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Optimization study of hybrid virtual network mapping algorithm (VNE) based on cost optimization and energy efficiency optimization theory

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Abstract. The virtual network mapping algorithm can effectively change the phenomenon that the energy consumption of network technology is large in our country. In order to optimize the virtual network mapping algorithm better, based on the related literature summary, theories of virtual network mapping algorithm were clarified and model of virtual network mapping algorithm proposed was constructed in this study. By using the related optimization model, the running cost and the rate of network request acceptance of virtual network mapping model were calculated. The results show that the virtual mapping algorithm can reduce the running cost and increase the acceptance rate compared with the traditional mapping algorithm. The purpose of this research is to provide a reference for the optimization of related algorithms.

Key words. Cost optimization, energy efficiency optimization, mixed virtual network mapping algorithm.

1. Introduction

With the development of the times, various new science and technologies in modern time appear constantly and have been improved greatly. As a new technology which is developing more rapidly, information technology has a strong resource sharing. And the combination of this technology and other industries is strong, so it has been widely used in other industry development. As the advantages of this technology continue to increase, a variety of more systematic and scientific theoretical studies have been initiated, which has further promotes the further improvement and development of information technology. However, the rapid development of information technology has brought great convenience to people's production and life. At the same time, some uncoordinated problems have been further exposed, such as energy consumption. How to reduce the energy consumption of information technology

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through more perfect new technology has become an important problem to be solved urgently in the development of science and technology in the times. Based on the related theories of cost optimization and energy efficiency optimization, the hybrid virtual network mapping algorithm (VNE) of information technology was optimized in this study. A kind of new information technology with lower energy consumption was determined, which provided certain theoretical support and reference for the follow-up research.

2. State of the art

The development of information technology has brought the extremely important influence and the positive promotion function for the progress of other industries in the present era. As an important science and technology in the development of the times, information technology is often used to fulfill the user's needs by running some applications on the server. Although this technology has brought great convenience to people's production and life, the traditional network information technology has greatly consumed some network resources and energy [1]. Statistics show that the most technologically advanced supplier of information technology in the world today is the Akamai Company in the United States. The vigorous development and advancement of the information technology of the company has caused great consumption for the use of electricity cost in the current era. As a big country in the economic and scientific and technological power in the current era, the rapid development of mobile internet companies has further caused the extensive use of related resources in China [2]. Therefore, the energy consumption of information technology has become one of the most important subjects in the development of information technology. Some researchers have pointed out that network virtualization should be the main direction of network development in the future development of network information technology. The technology should be based on the shared network platform and make use of a variety of different virtual resources so as to improve the operation efficiency of network system, and further reduce the physical resources borne by the amount of resources in order to achieve the purpose of energy conservation [3]. There are many techniques that have already been put into use. As a novel theory, the hybrid virtual network mapping algorithm has a very important positive impact on the energy saving in the development of the whole information technology [4]. Many researchers have begun to pay attention to it and constantly improve the relevant theories, which provide technical support for the development of information technology [5].

2.1. Methodology

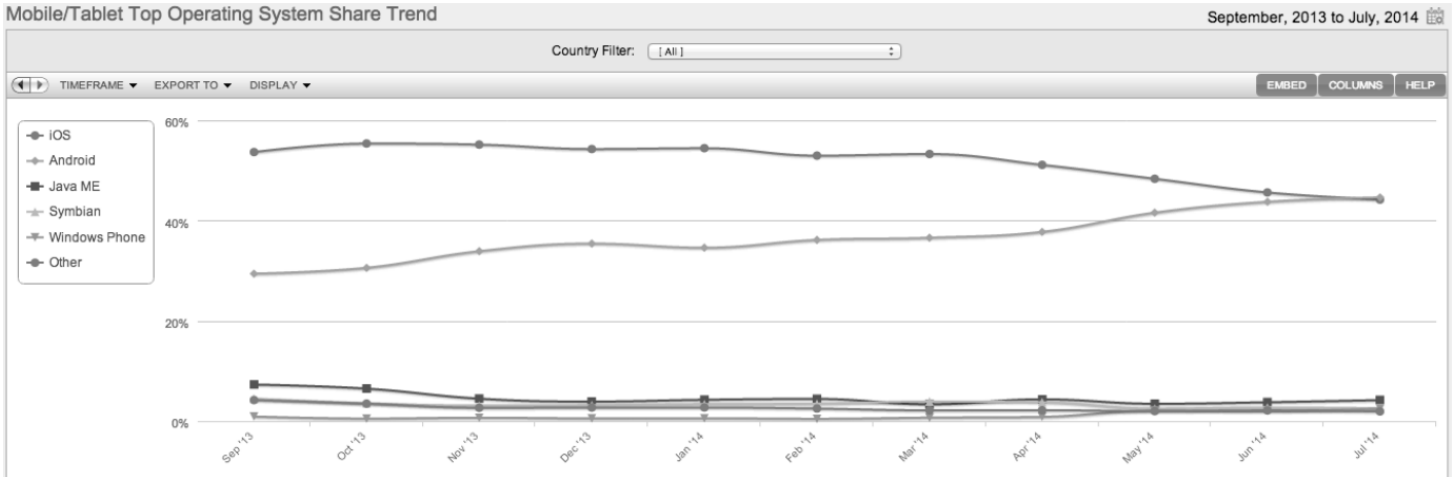
With China's entry into the new century, China's various technologies have been greatly improved and developed, and people's living standards have also been improved greatly. Now, many new techniques have begun to gradually enter the people's field of vision, and have brought great convenience to the production and life of the people [6]. With the development of mobile internet technology, more and more

new businesses are emerging. This better meets the actual needs of some industries or individuals in our country to a certain extent (Fig. 1).

Fig. 1. Rapid development of network technology

However, with the rapid development and application of network information technology in our country, some drawbacks have begun to emerge. The whole network technology is beginning to show a rigid phenomenon. According to statistics, data traffic used by China's network users reached 20523 PB due to certain network activities in 2015. And most of the data traffic is mainly used for network video viewing [7]. Network users in our country usually look at the rate of VOD on some network video. Based on the rate of request, the video you might want to watch is determined. Then through the use of the client, the publication of network video online shop is connected so as to obtain relevant video resources. However, in this process, some servers may have a higher hot spot of video resources, which may lead to a larger load on the server terminal because of excessive user access. This can directly lead to low efficiency of resource delivery and limit the scalability of traffic (Fig. 2). Especially in the application of network technology of traditional TCP/IP architecture, the perfection of its structure is relatively poor. A large number of accessing customers may make the network technology system unable to load larger amounts of data. This situation makes the operation of the network system a certain resistance. A large number of energy materials are consumed, which makes the traditional network technology system facing more severe use challenges [8]. In addition to the expansion of network traffic caused by the excessive amount of user access mentioned in the above articles, another issue that needs further attention is the scalability of the routing problem. In the development of traditional network information technology, IP addresses can be used to mark the location and identity of network nodes. Therefore, when the location of some physical devices changes, it may affect the communication process of the entire network. This limits the freedom of certain network physical devices to a certain extent. It has a negative impact on the expansion of routing, and indirectly affects the efficiency of the use of the network, resulting in waste of resources [9].

In view of the above problems, many researchers in our country put forward the application of network virtual technology in the development of actual network



MONTH	IOS	ANDROID	JAVA ME	SYMBIAN	WINDOWS PHONE	OTHER
September, 2013	53.68%	29.42%	7.31%	4.48%	0.92%	4.20%
October, 2013	55.39%	30.58%	6.47%	3.58%	0.50%	3.48%
November, 2013	55.17%	33.89%	4.49%	3.12%	0.67%	2.66%
December, 2013	54.27%	35.41%	3.90%	3.18%	0.55%	2.70%
January, 2014	54.46%	34.60%	4.26%	3.41%	0.56%	2.72%
February, 2014	52.96%	36.14%	4.44%	3.50%	0.45%	2.51%
March, 2014	53.29%	36.58%	3.36%	3.92%	0.69%	2.17%
April, 2014	51.11%	37.75%	4.36%	3.77%	0.83%	2.18%
May, 2014	48.34%	41.58%	3.46%	2.52%	2.10%	2.00%
June, 2014	45.61%	43.75%	3.77%	2.73%	1.99%	2.15%
July, 2014	44.19%	44.62%	4.19%	2.57%	2.49%	1.94%

Fig. 2. Data flow related data logging

technology. And through the further improvement of the technology, higher resource saving rate and data transmission efficiency are obtained [10]. Nowadays, the research of this kind of technology in our country is mainly in the realization of the technology and all aspects of its mapping. However, because our research on this technology is still in the initial stage, the related theories and techniques are not mature enough, so the generalization is still poor. In this context, it is necessary to put forward and improve the relevant technical algorithms so as to achieve further optimization of the whole technical performance [11]. On the basis of consideration of the operation cost and energy consumption of the technology, it also needs to discuss its application reliability and science in the course of the study, so as to form a more perfect new network technology and provide some technical support for the development of other industries. This study will discuss and analyze the related aspects of hybrid virtual network mapping algorithm (VNE) based on two aspects of cost optimization and energy efficiency optimization. Moreover, on the basis of optimizing the original algorithm, better technical algorithm is determined, so as to provide a certain reference for the later research. The related research methods are as follows:

(1) First of all, through the reading of relevant information, the relevant main theoretical basis for the study was identified and clarified. On the basis of a clear understanding of the relevant theoretical foundations, the related application technologies of the traditional virtual network mapping model were analyzed, and then the relevant research ideas of node segmentation in this study were obtained.

(2) On the basis of understanding the relevant theories, in order to better guarantee the design of the associated virtual network mapping algorithm model has lower operating costs, a more optimized mathematical model formula was introduced in the construction of the related network mapping algorithm model. Index value experiment was carried out to obtain data through related mapping algorithm. Then, the performance of the model was compared and analyzed with the traditional network mapping algorithm. The mathematical model of correlation optimization used in this study is as follows:

Objective function:

$$\min \sum_{(u,v)\in E} \sum_{i=1}^{k} c_i(u,v) f_i(u,v)\,. \tag{1}$$

Here, E represents all links and u and v represent different nodes respectively. Function $f_i(u,v)$ represents the traffic data that flows through the associated nodes and $c_i(u,v)$ represents the cost of the unit flow through different nodes.

Capacity restriction formula:

$$\sum_{i=1}^{k} f_i(u,v) \le b(u,v)\ \forall (u,v) \in E\,. \tag{2}$$

Here, $b(u,v)$ represents the maximum flow capacity that a link can afford.

Range restriction formula:

$$f_i(u,v) \geq 0,\ 1 \leq i \leq k\ \forall (u,v) \in E\,. \tag{3}$$

The formula is a non-negative restriction on the traffic capacity carried by a link.

(3) The designed network virtual technology was optimized by using the relevant optimization mathematical model, so as to construct a virtual network mapping algorithm with lower cost and better energy efficiency. Moreover, the energy saving strategy in this algorithm was discussed in depth, and the main modes of energy saving were analyzed. Then, the performance of the adaptive algorithm was calculated and compared by the experimental method of the actual case.

3. Result analysis and discussion

Development of times makes the network information technology gradually become one of the important science and technology in the development of the times. However, due to the influence of network structure, traditional network information technology may cause the limitation of energy consumption when facing large traffic load. And the mapping algorithm of network virtual network is proposed, which provides some positive effects on the solution of this limitation. Nowadays, all countries in the world have begun to search for a more efficient and efficient network virtual network mapping algorithm, so as to solve the main problems faced by traditional network technology [12]. The virtual network mapping model refers to the sharing of the same network physical resources between different virtual networks. The virtual network is mainly replaced by a number of different virtual nodes. Then, the virtual link is used to connect all the virtual nodes with the network physical resources, so as to realize the related data transmission path and share the data resources. The proposed network mapping model can better meet the actual needs of people and reduce the use of related energy consumption due to the shared processing of a variety of architectures [13].

Relevant information was read and summarized in this study firstly. Based on the understanding of the underlying network graph of traditional network technology and the relevant theories, the segmentation of virtual network technology was introduced. Thus, the model of network virtual technology was created, as shown in Fig. 3 [14]. Among them, the letters in the model represented different element nodes, and the dotted line represented the element link between the different element nodes.

On the premise of segmenting the link mapping path of the related model, the study generalized the parameters of the whole model and applied it to later model optimization. The list of related parameters is shown in Table 1.

Table 1. List of related model parameters for this design

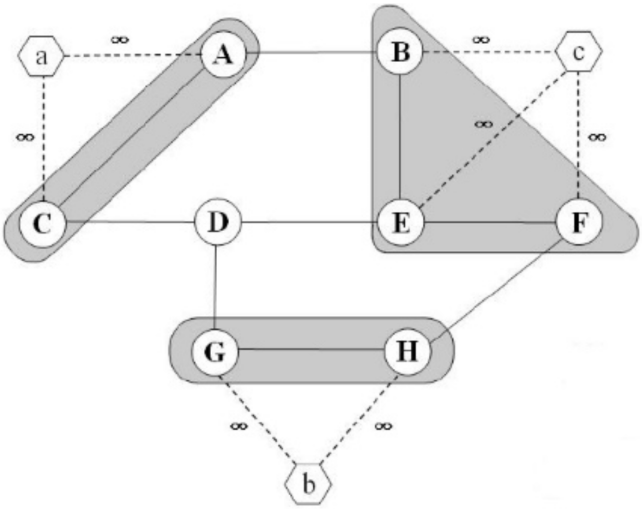


Fig. 3. Network virtual technology model constructed by this research

Parameter name	Parameter nominal
$R_E(u,v)$	The residual bandwidth capacity of the underlying link u,v
$R_N(n^{\mathrm{s}})$	The residual CPU capacity of the underlying node N^{S}
$b\left(e_i^v\right)$	Article i bandwidth requirements for virtual link e_i^v
$c\left(n^{\mathrm{v}}\right)$	The residual CPU capacity of the underlying noden^{v}
$c_0\left(n^{\mathrm{v}}\right)$	CPU capacity requirements for traffic independent parts of virtual node n^{v}
$B\left(n^{\mathrm{v}}\right)$	The maximum amount of traffic that virtual node n^{v} needs to handle

On the basis of understanding the related parameters of the virtual network technology model that has been constructed, the performance of the mapping algorithm of the virtual network mapping algorithm and the traditional network technology was compared and analyzed through the relevant experimental data in this study. In order to speed up the optimization speed of the related algorithms, the method of direct solution of the above mathematical formula model was studied so that it was possible to study the efficiency of the data in this study. Since the actual network cannot be studied, this study is mainly to simulate the whole experiment through some virtual networks. Firstly, the bandwidth distribution of 10 randomly acquired virtual network link requests was studied. The bandwidth requirement is shown in Table 2. Through the analysis of the optimization of all bandwidth values, this study considers that when the bandwidth value is set to 0.5, the interval of the bandwidth distribution is even.

Table 2. Bandwidth requirements for virtual links in this study

Load	Evenly distributed intervals of bandwidth
0.1	[2, 3]
0.2	[4, 6]
0.3	[6, 9]
0.4	[8, 12]
0.5	[10, 15]
0.6	[12, 18]
0.7	[14, 21]
0.8	[16, 24]
0.9	[18, 27]
1.0	[20, 30]

In order to simplify the relative process of experiment, the values of all virtual nodes were set to 0.1 in this study. Then, the cost weights values of the virtual network mapping algorithm were set differently. When carrying out different mapping cost weighting values, the conclusion of average mapping cost of the virtual network mapping algorithm and the traditional network mapping algorithm was carried out by using the above mathematical model. The results are shown in Table 3. The results show that the running cost of the mapping algorithm is related to the cost weight and the setting of bandwidth. With the increase of bandwidth settings, the running cost of the network virtual mapping algorithm (VNE) and the traditional mapping algorithm show an increasing trend. The two mapping algorithms have positive correlation with the mapping weight value (β). With the increase of mapping weight (β), it shows a gradually increasing trend. Therefore, when optimizing different mapping algorithms, it is necessary to consider the optimization of the bandwidth and the setting of the mapping weight value as much as possible. The research further compares the operation cost of the network virtual mapping algorithm and the traditional mapping algorithm. The results show that the operating cost of the network virtual mapping algorithm is lower than that of the traditional network technology regardless of the setting of any weight value. However, the savings rate of different weight values is also different. When the weight value is relatively small, the cost savings of the network mapping algorithm compared to the traditional mapping algorithm are significantly lower than the cost savings when the weight value is set larger. This is probably because when the mapping weight value of the node is set to smaller value, the segmentation mapping has less impact on the total cost. Thus, the total operating cost can be reduced as much as possible so that the final rate of saving is relatively large [15].

Table 3. Comparison of the cost of the network virtual mapping algorithm and the traditional mapping algorithm when different mapping weights are used

	$\beta = 0.2$			$\beta = 1$			$\beta = 5$		
Load	VNE	tradition	Cost saving rate	VNE	tradition	Cost saving rate	VNE	tradition	Cost saving rate
0.1	19.0	25.3	24.9 %	30.6	36.2	15.5 %	88.6	90.9	2.5 %
0.2	43.1	57.2	24.7 %	67.3	80.1	16.0 %	188.4	194.3	3.0 %
0.3	72.2	93.3	22.6 %	107.3	126.8	15.4 %	281.4	291.7	3.5 %
0.4	113.5	141.9	20.0 %	159.4	185.4	14.0 %	388.1	403.2	3.7 %
0.5	154.3	185.7	16.9 %	214.2	242.7	11.7 %	513.6	528.3	2.8 %
0.6	179.4	203.8	12.0 %	252.3	272.4	7.4 %	586.4	608.8	3.7 %
0.7	200.8	233.7	14.1 %	281.6	310.8	9.4 %	670.2	696.6	3.8 %
0.8	235.6	250.0	5.8 %	327.8	354.9	7.6 %	786.2	806.9	2.6 %
0.9	251.5	276.3	9.0 %	356.8	380.0	6.1 %	827.9	860.3	3.8 %
1.0	277.3	312.9	11.4 %	393.4	421.9	6.8 %	910.1	967.0	5.0 %

Finally, the acceptance rate of network requests under different mapping algorithms was calculated. The results are shown in Fig. 4. The results show that the network virtual mapping algorithm (VNE) has higher acceptance rate for the virtual network request than the traditional mapping algorithm when the bandwidth load is large. This may be because it saves more running costs and thus accommodates a larger amount of data request commands.

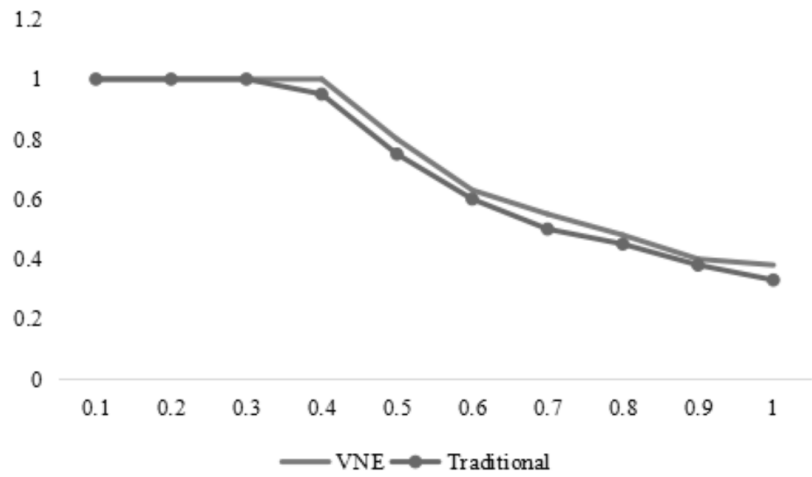


Fig. 4. Average acceptance ratio of network virtual mapping algorithm (VNE) and traditional mapping algorithm for virtual network requests

4. Conclusion

With the development of the times, network information technology has been improved greatly, while the technology has brought great convenience to people's production and life, some incompatible factors have begun to appear. In the traditional network technology, the expansion of flow is weak, and the demand for energy consumption is increasing due to the limitation of the operation structure. As an important direction of the development of network information technology, the network virtual mapping algorithm can improve the operation efficiency of network technology and reduce the related cost effectively. In order to better optimize the design of network virtual mapping algorithm in our country, the related theories were analyzed, and a simple virtual mapping algorithm model was designed in this study. Then, the mapping cost and acceptance rate were calculated by the relevant optimization model. The results show that the mapping algorithm has relatively low mapping cost, and the acceptance rate of virtual requests is high, and then it can be applied to the subsequent improvement of related technologies. However, this research is more simulation virtual process and lacked practical application, which may cause the result to have certain limitation and insufficiency. However, this study can still provide some reference and scientific support for the improvement of related technologies and theories in China.

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