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Research Article

Intelligent Development of Enterprise Management Innovation Based on Artificial Neural Network

Jintao Wu[1,2] **and Xinlong Ding**[3]

[1]*Department of Economic and Social Management, Maanshan Teacher's College, Maanshan, Anhui, China*
[2]*Graduate School, Lyceum of the Philippines University, Cavite, Philippines*
[3]*School of Electrical and Information Engineering, Anhui University of Technology, Maanshan, Anhui, China*

Correspondence should be addressed to Jintao Wu; jintao.wu@lpunetwork.edu.ph

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Artificial intelligence technology is gradually entering all aspects of our lives while also promoting the development of various fields. Artificial intelligence can also solve problems that could not be solved by computing before. This paper combines artificial intelligence and network function virtualization, two very advanced and popular technologies in modern society, and uses neural networks to solve and develop the service chain problem in network function virtualization. The simulation shows that all algorithms almost decrease linearly with the change of VNR. This decrease means that there is no noise. The optimal mapping of each VNE problem can be achieved within the scope of the existing solutions, and the heuristic method is to try to find possible mappings. In terms of enterprise management innovation, this article points out the need to strengthen in-depth cooperation and exchanges between universities and enterprises. At the same time, the government, as a third party in cooperation, should play an active leadership role and an intermediary coordination role. In terms of innovation management cooperation, the establishment and improvement of government plans and policy support mechanisms are important external driving factors.

1. Introduction

China's economic and social leaps and progress are closely linked to the development of manufacturing. Regarding the improvement of the innovation capability of enterprises, the current theoretical research lags behind actual needs, which has a negative impact on the development of my country's manufacturing industry. On the one hand, advanced equipment and technology promote the progress of the manufacturing industry. In terms of introducing management methods and innovative management methods, many manufacturing companies in China are also facing management problems related to back management methods and rigid management methods. The research on innovation in the business sector is relatively mature, while business management innovation, especially the research on innovative methods of production methods, is still in its initial stage, and manufacturing companies lack the necessary theoretical support and guidance. The emergence of network function virtualization technology provides operators with new ideas [1]. In order to solve the above problems, this technology uses software to realize the functions originally performed by proprietary devices and converts network requests into an orderly arrangement of multiple virtual network functions. Compared with the existing system, the performance of this system is significantly improved [2, 3]. Artificial intelligence technology is gradually entering all aspects of our lives while also promoting the development of various fields. Artificial intelligence can also solve problems that could not be solved by computing before [4]. As a typical artificial intelligence method, an artificial neural network (ANN) constructs a set of nonlinear signal processing systems [5]. In order to solve some large and complex problems of the biological neural system, the simulation of the nonlinear system not only greatly improves the time cost but also has good parallel processing ability.

2. Related Work

The results of NFV system research include many indicators. The literature proposes to establish a hybrid linear model to determine the total energy consumption of a minimum server, router ports, repeaters, optical cable amplifiers, switches, etc. [6]. It constantly searches for the optimal solution and adds a taboo list to ensure that the resource results are working towards the best solution so as to achieve better resource utilization. A key feedback of a closed-loop algorithm is proposed, which uses the reflection of the main topology of the mapping to jointly improve the deployment of NFV and finally achieve the idea of saving bandwidth [7]. Similarly, some research also pointed out two protection measures to ensure the safety of the system. The creation of better scheduling plans to update the original transportation delay problem and points out the current research direction [8]. The virtualization of network functions is not limited to a single network but can also be used in large-scale data centers, optical networks, and other network environments, and related research continues. In the current popular neural network technology, this method is used to simulate the working principle of biological neurons, and a set of high-performance computer models is established [9]. In recent years, the neural network model has been continuously improved and used to deal with various complex problems. The current classic neural networks include the recurrent neural network (RNN), convolutional neural network (CNN), deep neural network (DNN), and others. Due to its response system, RNN is mainly used to solve timing or correlation problems [10]. It is recommended to use the time series characteristics of the recurrent neural network to judge the weather.

Virtual network technology can build multiple virtual networks on the basic physical network with the help of abstraction, isolation, and other mechanisms. In the software logical network topology, different needs of the service network can be met so that network resources can be configured and managed more flexibly without worrying about the physical topology of the basic network [11]. The creation of virtual networks can make the network richer and improve the efficiency of network utilization. At the same time, network management means will be well strengthened to provide operable methods for the intelligent information needs of Internet users [12]. In order to make the network more widely used, it is necessary to make necessary improvements and breakthroughs to the traditional network [13, 14]. Virtual network technology is a powerful method to strengthen the richness of the network, improve the use of network resources, and strengthen the network management and is one of the research focuses of researchers in the world in recent years [15]. The literature proposed that network technology can enable network operators to apply new network architectures, protocols, and procedures without affecting the normal operation of the network, thereby effectively supporting the improvement of network architecture and technology [16]. The literature proposes that virtual network technology can not only allow it to develop from the current network to the future network but is also one of the key features of the future Internet. Therefore, virtualization technology has attracted more and more attention from the research community and the business community. Become the center of network research. In the academic field in the future, science and technology research programs in western developed countries have begun to support network technology research, and China has also implemented many related research projects and content.

3. Analysis of the Virtualization of Network Functions Based on Artificial Intelligence

3.1. Analysis of Artificial Intelligence Related Content. In general, an artificial neural network usually consists of several layers, and different measures are taken for the information connected to different layers. After the system accesses the signal, each layer will process it in time and finally output the processing result. As mentioned above, commonly used neural network systems generally include an input layer, a hidden layer, and an output layer. Data are transmitted and processed in each layer. Finally, the system becomes more stable. The theoretical characteristics of artificial intelligence mainly include the following four aspects: calculation performance, convergence performance, and summary statistics performance. Convergence reflects the performance of the system for big data processing, inductive statistics reflect the learning performance of the system, the education process is the process of inductive statistics, and the output of the neural network can be expressed as follows:

$$y = f\left(\sum_{i=1}^{n} w_i x_i + b\right). \tag{1}$$

3.2. Overview of Network Virtualization. In a virtual network, there are three different parts: Infrastructure Provider (InP), Service Provider (SP), and End User (EU). The infrastructure provider is responsible for the construction and management of the basic physical network, providing such as physical network connection and routing to the service provider; the service provider is responsible for renting out physical network resources from the basic physical network facilities to establish a virtual network that provides end-user transmission services, reducing the cost of operating and maintaining the physical network, as shown in Figure 1.

The important role of virtual management of network resources is to meet the service requirements of end users in different aspects. By connecting the basic physical network, we can enhance our understanding of basic network resource information, connect the physical network and the virtual network, and allow users to configure and manage the necessary resources. Therefore, end users can use physical network resources through virtual networks and plan according to specific needs.

As shown in Figure 2, there are differences in resource management, and virtual management of network resources can be divided into three specific parts: first, virtual

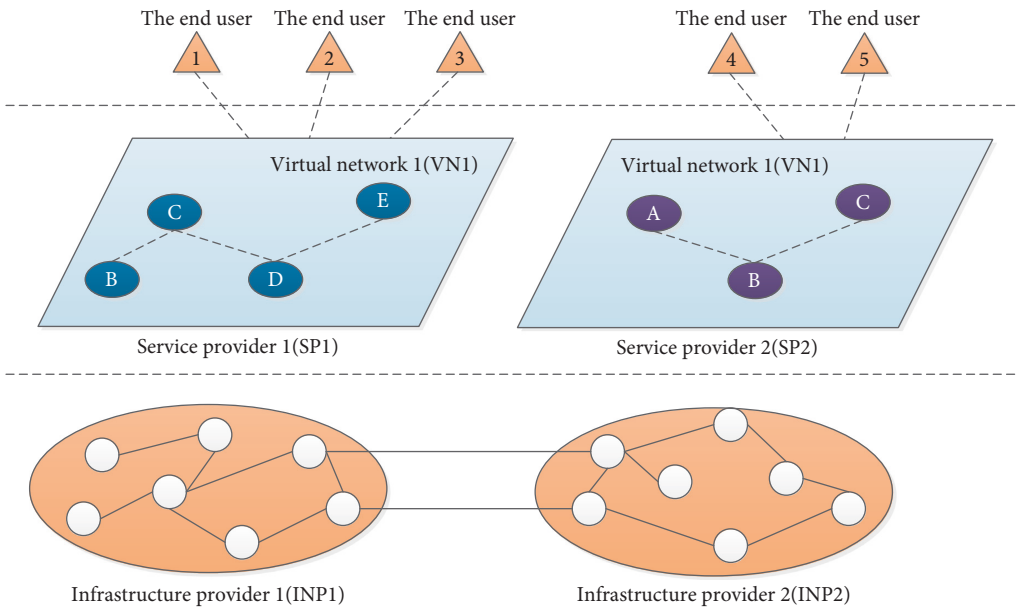

Figure 1: Network virtualization model.

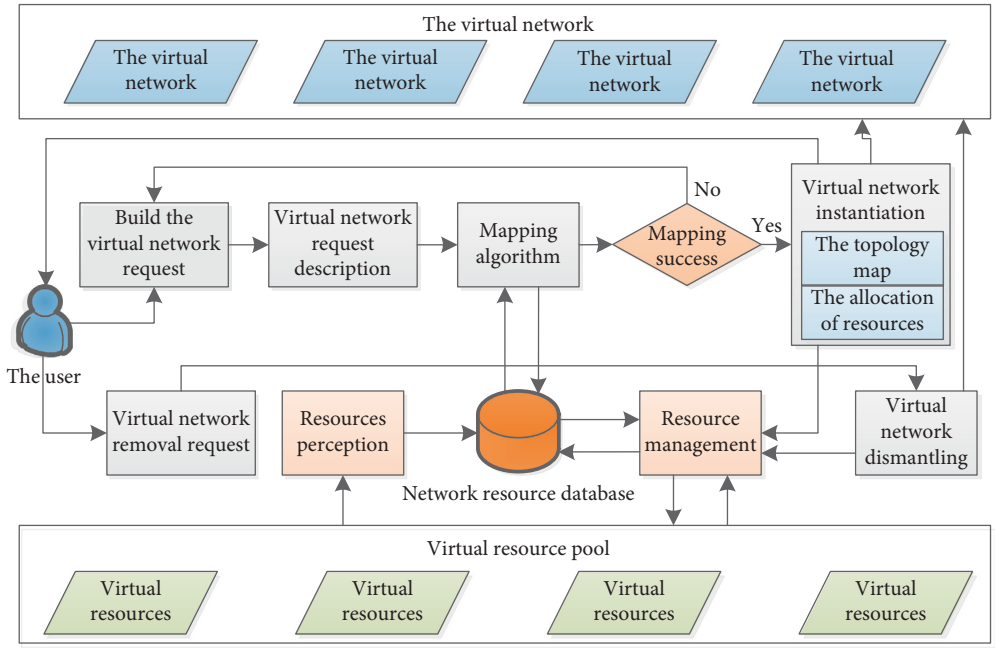

Figure 2: Virtual network resource management model.

management of network resources, that is, leasing network resources from the underlying network to establish virtual resources. Use the resource library to search and feel physical resources and categorize these resources to promote a unified narrative and application of virtual resources. Secondly, in virtual resource mapping, the module dynamically allocates and arranges the leased network resources according to the received service needs, maps the service requests required by the network, and coordinates the network resources. Thirdly, virtual network management is to meet the requirements of the virtual network by running the virtual network management part of all resource libraries, so as to reasonably allocate the virtual network and allocate the physical resources to the most appropriate area. Solve the physical needs of the virtual network through the resource library, provide a reasonable solution for optimizing resource allocation, and help to dynamically manage resources.

The most important deployment of network virtualization is to separate the underlying infrastructure and multiple service networks from traditional ISPs, which will greatly help the dexterity, clarity, and security of future networks. This article divides the role of the traditional ISP into several different parts and proposes a number of

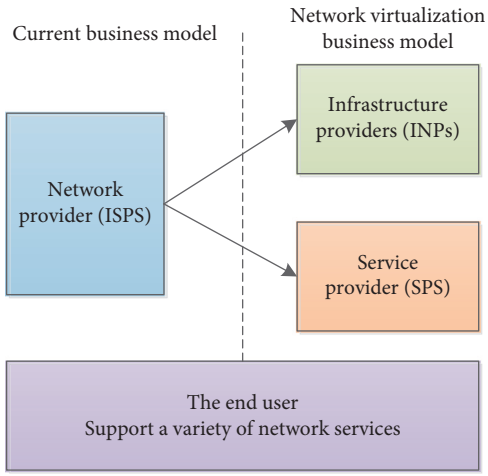

Figure 3: Current business model and NV business model.

different NV models. Figure 3 shows the difference between the current business model and the NV model.

How to successfully deploy the various nodes and connection resources of the virtual network to the physical network is the core and key of virtual network mapping. Virtual network mapping is not only an efficient and reasonable mapping of virtual networks to one or more basic physical networks. It is the core issue of virtual network mapping. Due to the virtual network folder, the efficient management and application of the underlying physical network are an NP problem, and the relevant solutions are mainly heuristic algorithms, as shown in Figure 4.

Virtual network mapping is mainly divided into two parts: node mapping and link mapping. When a user initiates a virtual network request, based on the physical network resources that the service provider has, the node mapping function is

$$M_N(M) = M_N(N). \tag{2}$$

The link mapping function is

$$M_N(\ ): N_V \longrightarrow N_s. \tag{3}$$

The reception rate formula of a virtual network is as follows:

$$ar = \frac{\text{VNRs}_{\text{accepted}}}{\text{VNRs}_{\text{total}}}. \tag{4}$$

Generally, the cost ratio R/C is the standard to judge the efficiency of mapping, which is as follows:

$$\frac{R}{C} = \frac{R\left(G^V\right)}{C\left(G^V\right)}. \tag{5}$$

The average transmission delay divided by the number of virtual links is

$$\text{Delay}_{av} = \frac{\sum_{MN \in \text{VNRs accepted}} \text{Delay}_{MN}}{\text{Num}_{MN}}. \tag{6}$$

The coordinates x and y are used to represent the position of the node:

$$\text{Dis}(\text{loc}(m), \text{loc}(M)) \le LR(M). \tag{7}$$

In VNE, the formula for the bottom remaining nodes is as follows:

Remaining bandwidth of link mn is

$$R^s(mn) = B^s_{mn} - \sum_{MN \uparrow m} B^V_{MN}. \tag{8}$$

The available bandwidth of path mn is

$$R^S\left(P_{mn}\right) = \min R^S(ab). \tag{9}$$

The virtual node in VNR should be reflected on the bottom node. It is subordinate to

$$\begin{aligned} C^V_M &\le R^S\left(M_N(M)\right), \\ \text{Dis}\left(\text{loc}\left(M_N(M)\right),\ \ \text{loc}(M)\right) &\le LR(M). \end{aligned} \tag{10}$$

Virtual link mapping in VNR is restricted by

$$\begin{aligned} B^V_{MN} &\le R^S\left(P_{M_N(M)M_N(N)}\right), \\ D_{M_N(M)M_N(N)} &\le D^V_{MN}. \end{aligned} \tag{11}$$

3.3. Network Function Virtualization Optimization Model and Its Algorithm Implementation. The position of the virtual node can be deviated as

$$\begin{aligned} &\text{Dis}\left(\text{loc}\left(M_N(M)\right), \text{loc}(M)\right) = \sqrt{\left(X_M - X_m\right)^2 + \left(Y_M - Y_m\right)^2}, \\ &\sqrt{\left(X_M - X_m\right)^2 + \left(Y_M - Y_m\right)^2} \le LR(M). \end{aligned} \tag{12}$$

The binary variable x is on the subbottom node m of the virtual node M. The virtual node variable values are

$$x^m_M = \begin{cases} 1, & M \longrightarrow m, \\ 0, & m. \end{cases} \tag{13}$$

The virtual link value is

$$x^{mn}_{MN} = \begin{cases} 1, & MN \longrightarrow mn, \\ 0, & \text{other}. \end{cases} \tag{14}$$

The virtual node is mapped to the underlying node and assigned to the virtual node M:

$$\forall M \in N^V, \sum_m x^m_M = 1. \tag{15}$$

The relationship between the virtual node M and the underlying node m is as follows:

$$\forall m \in N^S, \sum_M x^m_M = 1. \tag{16}$$

The node capacity mapped from the virtual node M to m is as follows:

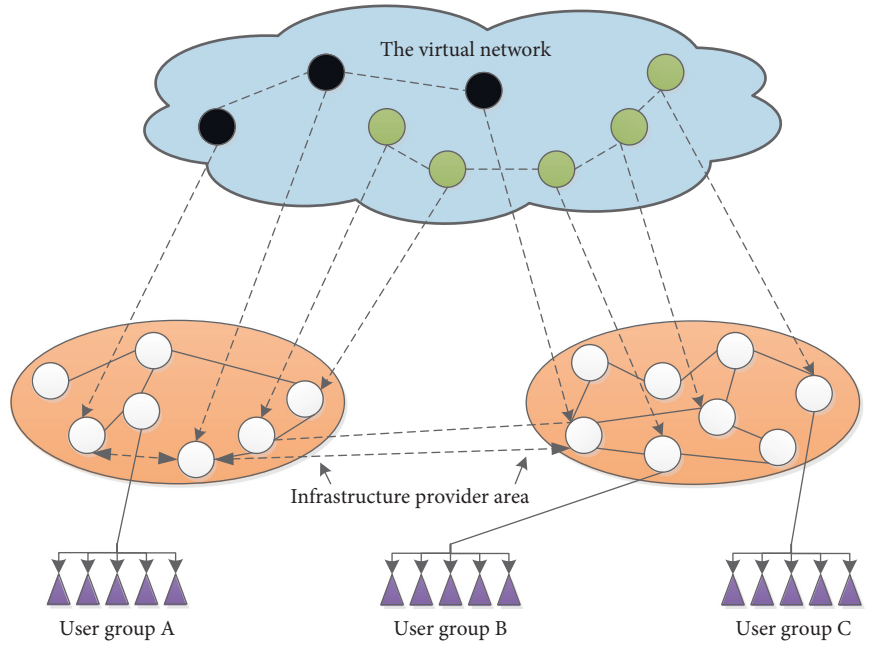

Figure 4: Virtual network mapping problem model.

$$\forall m \in N^S, \sum_M x_M^m \cdot C_M^V \le C_m^S. \tag{17}$$

Commodity flow will increase the delay propagation of virtual link as

$$\begin{aligned} &\forall mn \in P_{mn}^s, \\ &\exists MN \in L^V, \\ &\sum_{mn} B_{MN}^V \left(y_{MN}^{mn} + y_{NM}^{mn}\right) \le B_{mn}. \end{aligned} \tag{18}$$

The link bandwidth must protect the spare link bandwidth and meet the requirements of mapping bandwidth:

$$\begin{aligned} &\forall mn \in P_{mn}^s, \\ &\exists MN \in L^V, \\ &\sum_{mn} B_{MN}^V \left(x_{MN}^{mn} + x_{NM}^{mn}\right) \le B_{mn}. \end{aligned} \tag{19}$$

In the VNE algorithm, virtual link delay propagation is added:

$$\begin{aligned} &\forall MN \in L^V, \\ &\exists MN \in P_{mn}^s, \\ &\sum_{mn} D_{mn} \left(y_{MN}^{mn} + y_{NM}^{mn}\right) \le D_{MN}^V. \end{aligned} \tag{20}$$

According to the VNR revenue, the CF function is formulated to reduce the bottom node capacity and link bandwidth:

$$\min\left(\alpha \sum_M x_M^m C_M^V\right) + \beta \sum_{MN} \sum_{mn} \left(y_{MN}^{mn} + y_{NM}^{mn}\right) D_{MN}^V D_{mn}. \tag{21}$$

If the propagation of the underlying link is delayed, then

$$\min\left(\alpha \sum_{MN} \sum_{mn} \left(y_{MN}^{mn} + y_{NM}^{mn}\right) D_{mn}\right). \tag{22}$$

CF function optimizes the mapping of VN as

$$\min\left\{\alpha \sum_m \sum_M \frac{x_M^m C_M^V}{R^s(m)} + \beta \sum_{MN} \sum_{mn} \frac{\left(y_{MN}^{mn} + y_{NM}^{mn}\right) D_{MN}^V D_{mn}}{R^s(mn)}\right. \tag{23}$$

The other VNE algorithms are greedy mapping and shortest path mapping (g-sp), greedy mapping and multipath mapping (g-mcf), mapping of uncertain coordination nodes, and shortest path connection graph (r-vins-sp). The shortest path connection is nr-sp. Node mapping and several kinds of material flow mapping is nr-mcf. These are the typical VNE algorithms in VNE research.

3.4. Experimental Results and Analysis. Figure 5 shows the average VNR frequency, which is the main data for evaluating different VNE algorithms. It can be seen from the figure that the receiving speed of all algorithms almost decreases linearly with the change of VNR. This decrease means that there is no noise. Unlimited basic resources accept more VNRS. In addition, vne-cnpa is better than heuristics, and the gap between the optimal heuristic and vne-cnpa-cf is at least 20%. Therefore, the optimal mapping of each VNE problem can be achieved within the scope of the existing solutions, and the heuristic method is to try to find possible mappings. Another reason is that vne-cnpa will consider all possible solutions instead of some partial solutions.

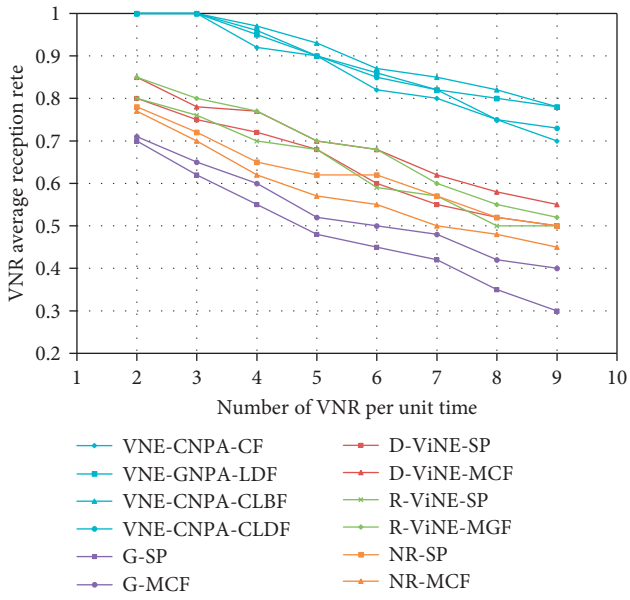

Figure 5: VNR average reception rate.

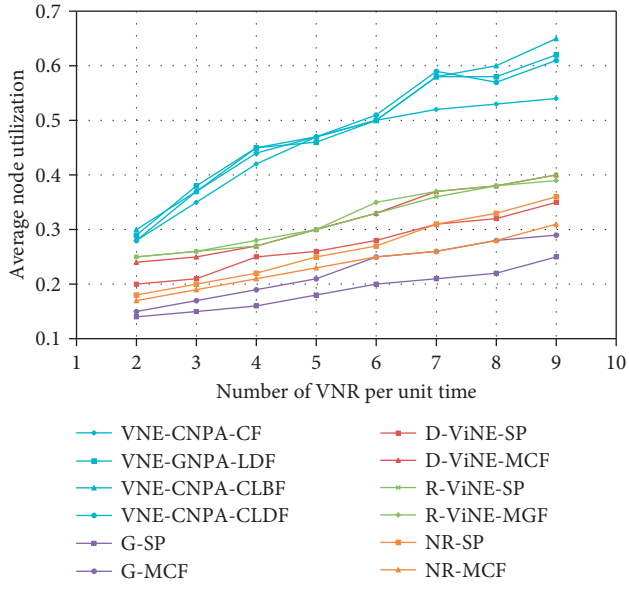

Figure 6: Average node utilization.

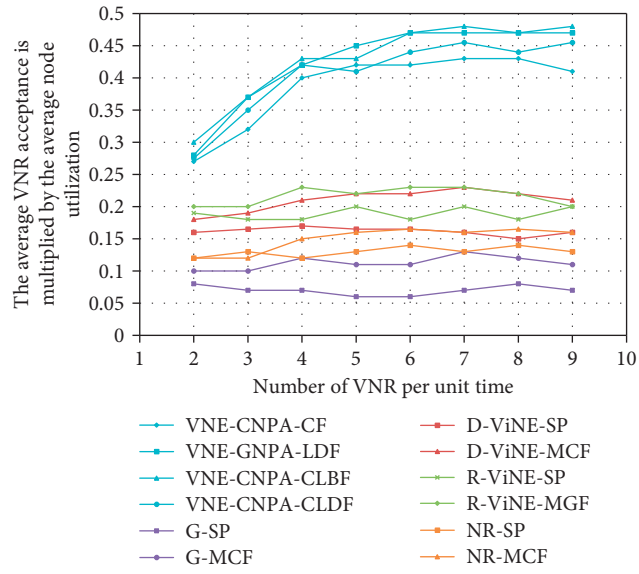

Figure 7: Average VNR reception rate multiplied by node utilization.

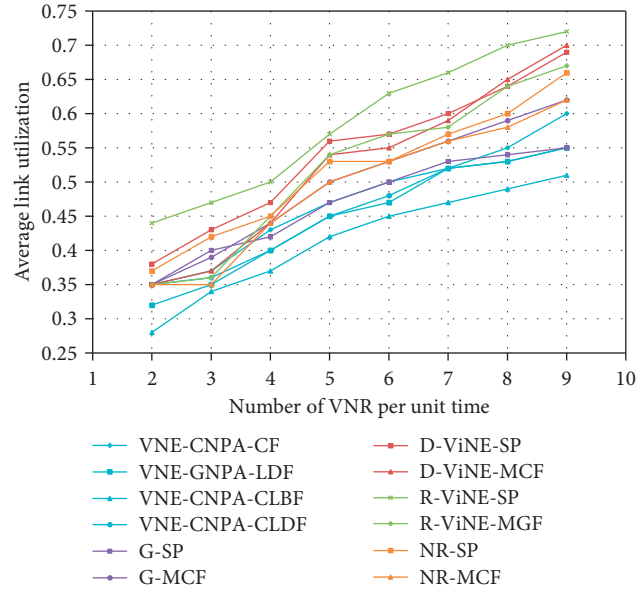

Figure 8: Average link utilization.

The average usage of nodes is shown in Figure 6. As the arrival speed increases, the node utilization of all selected algorithms also increases. In the two VNRS, the usage rates of heuristic and vne-cnpa are reduced by 29% and 35%. As shown in Figure 7, the node utilization rate of vne-cnpa is higher than the heuristic algorithm because vne-cnpa can absorb more VNRS than the heuristic algorithm. If the VNRS data value is huge, the vne-cnpa algorithm can clearly map the VNR and expand the underlying network node to the maximum capacity.

The connection utilization of all algorithms is shown in Figure 8. Obviously, the vne-cnpa algorithm is the low-level connection utilization of the vne-cnpa-clbf algorithm; in Figure 8, the connection utilization of the algorithm using the greedy directory graph (nr-sp, g-sp) is small. Although MCF is suitable for link mapping, it is important to map virtual nodes and synchronize links according to a mathematical programming model, so vne-cnpa is tightly coupled with the use of links.

As shown in Figure 8, the connection utilization also depends on the VNR reception rate, and Figure 9 shows the VNR reception multiplied by the connection utilization. The arrival rate rises to 5. Heuristics is selected, and the others are basically constant.

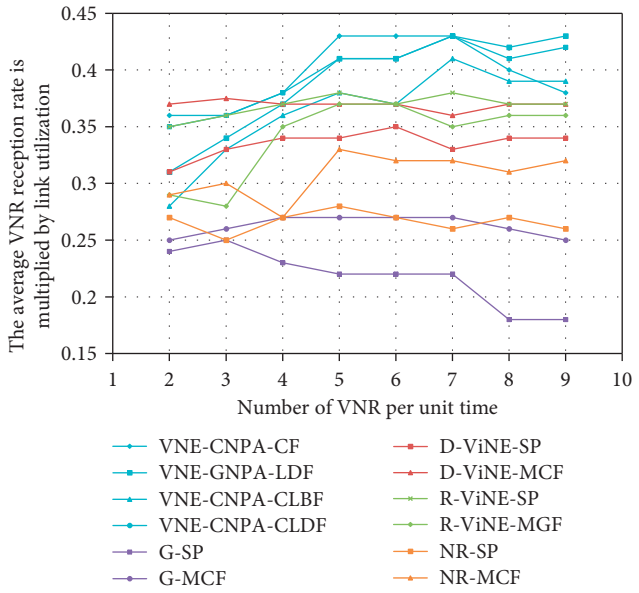

Figure 9: Average VNR reception rate multiplied by link utilization.

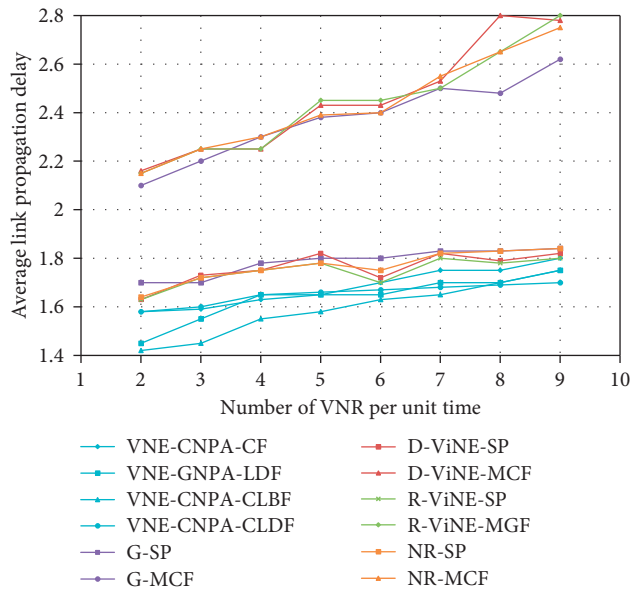

Figure 10: Average link propagation delay.

Figure 10 plots the average virtual link extension delay versus VNR arrival speed, and in contrast to the increase in the number of VNRSs, the average virtual link extension delay for all selected algorithms increases, which is the same as the nodes shown before.

4. Innovative Design and Application of Business Management Based on Digitalization

4.1. Data Collection and Collation. Table 1 is the case identification situation of CK company's production management innovation method, which is explained in 4 categories.

Based on the basic theory, through the public decoding, principal axis decoding, and selective decoding of the data of Chinese enterprises, the scope and categories that affect the way of management innovation of Chinese enterprises are extracted. Table 2 shows the relationship between 18 concepts and five categories. Finally, selective decoding is performed using the five categories mentioned above to connect to the complete story. The main category is the selection of enterprise management innovation. The efficiency of data collection and decoding is verified, and four subcategories are realized, namely the industrial sector, enterprise strategic management and team cooperation, and enterprise innovation.

4.2. Innovative Design Method of Enterprise Management Based on Digitalization. Modern information and communication technologies are becoming more and more popular among companies and always generate large amounts of data. The intelligent connection of everything enhances the fluidity of factors. The source of business is transformed from traditional production factors in the industrial economy to new production factors in the digital economy. On the one hand, the speed and scope of data technology have exploded, and collecting and transmitting at low cost becomes a reality; on the other hand, by analyzing and using a large amount of unstructured data, companies can find user needs and increase productivity through data analysis. With the rapid development of the digital economy, new business practices continue to emerge, and the industrial characteristics of cross-border integration are particularly prominent. Based on the intelligence of the network and cross-border integration, the number is the element, the business is the main factor, and the business management innovation theory that focuses on the analysis of complex organizations and system structures has become a powerful tool for managing cross-border integration.

Industry boundaries, organizational boundaries, and supply-demand boundaries are constantly being eliminated. The reconstruction of territory and the innovation of organizational forms have become the main content of enterprise management innovation. The integration of financial capital and intellectual capital is the company's new development momentum. Organizational forms are becoming more and more grid-like. The new organization has several characteristics of self-organization, infinity, decentralization, and teamwork. The business world is increasingly seeking professionals and composite personnel. Some traditional jobs in the company are gradually disappearing, and the demand for complex, professional, and technical personnel as well as high-quality personnel continues to grow.

4.3. Policy Recommendations to Promote the Development of Innovative Methods of Corporate Management. Enterprise management innovation cooperation is part of the cooperation between universities and enterprises. The government plays an important role in university research

Table 1: Open decoding of CK company production management innovation method cases.

Data	Concept	Category	Category nature	Property attribute
a1: the chairman believes that technology and management innovation are the dual cores of promoting enterprise development	Promote innovation	Team innovation	Team innovation form	Radical or conservative
a2: the chairman believes that the entrepreneurial team composed of three to four people has a close innovative spirit for development and exploration	Innovative spirit			
a3: in 2011, the company produced 160 million as output value through 82 people	Teamwork			
a4: after the company outsources, the company's mechanism is streamlined and efficient	Organizational flattening	Organizational culture innovation	Innovative atmosphere	Organizational culture innovation: high or low
a5: the company strengthens innovative training for employees	Human resources			
a6: from the outside, due to lack of competent authorities or industry associations, the standards cannot be updated	Industry instability	Industry environment	The complex and unstable environment of the company's industry	Industry environment: high or low instability
a7: the company faces fierce competition, and foreign-funded enterprises have also entered the Chinese market.	Fierce competition			
a8: at present, the company has cooperated with related professional research institutes and well-known universities in China.	Combining industry and research			
a9: in 2009, the company was focused on training by the government, and all aspects received government support.	State aid			
a10: the company has cooperated to develop a new system, but it does not have core technology and cannot meet customer requirements	Stable customer demand			
a11: the company adheres to the development concept and uses new ideas to promote the company's development	Strategic policy	Corporate strategic management	Company strategy orientation	Strategic orientation: cost leadership, differentiation, and focus strategy
a12: the chairman believes that the company has strong decision-making capabilities and resource acquisition capabilities	Strategic management system capabilities			
a13: the corporate label is used emphatically, and the corporate brand and development are greatly supported	Brand honors			
a14: the company sums up its experience in failure and obtains a national patent	Practice of innovative methods			

Table 1: Continued.

Data	Concept	Category	Category nature	Property attribute
a15: the company has changed the traditional model, and the company has achieved significant development	Progressive management innovation	Abrupt management method innovation	Innovation in management methods	Progressive management method innovation
a16: the chairman believes that the company's return rate is low, but the downtime is long, and production needs to be further improved.	Mature production method			
a17: participate in the study of government organizations many times to improve the management innovation ability	Learn and grow			
a18: all work must be performed in accordance with regulations and constantly updated and improved	System innovation			

Table 2: The corresponding relationship between categories and concepts of influencing factors of management innovation methods in Chinese manufacturing enterprises.

Category	Concept
Team innovation spirit	Promoting innovation and group collaboration
Organizational innovation culture	Solid organization and brand reputation
Industry environment	Industry instability, customer demand diversity, state aid, business combination
Corporate strategic management	Catastrophe management method, strategic management system capability
The choice of management innovation method	The innovation of the mutation management method and gradual management method

cooperation. It has been verified by other countries that the government often needs to play different roles in different periods of industrial development. Universities should conduct research based on their goals and actual conditions. First, the government should play a leading role. The government should formulate incentive measures and guidelines to promote cooperation in management innovation, especially in the following areas: financial support, property rights definition, and regulatory support. Secondly, the government should play the role of a regulator, and government service departments should support the cooperation between universities and the business world through relevant systems and departments and carry out intermediate coordination and adjustment.

The government must lead the overall situation more macroscopically and formulate long-term development plans and policies based on local conditions to guide the development of cooperation. It is necessary for the government to promote the retention of the cooperative intentions of individual subjects throughout the process. The government must formulate a development plan that combines the medium and long terms with the short term to ensure that companies, universities, intermediaries, and other institutions are profitable, thereby achieving the goal of improving the city's overall innovation capabilities. The first is to promote the development of university scientific research cooperation, encourage scientific research institutions and enterprises to cooperate, encourage cooperation from low-level to high-level collaborative development, and expand the aspects of collaboration. From simply investing in scientific research results, patented technology, and production process procurement, we should turn to the road of high-level collaboration, such as business collaboration in schools, development of information of R&D centers, and technology sharing; secondly, strengthen guidance in university scientific research cooperation.

5. Conclusion

This paper combines artificial intelligence and network function virtualization, two very advanced and popular technologies in modern society, and uses neural networks to solve and develop the service chain problem in network function virtualization. In terms of enterprise management innovation, this article points out the need to strengthen in-depth cooperation and exchanges between universities and enterprises. At the same time, the government, as a third party in cooperation, should play an active leadership role and an intermediary coordination role. In strengthening innovation management, the government should issue corresponding support for the policies and measures of the People's Republic of China and give some policy dividends to support. In terms of innovation management cooperation, the establishment and improvement of government plans and policy support mechanisms are an important external driving force for enterprise management innovation cooperation in the initial stage.

Data Availability

The 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.

References

[1] Etsi Industry Specification Group (Isg) Nfv, *ETSI GS NFV 002 V1.2.1: Network Functions Virtualization (NFV); Architectural Framework*, ETSI: European Telecommunications Standards Institute, Frankfurt, Germany, 2014.

[2] G. A. Gallardo, B. Baynat, and T. Begin, "Performance modeling of virtual switching systems," in *Proceedings of the IEEE 24th International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS)*, pp. 125–134, London, UK, September 2016.

[3] S. Azodolmolky, R. Nejabati, M. Pazouki, P. Wieder, R. Yahyapour, and D. Simeonidou, "An analytical model for software defined networking: a network calculus-based approach," in *Proceedings of the IEEE Global Communications Conference (GLOBECOM)*, pp. 1397–1402, Atlanta, GA, USA, December 2013.

[4] D. Watson, J. Womack, and S. Papadakos, "Rise of the robots," *Critical Care Nursing Quarterly*, vol. 43, no. 3, pp. 303–311, 2020.

[5] M. Chen, U. Challita, W. Saad, C. Yin, and M. Debbah, "Artificial neural networks-based machine learning for wireless networks: a tutorial," *IEEE Communications Surveys & Tutorials*, vol. 21, no. 4, pp. 3039–3071, 2019.

[6] R. Bolla and R. Bruschi, "Linux software router: data plane optimization and performance evaluation," *Journal of Networks*, vol. 2, no. 3, pp. 6–17, 2007.

[7] M. Dobrescu, N. Egi, K. Argyraki, B. C. Chun, K. Fall, and G. Lannaccone, "RouteBricks: exploiting parallelism to scale software routers," in *Proceedings of the ACM SIGOPS 22nd symposium on Operating systems principles*, pp. 15–28, Montana, USA, October 2009.

[8] Z. Su, B. Baynat, and T. Begin, "A new model for DPDK-based virtual switches," in *Proceedings of the IEEE Conference on Network Softwarization (NetSoft)*, pp. 1–5, Bologna, Italy, July 2017.

[9] H. Li, Z. Bian, P. Zhang et al., "Application-oblivious L7 parsing using recurrent neural networks," *IEEE/ACM Transactions on Networking*, vol. 28, no. 5, pp. 2009–2022, 2020.

[10] W. Lucas, C. Hartmann, M. Thiele, D. Habich, and W. Lehner, "Cardinality estimation with local deep learning models," in *Proceedings of the Second International Workshop on Exploiting Artificial Intelligence Techniques for Data Management (aiDM '19)*, New York, NY, USA, July 2019.

[11] M. Adil, J. Ali, M. Attique et al., "Three byte-based mutual authentication scheme for autonomous internet of vehicles," *IEEE Transactions on Intelligent Transportation Systems*, vol. 23, 2021.

[12] R. Kawashima, S. Muramatsu, H. Nakayama, T. Hayashi, and H. Matsuo, "A host-based performance comparison of 40G NFV environments focusing on packet processing architectures and virtual switches," in *Proceedings of the 5th European Workshop on Software-Defined Networks (EWSDN)*, pp. 19–24, The Hague, The Netherlands, October 2016.

[13] L. Rizzo and G. Lettieri, "VALE, a switched Ethernet for virtual machines," in *Proceedings of the 8th international conference on Emerging networking experiments and technologies*, pp. 61–72, Nice, France, December 2012.

[14] R. V. Mendonça, J. C. Silva, R. L. Rosa, M. Saadi, D. Z. Rodriguez, and A. Farouk, "A lightweight intelligent intrusion detection system for industrial internet of things using deep learning algorithm," *Expert Systems*, vol. 39, Article ID e12917, 2021.

[15] B. Zhang, X. Wnag, R. Lai, L. Yang, Z. Wang, and Y. Luo, "Evaluating and optimizing I/O virtualization in kernel-based virtual machine (KVM)," in *Proceedings of the IFIP International Conference on Network and Parallel Computing*, pp. 220–231, Zhengzhou, China, September, 2010.

[16] Q. Xiao, S. Chen, Y. Zhou et al., "Cardinality estimation for elephant flows: a Compact solution based on virtual register sharing," *IEEE/ACM Transactions on Networking*, vol. 25, no. 6, pp. 3738–3752, 2017.