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An object-oriented model of IPv4/IPv6 network management

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Abstract

Since the exhaustion of internet protocol version 4 (IPv4) address in the immediate future, internet protocol version 6 (IPv6) will be introduced and coexist with IPv4 for a long time. Besides extended address space, aggregative routes, automatic configuration, improved security, enhanced mobility and support for quality of service, IPv6 will also introduce much more complexity to current network caused by transition technologies. In this paper, an object-oriented model of IPv4/IPv6 network management is proposed. The model adopts hierarchical network management architecture and distributed object-oriented database. It's composed of three main components: Monitor, Collector and Object-Oriented Database. Through the prototype system the model has proved to be flexible, reliable and scalable in the complex IPv4/IPv6 network environments.

Keywords IPV4/IPV6, network, management, hierarchical, distributed, object-oriented

1 Introduction

Since the exhaustion of IPv4 address in the immediate future, IPv6 will be introduced and coexist with IPv4 for a long time. To solve the problem of IPv4/IPv6 coexistence and IPv4/IPv6 transition, more and more new technologies will be adopted in the future network. The world largest pure IPv6 network CERNET2 has constructed IVI [1] transition system based on stateless protocol address translating technology. Comcast the largest internet service provider (ISP) in USA has proposed three phases' plan for IPv6 transition and started 6RD [2], DS-Lite [3] and Dual-Stack technology trials among its customers. At the same time, most network carriers such as T-Mobile, NTT, France Telecom, China Telecom, China Mobile and China Unicom also have prepared all kinds of transition technologies for the approaching of IPv6.

But, besides extended address space, aggregative routes, automatic configuration, improved security, enhanced mobility and support for quality of service, IPv6 will also introduce much more complexity caused by transition technologies to current network. So, the network management model towards the future network needs to become more flexible, reliable and scalable.

Network management model can be classified as three architectures: centralized, hierarchical and distributed. The centralized network management model relies on single management center. The whole network management will not work if any problem occurred in the management center. It's not suitable for managing large-scale network with high reliable demands. So, the distributed and hierarchical network management is more acceptable.

Simple network management protocol (SNMP) [4] is an application layer protocol that facilitates the exchange of management information between management station and managed devices. It has become the de facto standard in computer network management. The basic functions of SNMP are monitoring network performance, recovering network fault, configuring network device and so on. SNMP network management focused on some variables of the managed objects which describe the system configuration. The variables in management information base (MIB) are very simple and can't be inherited. SNMP is difficult to manage complex network with different transition

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technologies. So, object-oriented technology can be used in network management to abstract the model of managed devices and reuse the attributes of the models and the policies to the models.

Therefore, IPv4/IPv6 network management can utilize hierarchical management to improve reliability, employing distributed management to obtain scalability and use object-oriented modeling to enhance flexibility.

2 IPv4/IPv6 network management model

2.1 Overview

The proposed IPv4/IPv6 network management model adopts distributed object-oriented database and hierarchical network management architecture. It's composed of three main components: Monitor, Collector and Distributed Object-Oriented Database (OOD) [5] as shown in Fig. 1.

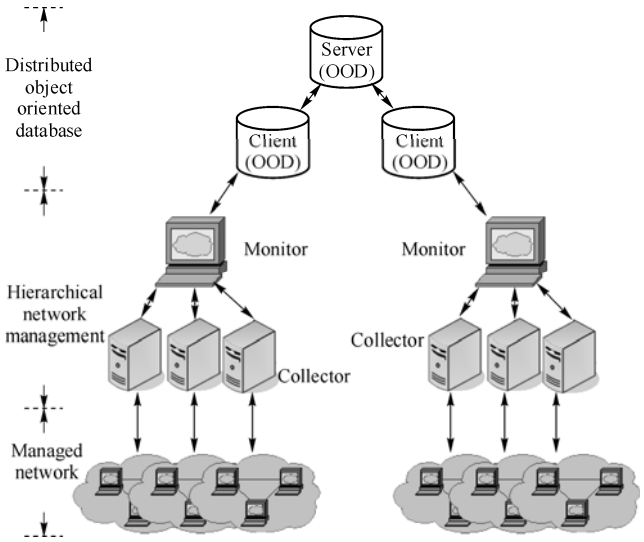

Fig. 1 IPv4/IPv6 network management model

The IPv4/IPv6 network may be divided into many isolated management domains by network layer protocol family, firewall or geographical scope. Any managed device identified by network layer address or domain name belongs to certain management domain. Managed device can be equipped with SNMP agent or secure shell (SSH) -based collecting plug-in to communicate with collectors. Agent and plug-in can not only receive, interpret and execute commands coming from collectors but also can operate on MIB and report the performance and events.

All the devices are supervised by a reachable collector within the same management domain. The collector can collect devices' information through SNMP or SSH channel. The former is supported by most network devices and the latter is very important when SNMP is not supported especially in some IPv4/IPv6 transition devices. Once the information is collected collector will process it and store the results in local round robin database (RRD) or relational database. Usually, real-time data such as throughput is stored in RRD database and statistical data such as online time is stored in relational database.

Many collectors in heterogeneous networks are managed by a reachable monitor through some predefined communication ports. The Monitor is responsible for providing collectors with the configuration data of managed devices, monitoring collectors' status and interacting with users. To improve the network management flexibility monitors obtain devices' configuration data from collectors, abstract the devices as classes and object which can be inherited and store them into the OOD.

The OOD used by monitor is distributed. There is a client of OOD resides on each monitor. All the clients are connected to the server of OOD and share the device objects with server on database level. Any client's fault will not affect the whole OOD and it can be recovered using the data from OOD.

2.2 Monitor

Monitor simultaneously listens on IPv4 and IPv6 connection. Therefore, the collector with pure IPv6, pure IPv4 or dual stack address can be effectively managed. Monitor is mainly composed of modeling module, performance collecting module, SNMP/SSH channel module, events module and user interface as shown in Fig. 2.

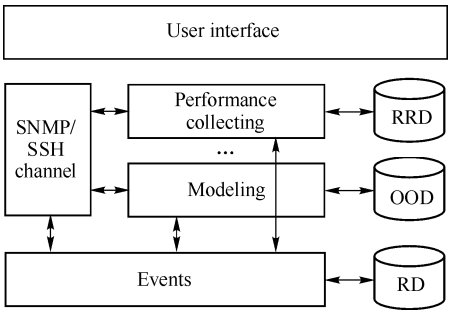

Fig. 2 Monitor

1) Modeling module

Modeling module can model managed devices through SNMP or SSH channel. Either channel can be used to collect detailed information from collectors and devices. The modeling module running on the monitors and collectors periodically, and use the results obtained from modeling to

construct objects. All the objects with detailed configuration data will be stored into the OOD and shared among monitors. The results obtained from modeling a collector with IPv6 address is shown in Fig. 3.

Fig. 3 Modeling results

2) Performance collecting module

The performance collecting module collects performance data and tracks its changes overtime. It is critical to know how much disk space is available, what the CPU load is and how long a web page takes to download. The performance collecting module runs on the collectors periodically and stores the data into local RRD.

RRD database is used to store and graph performance data. These data files have a fixed format dependent on their creation time, record data points and intervals. This data is later consolidated into coarser time units to reduce the total size of data files. The performance graph of an IPv6 collector is shown in Fig. 4.

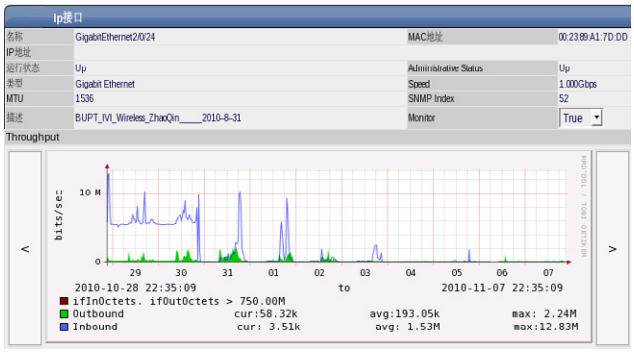

Fig. 4 Performance graph

3) SSH channel module

In case a device doesn't offer SNMP access, the SSH channel is used to establish connection between collector and monitor to start modeling and performance collecting.

4) Event module

When modules on monitor have detected failures or reached threshold, events are generated and stored in RD. Event module can generate different levels of alarm notification, waiting for system administrators to deal with them.

5) User interface

The system information feeds back to user through user interface based on hyper text transfer protocol (HTTP) protocol. User can access the IPv4/IPv6 network management system conveniently by any kind of web browsers.

2.3 Collector

Collector is responsible for modeling and performance collecting from managed devices. It is designed as Fig. 5.

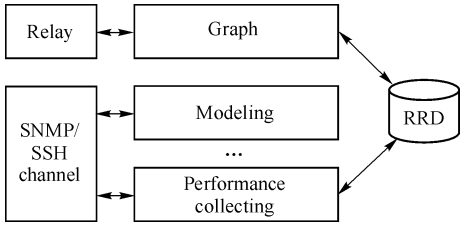

Fig. 5 Collector

Collector has a 'relay' module which redirects IPv4 and IPv6 monitor's graph requests to collector's graph module. The performance data is stored in collector's local RRD instead of in remote monitor's. So when monitor needs to show some appointed performance picture, the relay module will receive monitor's graph request and invoke graph module to generate performance graph using data from RRD.

2.4 Object-Oriented database

Object-Oriented database can simplify the traditional Objects to Relational mapping. If there are a lot of different types of objects in application and the relationship among them is very complex and mutable, relational database will not work very well. However, object database is particularly suitable for storing the configure information of managed devices and sharing them.

2.5 Communication mechanism

There are three communication methods between collector and monitor: SSH, representational state transfer (REST) and perspective broker (PB).

1) SSH

SSH the Secure Shell, is a popular and powerful, software-based approach to network security. The encryption used by SSH provides confidentiality and integrity of data over an insecure network, such as the Internet.

When we need to run plug-ins on collector and obtain the configuration data or performance data returned from it, we establish a SSH connection between monitor and collector, because SSH protocol can provide us a security and reliable transport channel to ensure the data not be changed during the transmission.

2) REST

REST is a method of marshaling data types and calling functions using HTTP which can reduce the complexity of development and increase scalability.

The network management model we proposed is object-oriented, so we can run any method of any object by using a simple URL by REST. Calls are in the following format:

username:passwod@host:8080/path_to_object/method_name?argument=value

3) PB

Perspective Broker is the protocol used for remote method calls and object exchange. This protocol is asynchronous and symmetrical. Use PB client can directly call the functions on server and get results returned from the functions.

In our network management model, there is a demon on monitor that in charge of connecting to object database also it has a collection of services that provided to other daemons. So the daemons on collector receive and transmit changes to object database and call remote methods of a particular service by establishing a PB connection with it.

3 System Performance and Safety

IPV4/IPV6 network management system is developed using Twisted frame. Twisted is an event-based and asynchronous network communication framework which allows programs to keep response when handling events without using threads. Twisted provides developers with a set of network and Internet communications tools and it has the advantage of high connection speed, high reliability and so on [6].

Abstracting network element as object will not only improve the development efficiency but also balance the load. The system is based on Twisted Asynchronous communication framework, which avoids single point failure and overcome the network bottleneck of C/S model. Meanwhile, through distributed database technology the object database can be shared credibly.

Monitor's and collector's own security is solved by a variety of firewall and antivirus software in this model but the communication security issue between monitor and collector node is more complex. It involves three aspects: first, mutual authentication between nodes; secondly, access authority of network node after the certification; finally is the problem of establishing a safety tunnel and the transmission of information among certified network nodes. The corresponding measures is to take SSH protocol to establish connection between two nodes. Through the methods above the data transmission's confidentiality, integrity and authenticity can be guaranteed.

4 Conclusions

In this paper, an object-oriented model of IPv4/IPv6 network management is proposed. It has been implemented based on the Twisted frame. It solved the problem that how to share data among multiple nodes effectively while greatly reducing the network traffic load. Through the prototype system the model has proved to be flexible, reliable and scalable in the complex IPv4/IPv6 network environments.

Acknowledgements

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