

## Network layer network topology discovery algorithm research

JIANXIA GE, WENYA XIAO  
 Center of Modern Education Technology  
 Xinxiang Medical University  
 Xinxiang, China  
 gjx@xxmu.edu.cn

**Abstract**—Along with the development of the network information age, people on the dependence of the computer network is more and more high, the computer network itself the security and reliability of becomes very important, the network management put forward higher request. This paper analyzes two algorithms of the network layer topology discovery based on the SNMP and ICMP protocol, based on this, this paper puts forward a improved algorithm of the comprehensive two algorithm, and makes the discovery process that has a simple, efficient, and has a strong generalization, and solved in the discovery process met the subnet judge, multiple access routers identification.

**Keywords**- *Network management; Topology discovery; SNMP; ICMP*

### I. NETWORK TOPOLOGY DISCOVERY

Network topology discovery is to obtain and maintain the network node existing information and connection relationship information between them, and on this basis to draw out the whole network topology. Network topology shows the existence of network devices and connections between them. Network administrators by the network topology structure of network information can be quickly locate fault, finding out the network bottlenecks, to more clearly understand the current network status, etc, so as to better manage and optimize the whole network.

At present, network topology auto-discovery in many ways, for the network layer topology discovery, this paper mainly discusses two ways, one is through the SNMP protocol access routers in the routing table, using the breadth-first traversal method; tow is to use ICMP protocol realized based on the depth of the ping, traceroute priority to traverse method.

### II. TOPOLOGY DISCOVERY COMMON TOOLS

Topology discovery tool commonly used a lot, this paper mainly introduces the following two.

#### A. *SNMP protocol*

Use the Simple Network Management Protocol (SNMP), a Management workstations can remote Management all network devices of support this protocol, including monitoring network status, modify network device configuration and receive network events warnings. etc. the SNMP protocol Using Management Information Base (MIB) management network devices configuration and

status information, each supporting SNMP is managed device maintains some MIB library. Among them, The most common is MIBII (RFC-1213) and Bridge-MIB (RFC-1493). In order to make the topology discovery process is versatile, select MIB-II as a topology discovery tool. MIB - II is made up of many different groups, the topology discovery algorithm used in the System, Interfaces and IP group<sup>[1]</sup>.

#### B. *ICMP protocol*

In the network topology discovery using mainly the Internet Control Message Protocol (ICMP) of the echo (response) request, echo response and overtime this three kinds of messages. Topology discovery tools commonly used in Ping is to use the ICMP echo message found network connectivity, and Traceroute is to use of ICMP timeout message found in the network path between two nodes.

### III. NETWORK LAYER TOPOLOGY DISCOVERY ALGORITHM

Network layer topology discovery is the routing table by querying the designated area of default gateway, find out a range of routers and subnet topology structure. Gateway and subnet can be thought network topology structure of the nodet, which gateway node is adjacent node of subnet and other gateway node , and subnet nodes can be thought gateway and adjacent node , at least adjacent with its default gateway, network topology automatically search is actually a graph traversal process<sup>[2]</sup>.

Network topology discovery algorithm principle is: through the use of standard protocols for Internet ICMP, SNMP, RIP and on the specified network devices checks, through all device nodes, because the relationship between subnets and routers as well as the router and the router can get from the routing table, use ipRouteTable to judge the topology of the network layer, then use certain algorithm can obtain the equipment routing information, so as to obtain network topology information<sup>[3]</sup>.

#### A. *Based on the SNMP network layer topology discovery algorithm*

##### a) *Algorithm thought*

Based on the SNMP network layer topology discovery algorithm is mainly through the SNMP protocol to obtain MIB and network topology information, and then to analysis these information processing, so as to obtain the

topological structure. Routers use the network layer defines the "logical" network address (IP address) to distinguish different networks, realize the network interconnection and isolation, due to host and router are kept with a routing table, the routing table clearly lists arrive at the destination of the next hop router, and MIB ( Management Information Base ) library of which have the abstract from the table, through the use of the SNMP protocol can easily get router routing table information. So, as long as the departure from the management station arrive at the next router of specified in the routing table, repeatedly executed until the destination IP routing layer can be found the found the network topology<sup>[4]</sup>.

#### *b) Algorithm processes*

First will be a router (usually is the default of administrative workstation router) as the starting point of the topology discovery, added to the router queue to be searched WaitDis\_list; then removed from the WaitDis\_list an IP as the analysis of the current router, by the SNMP reading the current router's MIB information database, get this IP MIB in the library in the ipRouteTable data; then traverse each record in the table, when ipRouteType = direct (directly connected), it Will ipRouteDest and ipRouteMask according to bitwise and operation, has directly connected subnet address information<sup>[5]</sup> and the router and the subnet connected information, added the subnet to the subnet queue, at the same time, the router and the subnet connection relationship added to connect queues; when ipRouteType = indirect (indirect connection), find the next hop router directly connected router ipRouteNextHop, if not discovered, add it to the router queue, and added ipRouteDest to be found router queue WaitDis\_list; then continue the search from the router to be in the queue WaitDis\_list remove the router IP topology discovery, until the search for the router queue WaitDis\_list be empty, when WaitDis\_list all IP were processed to generate the network topology structure.

### *B. Based on ICMP protocol network layer topology discovery algorithm*

#### *a) Algorithm basic idea*

ICMP protocol as TCP / IP protocol in a cluster, in the majority of network devices to be supported at the network layer topology discovery, mainly based ICMP protocol Ping, traceroute tool for topology discovery. The basic idea is to use the ping command to determine the active device's IP address, then traceroute Trace route to these IP addresses, to queue, get the router analyzes the relationship between the IP router connection information, and then testing multiple access routers, to send ICMP packets to get the network address and subnet mask address of the router interface IP address and analyze the subnet IP address, subnet router and get connected.

#### *b) algorithmic process*

First, ping the address space of all the IP addresses, the IP address will be added to the response to active queue AliveList, to determine the active device; then traceroute

Trace AliveList each IP address, the router will be found to have been found router queue RouterList, the connection between the router to add the link queue LinkList; and detection multiple access routers, combined under the same router a different IP address; to the activities of the IP address of the router sends an ICMP address mask request packets, access to network address mask, the mask and get the address for the IP address "and" operator to get the subnet address and subnet mask, the subnet to the child have been found in New Jersey out SubnetList. Finally, by analyzing the router interface IP address and subnet IP address, get a router and subnet, and connect the router and the subnet connected to the relationship in the connection queue LinkList.

### *C. Comparison of the above two methods algorithms*

SNMP-based algorithm using breadth-first traversal, SNMP protocol is a simple and efficient network management protocol, the discovery process efficiency, need only to traverse the router's routing table can get the topology information, but do not support or no SNMP hosts and routers can not be detected. Therefore, the advantages of the method is simple and found that speed, system and network overhead is small. Drawback is that versatility is not strong.

ICMP protocol-based approach, using the depth-first traversal, ICMP protocol is TCP / IP protocol suite in the part of the LAN is widely used for most network environments, common good. This method uses the ICMP protocol of the main ping and traceroute tools, due to the need to send a large number of ICMP packets, increasing the network load, also increased the time required to find, so this method advantage is versatility, the relative disadvantage is to achieve complex and found that slow, and found the results less than the accuracy of methods based on SNMP protocol high.

### *D. Network Layer Topology Discovery Algorithm*

#### *a) Improved algorithm basic ideas*

After thinking more on the two algorithms, the study of the actual network environment, the majority of current network devices support the SNMP protocol, only a very small part of the device does not support the SNMP protocol network management functions. Based on this situation, improved algorithm combines the topology discovery algorithm based on SNMP and ICMP protocols based on topology discovery algorithm, in the discovery process, give priority to the use of SNMP-based approach to search, when the encounter does not support the SNMP protocol network equipment, turned to methods based on the ICMP protocol. So that most of the network topology is used when the SNMP-based algorithm, making the discovery process is simple and efficient. While using the algorithm based on the ICMP protocol, with the discovery of small devices do not support the SNMP protocol capability, there is a strong commonality.

*b) Improved algorithm process*

Improved algorithm main steps: First, the IP address from the pending queue IP\_list (initialized to be the search for the entire range of IP addresses) to remove an IP address, ping the IP address, check the response, if no response, continue to take the address ; otherwise respond, to get the IP address belongs to the subnet address, and then get the subnet address of the default route will search its routing address to the router queue to be WaitDis\_list, and then search for the router to be out of a router queue WaitDis\_list, determine whether the router supports SNMP protocol, if supported, the router has been found to support added to the SNMP protocol SNMP\_list queue, use SNMP-based network layer topology discovery algorithm for topology discovery; if not support, added to the router is not found the SNMP protocol UNSNMP\_list queue, using the ICMP protocol based network layer topology discovery algorithm for topology discovery; then check the router queue WaitDis\_list be searched is empty, if empty, check IP\_list queue, otherwise, return again to take a queue from WaitDis\_list routers; check IP\_list queue is empty, if empty, end, or return from the IP\_list take an IP address, followed by cycle, until IP\_list queue is empty.

Algorithm flow chart shown in Figure 1.

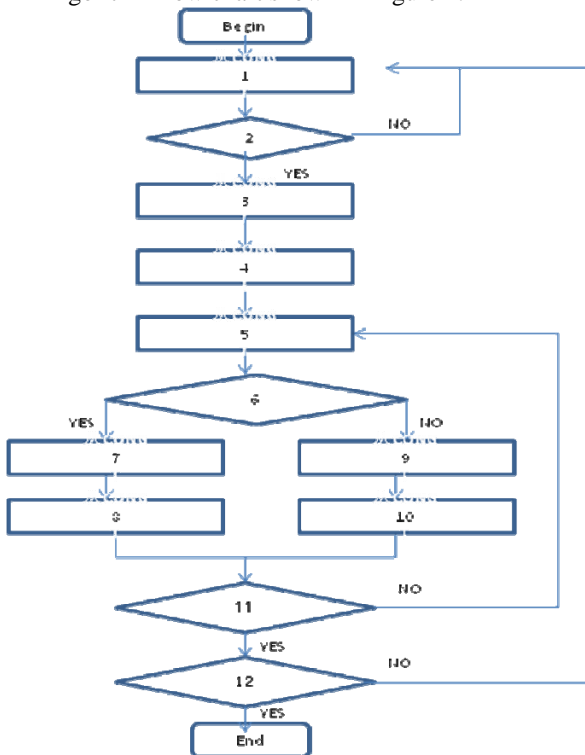


Fig 1 Flow chart of improved topology discovery algorithm at the network layer.

Flow chart notes:

1. Take a IP\_list from the IP address, Ping the address
2. response ?
3. Get the IP address subordinate subnet address
4. Get the subnet addresses a default route, join

- WaitDis\_list queue
5. From WaitDis\_list take a router in the address
6. Support the SNMP protocol?
7. add the router to the SNMP\_list queue
8. Based on the SNMP protocol algorithm for topology discovery
9. Add the router to the UNSNMP\_list queue
10. Based on the CIMP protocol algorithm for topology discovery
11. WaitDis\_list is empty?
12. IP\_list is empty?

Improved algorithm is as follows:

```

DisNetworkLayer(IP_list)
{
  While(! Is Empty(IP_list))
  {
    Ip =TestAlive(IP_list);           //step1
    Subnet = GetSubnet(ip);           //step2
    Router = GetDefaultRouter(subnet); //step3
    WaitDis_list.Add(router);
    While(! Is Empty(WaitDis_list))
    {
      r=WaitDis_list.MoveHead(); //step4
      if(Is Support SNMP(r)) // step5
      {
        SNMP_list.Add(r) //step6
        DisBased On SNMP(r, Subnet_list,
Link_list, IP_list);
      }
      else
      {
        UNSNMP_list.Add(r) //step7
        DisBased On Unsnmp(r, Subnet_list,
Link_list, IP_list);
      }
    }
  }
}
    
```

Step1. IP\_list the IP address for sending ICMP echo request packets to find an active device, the IP address will be visited to remove from the IP\_list. If IP\_list is empty, the algorithm terminates.

Step2. Step1 find activities to the device sends an ICMP address mask request packets to get the subnet mask, the IP address and subnet mask "and" operation to determine its own subnet address.

Step3. Step2 to get the subnet to determine the default router, add it to WaitDis\_list queue.

Step4. If WaitDis\_list queue is empty, then go to step1, or remove a queue from WaitDis\_list as the current router r.

Step5. R, by reading the current router MIB repository to determine whether the router supports SNMP. If not, turn step7.

Step6. The current router r to SNMP\_list queue. R as a starting point to the router, using the aforementioned

SNMP-based network layer topology discovery algorithm for topology discovery. Subnet will be found to have been found in the sub-Nets column Subnet\_list, and belongs to the subnet IP address of all remove the queue from IP\_list, while the current connection between the router and the subnet to Link\_list queue. Determine whether the next hop router has been found that if not discovered, to add it to WaitDis\_list queue. Turn Step4.

Step7. The current router r to UNSNMP\_list queue. R as the IP address of the search, using the aforementioned protocol based on a common network layer topology discovery algorithm for topology discovery. Subnet will be found to Subnet\_list queue, and belongs to the subnet IP address of all remove the queue from IP\_list, while the current router, the connection between r and subnet to have been found in the connection queue Link\_list. Merge tracking multiple access routers on the path, will not add to the WaitDis\_list found off the queue. Turn Step4.

#### E. Network Layer Topology Discovery object is discussed<sup>[6]</sup>

##### a) To determine the default router subnet

One way is to access the computer where the topology discovery process SNMP MIB II in ipRouteTable, if there are ipRouteDest record is 0.0.0.0, then the computer where the program has a default gateway, the record ipRouteNextHop value is the default gateway address. Check the default gateway ipForwarding value of 1 if, and to provide tertiary services network device, then that is indeed the default gateway routing device, or not, the method can search the multiple routing devices, and asked them the information stored in the routing table integration, greater network topology. The method is suitable for most devices support SNMP subnet agreement.

Another method is to use a broader applicability to detect traceroute activity of each subnet address, the results of the path in the penultimate hop router most frequently as the default router of the subnet.

##### b) The current router directly connected subnet discovery

SNMP protocol to be supported for the current router all directly connected subnet address. Directly connected subnet information obtained through the following two ways:

One is by looking ipRouteTable in ipRouteType = direct entry, and then ipRouteDest "and" get on ipRouteMask subnet address. However, in some cases actually ipRouteDest that a specific host or subnet addressing the merger of sub-Fabric together.

Another is through ipAddrTable table, which will be ipAdEntAddr and get the interface on the ipAdEntNetMask subnet. But when a router interface, floating, that is not connected, via the interface's IP address for the subnet to subnet for the excess.

In this improved algorithm uses a combination of two methods, namely, the above two methods were used to obtain a collection of two subnet address, and then take the intersection of these two set of addresses. Actually obtained by the above two methods are available subnet information.

##### c) Identification of multiple access router problem

The router supports SNMP protocol for the identification problem. In this improved algorithm, the selection of all the routers IP address and interface number corresponding to the formation of a linked list, as the router's unique identifier. Although this method is more information recorded, but the identity of the router can be accurately identified.

Do not support the SNMP protocol for multiple access routers identify the problem. Using an alias probe<sup>[7]</sup> approach to merge multiple access routers. Implementation of the principle of the method is based on RFC1122 specification, in the RFC1122 specification provides a router sends a packet or a connection of the original address selection rules, DNS can use this rule with a number of multi-site equipment Interface address mapping for the same name, by querying the DNS information to determine the multiple-access devices.

## IV. CONCLUSION

Network management domain are mostly automatic topology discovery algorithm based on the SNMP protocol, but for various reasons, not all network devices support SNMP protocol, and there is access to management competence. Traceroute-based tool for the ICMP protocol to discover the topology, while a more versatile approach, but more complex algorithms and found that the need for a long time. This article presents an improved level of management within the network topology auto-discovery algorithm, using the SNMP-based algorithms and algorithms based on ICMP combination of methods, making improved algorithm has both a fast and efficient, but also has a strong common of.

- [1] Jia Lli, Bingxin Shi. Topological network configuration found for research [J], Computer Engineering and Applications, 1998,34 (12) :23-24.
- [2] Hao Nie, Qin Xia. Network Layer Topology Discovery Algorithm [J], Heilongjiang Science and Technology Information .2010,22:88
- [3] Lijuan He, Donghong Wang. Based on SNMP protocol network layer topology discovery algorithm [J]. Journal of Shijiazhuang Vocational Technology Institute. 2009,21 (6) :58-60
- [4] Jiahai Yang, Xiankun Ren, Peiyu Wang. Network management principles and implementation techniques [M]. 1st edition, Beijing: Tsinghua University Press, 2005
- [5] Siamwalla R, Sharma R, Keshav S.Discovering Internet topology[C].In : Proceedings of IEEE INFOCOM, 1999
- [6] Ying Ma. Computer network automatic topology discovery research [D]. Chongqing University, 2007
- [7] Weiming Zhang, Junyong Luo ,etc. The routers in the network topology discovery research and implementation of alias recognition [J]. Computer Engineering and Applications, 2004, (13) :143-146