VMware introduced commercial virtualization software that can run smoothly on the X86 platform, and virtualization technology finally came to the world of PC servers. From 2006 to now, virtualization technology has entered a period of rapid growth. Many manufacturers have sprung

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up, new technologies and application forms have emerged, and virtualization technology has continued to develop.

2.2. Research Significance

Enhance the productivity of enterprises. Virtualization technology realizes flexible scheduling and efficient utilization of resources by abstracting physical hardware resources into logical resources. Enterprises can dynamically allocate computing power, storage space and network resources according to actual needs, without purchasing a large number of expensive hardware devices for specific tasks, which greatly reduces the hardware cost of enterprises.

Improve resource utilization. Virtualization technology can support the dynamic sharing of physical resources and resource pools, centralize the management of scattered physical resources, and achieve dynamic balance and efficient reuse of resources.

Promoting the diversification of cloud computing services provides a guarantee for the security and reliability of cloud computing. Through virtualization technology, cloud computing platforms can support a variety of operating systems, applications, and development environments, providing a wealth of cloud service options, including IaaS, PaaS, SaaS, FaaS, CaaS, and more.

The future virtual operating system should be a highly distributed, enterprise-class operating system. The development of virtualization technology will have a positive impact on promoting the development of related industries and society.

3. Research Design and Methods

3.1. Selection of Research Objects

The research object of this paper covers the academic journal literature on virtualization technology published in CNKI from 2012 to the present, with a total of 3202 articles. This paper aims to reveal the development track, current situation and future trend of virtualization technology research. In addition, combined with the relevant data in the Web of Science database, a total of 4281 articles were included. This study further broadens the international perspective of analysis and strives to fully grasp the global research trends and hot topics in this field. Through the detailed analysis and interpretation of the above data, this paper hopes to clearly point out the key issues, main challenges and potential innovation directions in the research of virtualization technology, and provide valuable reference information for academia and industry.

3.2. Data Sources and Preprocessing

This paper takes the journal literature included in CNKI database as the retrieval data source, and carries out the retrieval strategy design. The search strategy mainly includes : the subject search term is set to ' virtualization technology ', the language is set to ' Chinese ', the journal source is set to ' all journals ', and the journal publication year range is set to ' 2012-2024 '.

3.3. Research Approach

3.3.1. ResearchTechnical Route

In this paper, we use two authoritative databases of CNKI and Web of Science for data collection. These two databases cover a wide range of academic journals, with high comprehensiveness, professionalism and authority. The quality of data is excellent, which has a high reference value for the research of virtual technology. In terms of data preprocessing, we use Pandas and jieba tools. In order to conduct an in-depth analysis of the collected literature, we selected two literature visualization tools, VOSviewer and CiteSpace.

According to Figure 1, the main research topics and objectives are the analysis of the development trend in the field of virtualization technology. In the data preprocessing stage, we mainly use the Pandas library in Python to clean and organize the collected data. Pandas is used to clean, transform and standardize the data, remove duplicate and irrelevant information, delete duplicate values, deal with missing values, detect outliers, etc., and convert the data into the required format. Support data type conversion, feature scaling, coding classification variables and other operations. At the same time, this

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paper uses PyCharm 's jieba library for Chinese text segmentation. In the process of visual analysis using VOSviewer and CiteSpace, the data after data preprocessing is used to generate the required visual map and interpret the analysis by adjusting the parameters and setting the screening conditions, and the extracted information and insights are transformed into specific suggestions and conclusions.

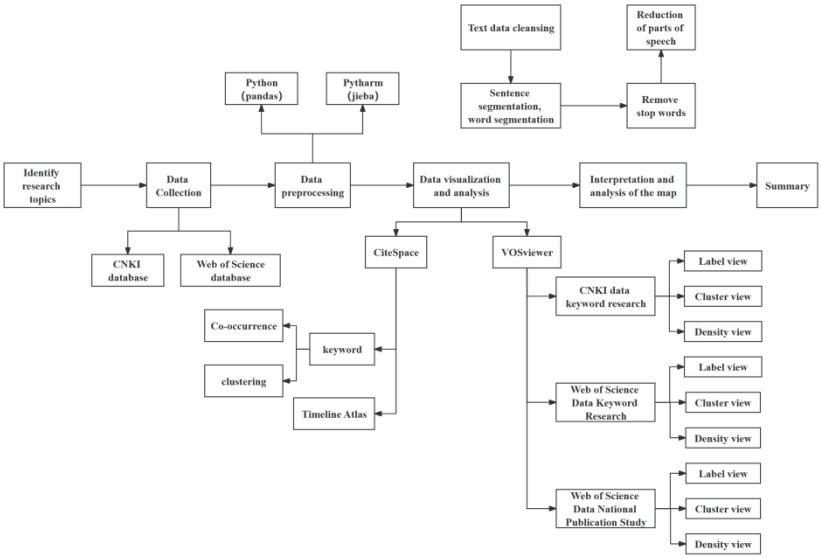

Figure 1: Research approach

3.3.2. Thesis Framework

The overall research framework of this paper is shown in Figure 2:

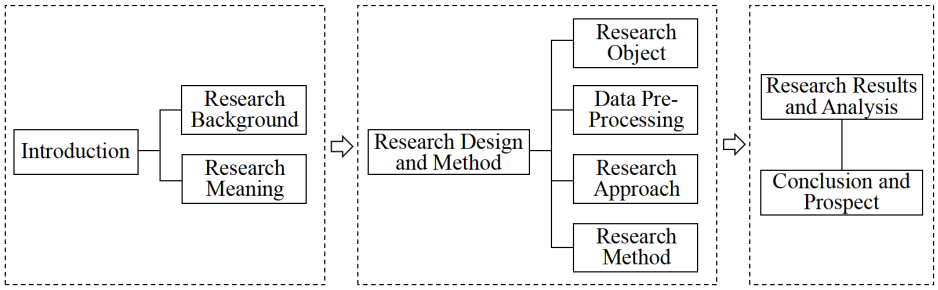

Figure 2: Thesis framework

3.4. Research Method

3.4.1. Literature Research

The literature research method, as an important scientific research method, is a process in which researchers systematically collect, screen, analyze and interpret relevant literature in order to form a scientific cognition of specific research topics. The core of the literature research method is to use the existing knowledge achievements of the predecessors, through the combing and integration of the literature, construct the theoretical framework, find the problem context, verify or refute the hypothesis, and provide the theoretical basis and empirical support for the new research.

3.4.2. Empirical Analysis

The empirical analysis method refers to the exclusion of subjective value judgments, only objective analysis of economic phenomena, economic behavior or economic activities and their development trends, only considering the laws of mutual connection between economic things, and according to these laws to analyze and predict the effect of people 's economic behavior.

3.4.3. Statistical Analysis

Statistical analysis refers to the use of statistical methods and knowledge related to the analysis of the object, from the combination of quantitative and qualitative research activities. It is a very important

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work after statistical design, statistical investigation and statistical collation. It is based on the analysis of the previous stages of work to achieve a deeper understanding of the research object.

3.4.4. Visual Analysis

Visual analysis is a kind of analysis method, which is mainly used in massive data association analysis. It can assist manual operation to carry out data association analysis and make a complete analysis chart. This approach allows analysts to extract useful information and insights from large amounts of data using the human visual system 's ability to quickly identify graphics and patterns.

4. Research Results and Analysis

Studying the hot topics in a certain subject area can help researchers reveal the key issues and research focuses in the subject area, so as to better allocate research resources, grasp the development direction, optimize research strategies, and promote the progress of the subject [1]. This article will analyze the hot research in the field of virtualization technology, and deeply study its field hotspots and future development trends.

4.1. Keyword Frequency, Density Analysis

4.1.1. Using VOSviewer for Keyword Density Analysis.

Figure 3: CNKI data VOSviewer keyword research-density view

In Figure 3, the density of keywords is represented by different color shades. The keywords in the figure include ' cloud computing ', ' server ', ' hyper-v ', ' data center ' and so on. Among them, ' cloud computing ' provides powerful computing power and storage resources for virtualization technology. Through the cloud computing platform, users can obtain the required computing resources on demand, so as to achieve efficient resource allocation and utilization.

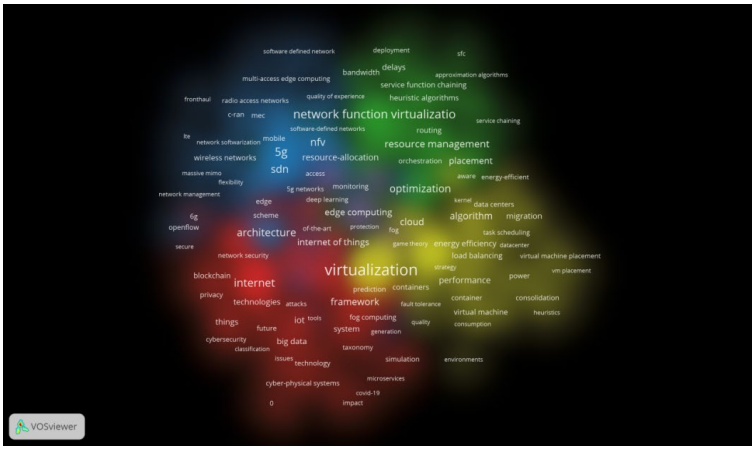

Figure 4: Web of science data VOSviewer keyword research-density view

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In Figure 4, different color blocks represent the density and importance of keywords. The red region centered on ' internet ' and the orange region centered on ' virtualization ' have higher keyword density, indicating that these words are more important in the graph and may be the core concept or theme in the current field ; the green area centered on ' network function virtualization ' and the blue area centered on ' 5g ' have lower keyword density, indicating that these words are related to the concepts or sub-themes associated with the central area, or some secondary or marginal topics.

4.2. Keyword Co-occurrence Analysis

Keyword co-occurrence analysis is used to discover the co-occurrence relationship between keywords in the research literature, and to reveal the degree of association between these keywords by quantitatively analyzing the frequency and location of keywords in the literature. In the keyword co-occurrence map, the number of nodes N is 220, and the number of links between keywords E is 188.

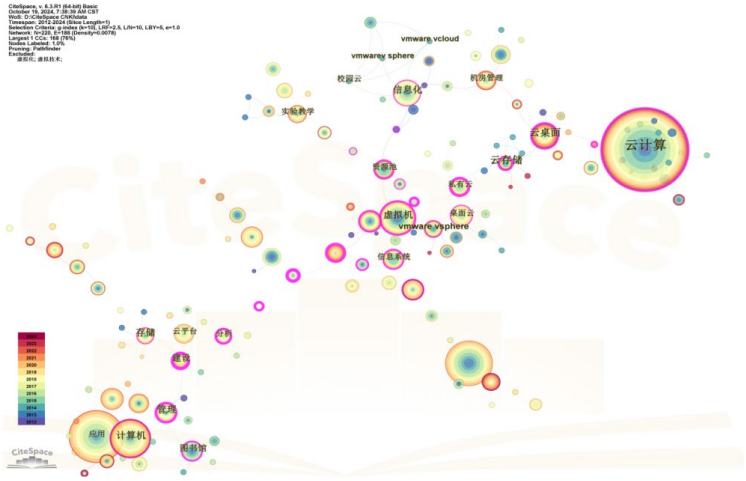

Figure 5: CNKI keyword co-occurrence map

In Figure 5, nodes with high centrality usually represent the core position or important influence of the keyword in the research field. From the perspective of centrality, the cloud desktop has the highest centrality, indicating that it has significant influence and importance in the field of virtualization technology. As an important application direction of virtualization technology, cloud desktop is a desktop virtualization solution based on cloud computing technology. It transfers the traditional desktop environment to the cloud server, and users can access and use their virtual desktop remotely through any terminal device. The centrality of virtual machines, cloud computing, and servers is 0.23, 0.21, and 0.19, respectively, indicating that they are also at the core of virtualization technology. The centrality of keywords such as data center, big data and application is relatively low, but it still reflects their influence in the field of virtualization technology to a certain extent.

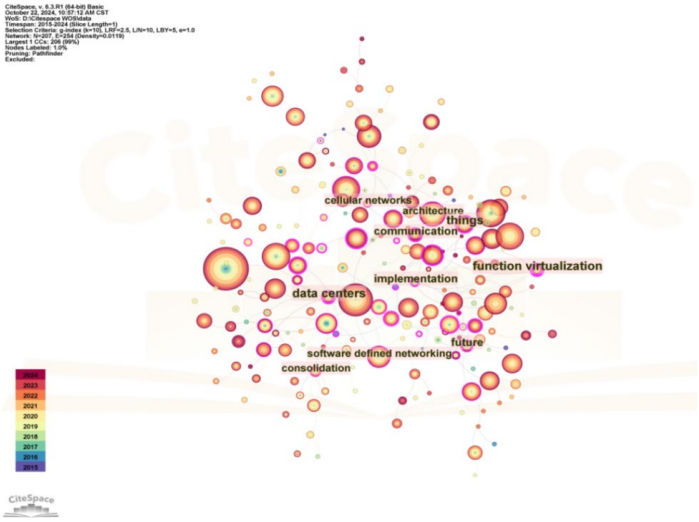

Figure 6: WOS keyword co-occurrence map

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In Figure 6, the field of virtualization technology developed rapidly in China in 2012 and received extensive attention abroad in 2015. During this period, virtualization technology has become a hot topic in the IT field. Major IT vendors such as VMware and Microsoft have launched their own virtualization products and solutions. At that time, the rapid rise of cloud computing technology and the increasing demand for efficient use of computing resources by enterprises promoted the great development of virtualization technology, making resources such as servers and storage more flexible to manage and optimize.

4.3. Keyword Cluster Analysis

Keyword clustering analysis is a commonly used text mining method, which is used to classify and organize keywords in a large number of text data to reveal their associations and patterns. In this paper, the keyword cluster analysis diagram is obtained by CiteSpace, and similar keywords are merged into the same cluster.

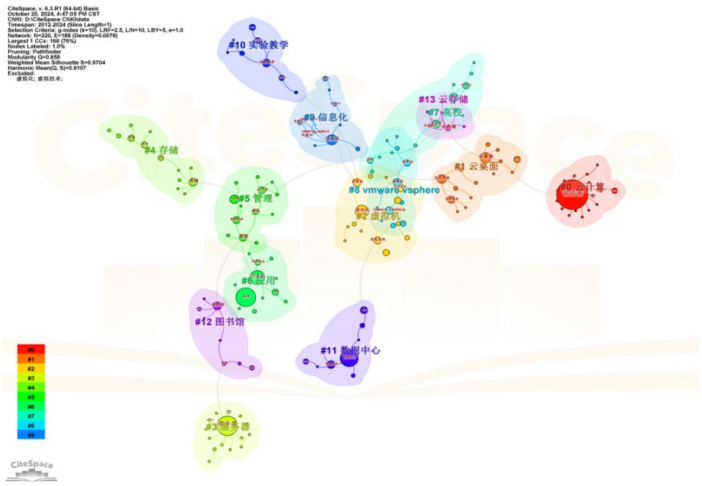

Figure 7: CNKI data keyword clustering diagram

The keywords in the keyword clustering graph are clustered into 69 categories. In order to ensure the clarity of the map, this paper only selects the first 13 representative clusters. From Figure 7, we can see that the keywords are clustered into 13 categories, namely, cloud computing, cloud desktop, virtual machine, server, storage, management, application, university, vmware vsphere, informatization, experimental teaching, data center, library, cloud storage. It can be seen from the figure that the Q value = 0.858 > 0.4, indicating that the clustering structure is significant and the clustering effect is good. The S value = 0.9704 > 0.7, indicating that the higher the similarity between the keywords in the clustering, the clustering results are convincing.

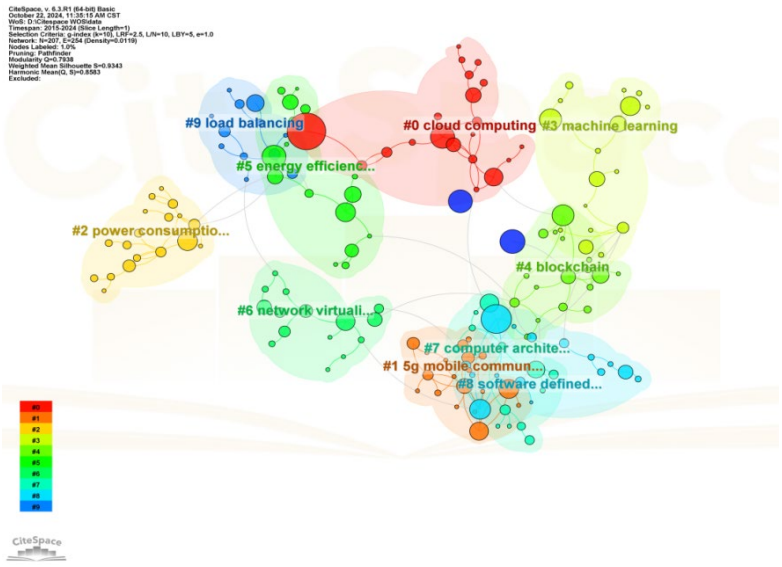

Figure 8: WOS data keyword clustering diagram

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In Figure 8, the keywords of web of science data are clustered. In order to ensure the clarity of the map, only the first 10 representative clusters are selected. From the figure, the keywords are clustered into 10 categories, which are cloud computing, 5g mobile communication, software defined networking, software defined networking, etc. It can be seen from the figure that the Q value = 0.7938 > 0.4, indicating that the clustering structure is significant and the clustering effect is good. The S value = 0.9343 > 0.7, indicating that the higher the similarity between the keywords in the clustering, the clustering results are convincing.

4.4. Keyword Timeline Analysis

Keyword timeline map is a visualization tool that integrates time factors into keyword cluster analysis. It can intuitively show the emergence, development and change of keywords in different time periods. In this paper, CiteSpace is used to visually analyze the time zone distribution of keywords, and the time line map of keywords is obtained.

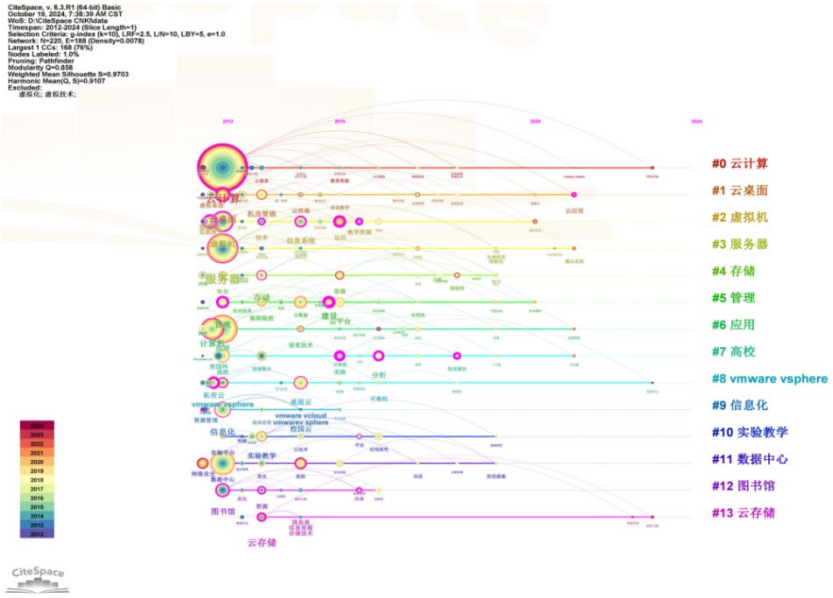

Figure 9: CNKI keyword timeline map

It can be seen from Figure 9 that the duration and keywords of each cluster are different. The high-frequency keywords are mainly concentrated in # 0, # 2 and # 5 clusters, while cloud computing, vmware vsphere, and cloud storage last for a long time, which means that these keywords have a high frequency and influence in the research process of virtualization technology.

Most of the keywords appeared in 2012. Among them, cloud computing occupies an important position in the graph, indicating that virtualization technology is widely used in cloud computing. Cloud computing relies on virtualization technology to achieve resource pooling and flexible management ; keywords such as cloud desktop, virtual machine and server are closely related, which together constitute the core part of virtualization technology, and these technologies continue to develop over time, reflecting the continuous progress of virtualization technology in computing resources and environment. Universities, experimental teaching and libraries were high-frequency keywords in 2012, reflecting the application of virtualization technology in education and academic fields. The keyword of hospital suddenly appeared in 2014 and became a hot topic, indicating that virtualization technology has been applied in the hospital field, such as medical information system virtualization, medical training and simulation. Cloud storage appeared in 2013, and the research time continues to this day. Information sharing and network storage in 2023 may become the focus of future research in the field of virtualization technology.

4.5. Topic Model Analysis - LDA

This paper reads the text data in the field of virtualization technology, performs Chinese word segmentation and preprocessing, then uses the LDA model for topic analysis, and finally outputs the feature words of each topic and the topic distribution of each document, which is used to explore and

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understand the main topics and trends in the field of virtualization technology.

First, the text data in the field of virtualization technology stored in the Excel file is read through the pandas library. Then preprocess, use jieba for Chinese word segmentation, remove stop words and short words, and only retain nouns, proper nouns and noun verbs. Perform feature extraction, convert the segmented text into a word frequency matrix, and filter important feature words. CountVectorizer is used to convert the preprocessed text data into a word frequency matrix (TF). The LDA model is trained, and the latent Dirichlet allocation (LDA) method is used to model the topic of the word frequency matrix and set the number of topics. The feature words of each topic are output to determine the topic distribution of each document, that is, the probability of each document on each topic.Through text preprocessing, feature extraction and LDA model training, this process finally obtains the main topics in the field of virtualization technology and the topic distribution of each document. Topic # 0 : experimental teaching and university computer environment, Topic # 1 : server resource management and enterprise data center, Topic # 0 : system architecture design and performance optimization, Topic # 3 : data center development trend and research, Topic # 4 : university information construction and digital campus, Topic # 5 : computer technology and social development, Topic # 6 : hospital information and intelligent medical care, Topic # 7 : network security and physical security management, Topic # 8 : university computer room management and solutions.

5. Conclusion and Foresight

5.1. Technical Trends

From the perspective of keyword analysis, cloud computing, servers, data centers, etc.are the core keywords in the field of virtualization technology, and over time, these technologies have shown a trend of continuous integration and development. Virtualization technology is gradually developing into a comprehensive operating system, and its future development direction will be a highly distributed, enterprise-class operating system [2].

5.2. Diversity of Application Scenarios

From the perspective of discipline distribution, virtualization technology takes the computer field as the core, and has penetrated in more than 20 fields such as education, medical care, and finance. It provides customized and industrial solutions for the development of different industries and meets the special needs of various industries. At the same time, virtualization technology plays an important role in enterprise IT architecture. From data center optimization, business continuity assurance to cloud service provision, the application scenarios are increasingly rich [3]. With the changing needs of users, virtualization technology is also showing a trend to a more subdivided and more professional direction.

5.3. Safety Performance Faces Challenges

Security isolation, data protection, access control and other issues in virtualization environment have become increasingly prominent. In order to cope with these challenges, more efficient security isolation technologies need to be developed. At the same time, it is also necessary to strengthen the data protection, access control and audit mechanisms in the virtualized environment to improve the overall security of the virtualized system. In terms of performance, with the continuous expansion of virtualization scale, performance bottlenecks, resource scheduling, fault recovery and other issues are becoming more and more complex. In order to optimize performance, it is necessary to study efficient resource scheduling algorithms to improve the resource utilization and performance of virtualization systems [4].

5.4. Strengthen Technological Innovation and Personnel Training

In view of the current development bottleneck of virtualization technology, we should increase investment in R & D in the field of key technologies, and strive to achieve new breakthroughs in core technologies [5]. The field should strengthen the training and introduction of virtualization technology talents, and cultivate talents with virtualization technology innovation ability.

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