An Improved Resource Management Approach for Distributed Network Endpoints†

Wang Bailing*, Wei Yuliang, He Hui, Liu Yang and Qu Yun

Harbin Institute of Technology at Weihai, Shandong, 264209
**wbl@hit.edu.cn*

Abstract

As IP technologies have provided the ability to establish dynamic security associations between endpoints emerge, virtual private networks (VPNs) are going through significant growth. The number of endpoints per virtual network is growing, and the resource management is becoming increasingly hard to predict. To study these issues, we abstract the distributed endpoints into a simple undirected graph, research on the graph and propose an adaptive searching method for resource discovery and management. The new searching strategy reduces the traffic impact to network and improves the ergodic theorem. We also proposed a new generation method, which could be used before traversed the resource. The simulation shows that the result is better than the known.

Keywords: *complex network, graph theory, cloud resource management*

1.Introduction

Resource management system is based on the resource database, and the resource database is through the standardized system of symbols and expression of the relationship between the reality of network resources (including physical resources and logical resources, *etc.*) in a one-to-one digital image. All queries for resources, statistics, scheduling program design, data analysis, decision support, are through resource management application computing image data in the database.

If the virtual image and the reality of network corresponding to a sufficiently have high accuracy rate, the computer virtual network based scheduling programs and other decision-making in the real network is executable, so as to achieve the purpose of efficient use of network resources and the rapid opening of the telecommunications business. Through various operations on the resource database, you can achieve real network operation guidance and resource scheduling assignment, so as to achieve the intensive management of the network.

In 2009, the St Andrews Cloud Computing Co-laboratory was launched, which is focusing on research in the important new area of cloud computing, and aims to become an international center of excellence for research and teaching in cloud computing, providing advice and information to businesses interested in using cloud-based services [1]. Their research also include cloud resource management.

In this paper, we investigated the resource management approach in a given distributed network endpoints. By different method, the distributed resource could be collected and put into database, but the influence to network are different. We propose a precomputed graph based endpoint traversal method, which could reduce the bandwidth and improve the information collection speed.

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2. Ergodic Theory

The technologies of information diffusion are first used to improve the performance of the network-based conference [2, 3]. Based on these technologies, we proposed a new graph ergodic mechanism based on an Adaptive Searching Tree (AST). Some of the lemmas have been proved in [4], which use this theory to improve the worm agent propagation, but we illustrated the proofs in detail for the integrity of this paper. Figure 1 illustrated the representative topology of a distributed network endpoints.

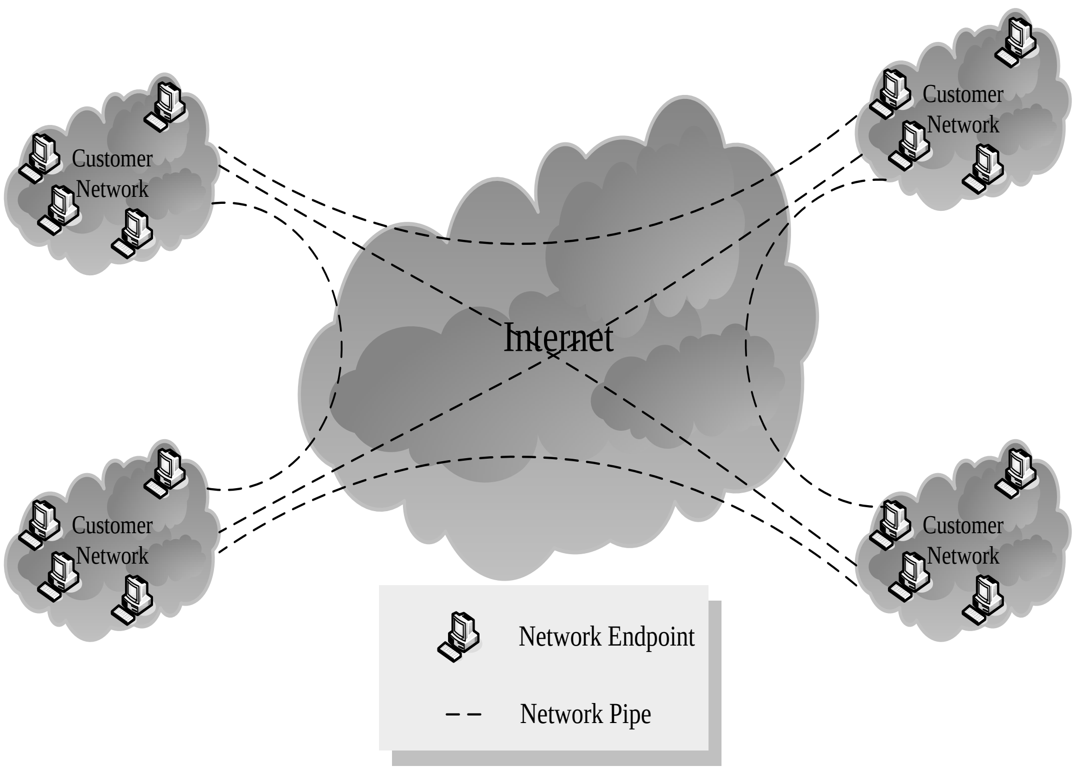


Figure 1. Representative topology of a distributed network endpoints

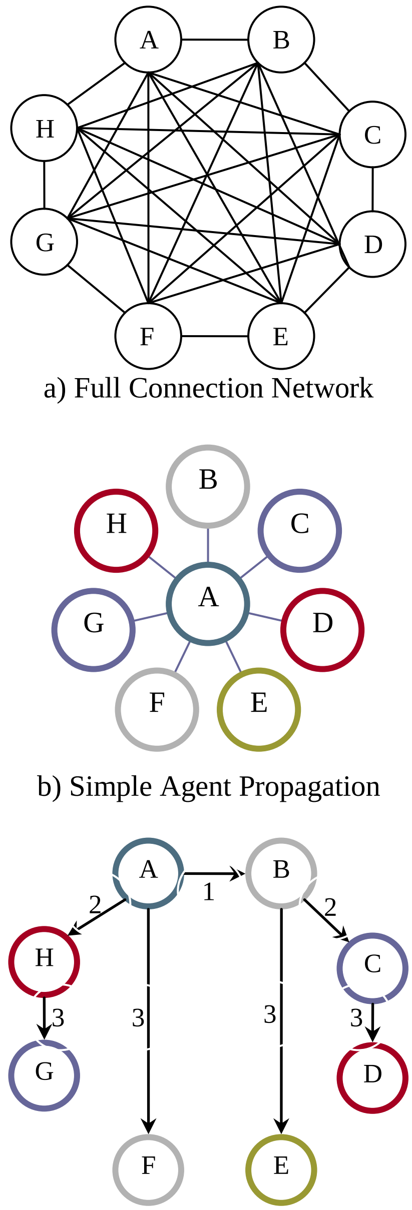
2.1 Adaptive Searching Optimal Tree

Definition 1 Adaptive Searching Tree (AST)

①The isolated node is a 0 rank AST;

②Suppose both T_1 and T_2 are *n-rank* AST, and their root nodes are r_1 and r_2, connect node r_1 and node r_2, then a new $(n+1)$-rank AST is created, and its root node r is node r_1 or node r_2.

③T is an *N-rank* AST If and only if T is created by step ①and step ②in limited times.



a) Full Connection Network

b) Simple Agent Propagation

c) 2-rank AST method

Figure 2. Comparison of different methods

Figure 2 c) is the example of 2-rank AST. In Figure 2, the node S is the information source node, and the number t on the link between every two nodes denotes that the information communication between these two nodes is finished in the t-th time tick.

Lemma 1 If T is an *N-rank* AST, then the number of the nodes in T must be 2^N

Proof:

(i) if $N=0$, according to definition 1, then we can conclude T is a 0 rank AST, and the number of the nodes is $2^N=2^0=1$. So Lemma 1 holds when $N=0$.

(ii) Suppose Lemma 1 holds when $N=k$, and the number of the nodes is 2^k.

Then, when $N=k+1$, according to definition 1, the $k+1$ rank AST is created by connecting the two k rank DBTs, and no more new nodes is added. So we can conclude the number of nodes in $k+1$ rank AST is $N=2^k+2^k=2^{k+1}$.

∴ Lemma 1 is reached by step i and step ii. $\blacksquare$.

Lemma 2 If T is an *N-rank* AST, then the diffusing delay time is N time ticks, which means all of the nodes will get the information after the *N*-th time tick.

Proof:

(i) According to definition 1, the diffusing delay time is 0 when T is a 0 rank AST.

(ii) Suppose Lemma 1 holds when $N=k$, and the diffusing delay time is N when T is an *N-rank* AST.

Then, when $N=k+1$, according to definition 1, the $k+1$ rank AST is created by connecting the two k rank DBTs, and no more new nodes is added. Denote node r_1 is the information source node in T_1; denote r_2 is the information source node in T_2; choose r_1 as the root node of the new created AST T. During the diffusing process, node r_1 will send the information to node r_2 first, and then node r_1 and node r_2 diffuse the information inside T_1 and T_2. So the total diffusing delay time is $D_T=\max\{D_{T1},D_{T2}\}+1=\max\{k, k\}+1=k+1=N$.

∴ Lemma 2 is reached. $\blacksquare$.

Deduction 1 Suppose the total number of the nodes in network G is Ω ($\Omega=2^N$), the information is diffused in accordance with definition 1, then, during the diffusing process, the delay time is N.

Proof

Deduction 1 will be reached simply by substituting Lemma 1 into Lemma 2. $\blacksquare$.

Lemma 3 Suppose the total number of the nodes in network G is Ω ($\Omega=2^N$), a K-way flash agent [Error! Bookmark not defined.] and a simple agent propagate all over the network G respectively. Then the two ways satisfy:

① if K<N, the Simple Agent propagate faster than the K-way Flash Agent.

② if K≥N, the Simple Agent propagate as fast as the K-way Flash Agent does.

Proof

First we prove ①. For the Simple agent propagating in network G, denote a_i as the new infected nodes at time tick i, denote A_i as the total infected nodes at time tick i, then a_i, A_i satisfies:

$$\begin{cases} a_i = \sum_{j=0}^{i-1} a_j \\ A_i = \sum_{j=0}^{i} a_j \end{cases} \tag{1}$$

For the 2-way Flash Agent propagating in network G, denote b_i as the new infected nodes at time tick *i*, denote B_i as the total infected nodes at time tick *i*, then, when $i \le K$, b_i, B_i satisfies:

$$\begin{cases} b_i = \sum_{j=0}^{i-1} b_j \\ B_i = \sum_{j=0}^{i} b_j \end{cases} \tag{2}$$

We conclude that, at any time tick $i \le K$, the agentss can propagate in the same speed. When $i \le K$, b_i, B_i satisfies:

$$\begin{cases} b_i = \sum_{j=1}^{k} b_{i-j} \\ B_i = \sum_{j=i-k+1}^{i} b_j \end{cases} \tag{3}$$

Hence $b_i<a_i$ holds at any time tick $i > K$. And the following inequation holds because $K<N$ holds:

$$B_i = \sum_{j=i-K+1}^{i} b_j < \sum_{j=0}^{i} b_j < \sum_{j=0}^{i} a_j = A_i \tag{4}$$

So we can conclude that when $K < N$, the Simple agent propagates faster than the Flash Agent does. ① is reached.

Second we prove ② in two situations. When $K = N$, according formula (1) and (2), we can conclude $A_i=B_i$ at any time tick. When $K > N$ ($N=\log \Omega$), the K-way Flash Agent propagate as fast as N-way Flash Agent in network G, and then we can conclude $A_i=B_i$ at any time tick.

∴ Lemma 3 is reached ■.

For the N-way Flash Agent, if N is too large, the agent will bring extra traffic load to network during propagating, and contrarily, it will spread slowly. Lemma 3 proves that AST propagation strategy is a time-optimal solution to K-way Flash Agent.

2.2 Generation Mechanism

In order to use the Adaptive Searching Optimal Tree strategy to generate the next IP address by an agent, a necessary and simple arithmetic should be given. We give the AST auto-generation mechanism including three steps:

① Pre-number the nodes in the network, such as the information source node is numbered 0, and the ordinal ones are numbered 1, 2, 3, …, Ω. Ω is the total number of the nodes.

②Denote *i* as the number of node A (except the leaf node), and denote son(*i*, *j*) as the function to compute A's *j*-th son node's number. Then son(*i, j*) satisfies:

$$son(i, j) = \begin{cases} (2 * i + 1) * 2^{j-1} - 1 & (i > 0, j > 0) \\ 2 * 2^{j-1} - 1 & (i = 0, j > 0) \end{cases} \tag{5}$$

③Repeat ②, and connect all of the nodes to the AST tree.

There're some favorable properties when the AST tree is generated based on the above mechanism, such as the followings:

- **Balanced:** During auto-generating process, at any time, any new node entering into the AST tree will not change the relationship between the connected nodes.
- **Absolute:** Any node in the AST tree can compute out all of its sons' number without any information communication.
- **Evenhanded:** Earlier the nodes entering into AST tree, earlier they get the information.
- **Precomputed:** For any given network, we can pre-generate the AST tree to forecast the propagation track.

The above properties are useful for the agent to traverse the cloud resource.

3. Simulation Experiments

We experiment with a resource management agent in a known cloud topology. First, the agent use AST scanning theorem, and then use sequence scanning theorem. We select the uniform sequence scan strategy as the comparison to the AST one. The results are illustrated in Figure 3.

The network model is the core of our simulation. We are looking for a model that is complex enough to represent prevalent characteristics of today's cloud. At the same time it had to be simple enough to enable efficient simulations. To highlight the traffic impact to network between these two strategies under the same condition, we assume that one packet passing through one link cause one impact to network and denote as τ.

Table 1. Parameters in the simulation

Parameter	Unit	Selected value
Endpoint Number	Hosts	20,000
Cloud Model	Simple directed connections	
Started population	Hosts	1
average collection rate	Hosts/Sec	1
Traffic Infection Factor	-	0.5

From Figure 3, we know that the propagation speed of AST agent is much faster than that of uniform scanning one. Note that: ①the active agent number begins to fall down after it reaches the maximum value since the agent are programmed to log out when there is no more scanning space; ②the maximum value of collected hosts in hierarchy scan is not as large as the one in uniform scan since the partition of network are not balanced. In this condition, the agents begin to probe inside the smallest block firstly will log out when there is no scanning space; Because we didn't consider about the topology factor in the mathematical model, which will enlarge the difference between two strategies.

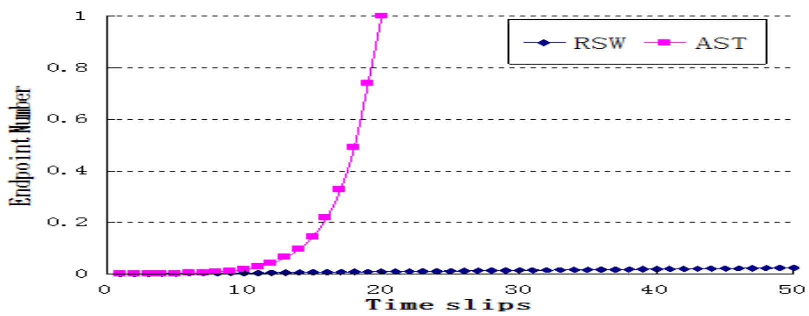


Figure 3. propagation comparisons among AST and RSW

4. Conclusions

By using the AST mechanism, resource management agent could reduce the traffic impact to network and increase the traversing speed obviously. Using the AST tree auto-generation method, the agent can pre-compute the spreading track to make the resource management much more traceable and controllable.The experiments show us the Simple agent can propagate faster and bring less traffic load to network than the traditional ones.

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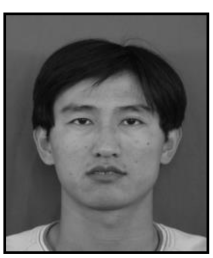
Authors

Wang Bailing he is working for Harbin Institute of Technology (abstract as HIT) as an associate professor. He got the Ph.D. degree from HIT in 2006. His research is mainly on information security, network security, parallel computing.

Wei Yuliang he is a master student in school of computer science and technology of Harbin Institute of Technology. His research is mainly on network security.

He Hui she is working for Harbin Institute of Technology as an engineer. She got the Ph.D. degree from HIT in 2007. Her research is mainly on network security and information security.

Liu Yang, Associate Professor, Liu Yang, his research fields include Network information Security Technology, Internet of Things Security Technology, *etc*. He has participated in many projects of Ministry of Information Industry and National Science, and he has published over 20 academic papers in journals and conferences both home and abroad.



Wang Xiaopeng he is working for Harbin Institute of Technology as an senior engineer. He got the master degree from HIT in 2012. His research is mainly on network security and application technology.