Research and Design of IPv6 Network Management and Operations Support System

Abstract:
IPv6 is the foundation of the development of Next Generation Internet (NGI). An IPv6 network management and operations support system is necessary for real operable NGI. Presently there are no approved standards yet and relevant equipment interfaces are not perfect. A Network Management System (NMS) at the network layer helps implement the integrated management of a network with equipment from multiple vendors, including the network resources and topology, end-to-end network performance, network failures and customer Service Level Agreement (SLA) management. Though the NMS will finally realize pure IPv6 network management, it must be accommodated to the management of relevant IPv4 equipment. Therefore, modularized and layered structure is adopted for the NMS in order to implement its smooth transition.

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1 Status Quo of IPv6 Network Development

The advantages of IPv6 over IPv4 are expanded addressing capabilities, improved manageability, security, mobility, and Quality of Service (QoS). Actually, IPv6 is designed to take the place of IPv4 used on current Internet[1]. As the trend goes, more IPv6-based Next Generation Internet (NGI) networks for experimental purposes are being built around the world. In addition, the IPv6 application is introduced to more and more countries as a response to the maturing NGI technologies and rising customer service requirements[2]. However, for the sake of an industrialized NGI and a manageable and operable IPv6 network, the problems of network management and operations support should be addressed first through technological means. In other words, to make the most of the NGI that features economy, high efficiency, and robustness, setting up a powerful network management and operations support system is no doubt a pre-requisite.

There are 3 features of the IPv6 network's development.

(1) Fast Network Development

Presently there are high recognitions on the IPv6 research and application. Japan and Europe have launched commercial IPv6 networks. China is building CERNET2, its second generation education and scientific research computer network that boasts the world's biggest pure IPv6-based backbone NGI. CERNET2 connects the core nodes in 20 major Chinese cities at the rate of 2.5-10 Gb/s, provides colleges and science research institutions with the 1-10 Gb/s IPv6 access service. It also connects to the international NGI via CNGI-6IX, the switch center of Chinese NGI. CERNET2 is a big step that China has taken in its infrastructure to further develop NGI technology and applications[3].

(2) Accelerated Standardization of IPv6

International standardization organizations like Internet Engineering Task Force (IETF), Third Generation Partnership Projects (3GPP), and International Telecommunications Union-Telecommunication Standardization Sector (ITU-T) are working hard on IPv6-related standards in their respective fields as IPv6 network construction speeds up around the world. These bodies work hand in hand on IPv6 standards regarding 3G standard implementation, addressing mode, handset-related device (router, agent server) support, Domain Name Server (DNS), security, Maximum Transmission Unit (MTU), network evolution, remote management, and mobile IPv6[4].

(3) Lagging Network Management

IPv6 network management requires the IPv6-based network management protocol and IPv6 network management information model, which are used by the

Network Management System (NMS) to exchange management information with the IPv6 devices. These technologies, however, are lagging behind the development of the IPv6 network and its standards as a matter of fact[5]. The IPv6-based network management protocol addresses the problem of running IPv4-related Simple Network Management Protocol (SNMP), Remote Monitoring (RMON) protocol, Internet Control Message Protocol (ICMP), System Log (SYSLOG) protocol, and Network Flow (NETFLOW) protocol on the IPv6 network.The IPv6 network management information model defines the Management Information Base (MIB) required to manage the IPv6 network. IETF is currently working on these technologies.

The IPv4 MIB used to be defined by RFC1902[6], while IPv6 MIB used to be defined by RFC2465[7] and RFC2466[8]. Both are now defined by RFC3291[9]. IETF has so far produced some MIB definitions related with IPv6 management in the following Request for Comment (RFC).

- RFC2096——IP Forwarding Table MIB[10]
- RFC2454——UDP MIB[11]
- RFC4022——TCP MIB[12]
- RFC2465——IP MIB

IETF is developing the definitions of mobile IPv6, Remote Authentication Dial in User Service (RADIUS) and MIB.

Presently, most IPv6 devices can hardly support SNMP, RMON, ICMP, SYSLOG, and NETFLOW protocols on a pure IPv6 network. All IPv6 experimental networks are running in a dual-stack (IPv4/IPv6) environment, and are managed in the IPv4-based SNMP access mode.

2 IPv6 NMS

Figure 1 shows 5 NMS function layers: the Network Element (NE) layer, network layer, service layer, transaction layer, and customer layer[13].

The NE layer NMS is usually provided by device manufacturers. It interfaces with the NE devices to perform NE configuration and collect information about NE status, faults and alarms.

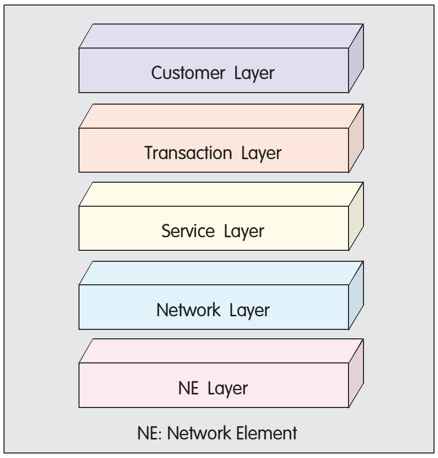
The network layer NMS is responsible for the network-wide monitoring and analysis. Its functions are:

- network topology monitoring and operation;
- network-wide resource collection and analysis;
- network-wide alarm report and handling based on the topology and resource data;
- centralized management of network management operations;
- network-wide configuration information collection and distribution;
- end-to-end network performance monitoring and analysis;
- flow direction and distribution monitoring and analysis;
- routing analysis and control.

The network layer NMS is always a general-purpose system and it uses the interfaces at the NE layer NMS to manage a network that is built up with devices from various vendors.

The service layer NMS is responsible for network services. It provides end-to-end service delivery, guarantee and monitoring in the customer service-oriented operations and maintenance mode. It further improves the network operations and maintenance work.

The transaction layer NMS is responsible for transactions related with the maintenance regulation and daily work including fault and service work order management, daily attendance, maintenance work planning and implementation. These are supposed to automatically streamline the operation and maintenance regulation through electronic means in a bid to boost customer satisfaction. The transaction layer NMS enhances network operations, maintenance, and enterprise management by combining their regulations.



▲Figure 1. NMS function layers.

The customer layer NMS provides service status report to customers outside the system including VIP customers and departments of an enterprise. The report helps rank the network carriers in service provisioning and serves as a shortcut to network service quality information needed by customers. The customer layer NMS focuses all its work on customer service to raise customer satisfaction to a new level.

The IPv6 network management and operations support system of today is able to deliver network layer NMS functions.

In order the IPv6 network management and operations support system to fit into real network applications and carrier-class network management, the system designers and developers are supposed to keep the following in mind.

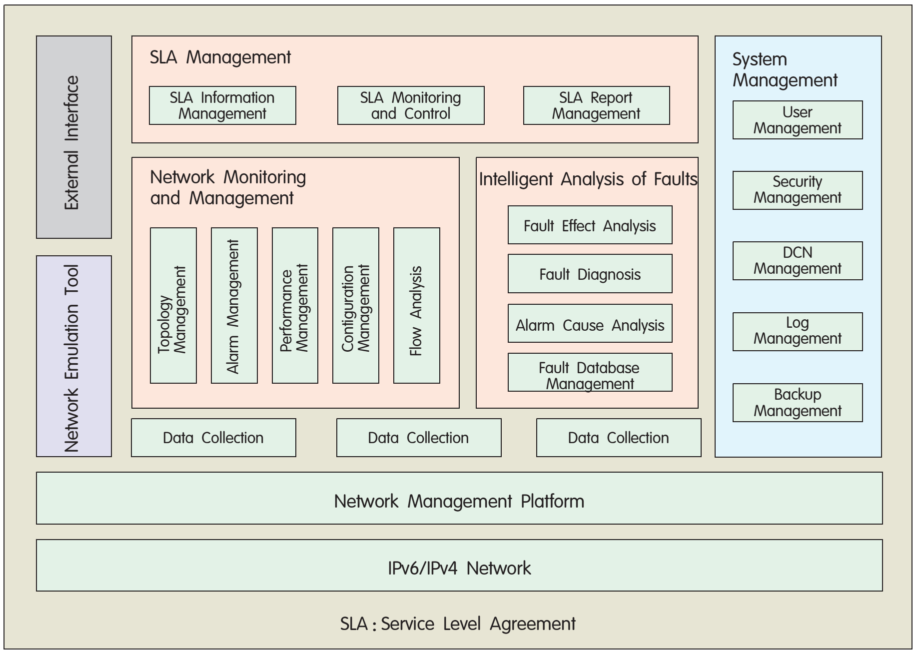
(1) Carrier-class Reliability

The NMS supports the telecommunications network by providing the telecom carriers with the network management service and the network status report. With the up-to-date knowledge of network operations, carriers are able to provide better QoS to their subscribers. As the telecom market competition scales up telecom QoS is all the more important, which in turn puts network management in more critical position.

The network management and operations support system will enhance the system reliability through all possible means (including software and hardware reliability). The NMS will use the distributed computation technology and modular design to minimize fault effect over the whole system. In addition, with its monitor module it can automatically monitor other software modules to detect and restart failing modules.

(2) Compatibility with IPv4 Network Management

The IP network takes a revolutionary process to be upgraded. IPv4 and IPv6 are destined to coexist for quite a while. This is why the NMS has to support both IPv4 and IPv6. To this end, the system



▲Figure 2. Functional structure of IPv6 based network management and operations support system.

will retain all IPv4 network management functions while expanding to support IPv6. It collects IPv4 MIB and IPv6 MIB information and the NM telecom protocol stack is adaptive to both IPv4 and IPv6 networks.

(3) Network Management Protocol Revolution Support

As the IPv6 network specifications and network management standards are being prepared the conformity of devices, with them is yet to be fine-tuned. Due to the product strategies of vendors, actually, there can be disparities in this conformity from vendor to vendor throughout the development path. This explains why the NMS should have the capability to integrate IPv6 devices from all vendors in a flexible and convenient way. It should also adapt to the NM protocol development based on Ipv4 and Ipv6 to support smooth upgrade. The system will support SNMP stack products based on Ipv4 and Ipv6. This way two NM telecom protocols (based on Ipv4 and Ipv6 respectively) can interconnect through simple configuration. The system should be available with the plug-in NM interface adaptation solution to put all different Ipv6 devices under its management frame in a flexible and convenient way.

(4) Openness

The system should be available with interfaces to connect with upper-layer NMS, peer application systems, and all NEs. It should support SNMPv1/SNMPv2C/SNMPv3 and RMON1/RMON2, which are standard NM communications protocols. It should be able to customize interfaces to provide special interfaces when necessary.

(5) Expandability and Persistence

The system should be able to fit telecom networks of all scales and layers. It can customize and expand functions easily. With its distributed architecture, new functions are added and the system is upgraded and expanded with least efforts. It should define unified internal interfaces so that when a new device is added, it only needs a proper collection module to include this device for management. It is also able to come up with enough processing capabilities to adapt to networks of a certain scale by way of changing host configuration or quantity.

(6) Ease of Use

The system only requires simple steps to be installed obviating the need of installing client tools. It takes the Browser/Server (B/S) structure and its interfaces are composed of user-friendly and illustrative Windows, Icons, Menus, and Pointers (WIMP).

(7) Security

The system should be able to guard against illegal operations and information theft. It will provide hierarchical user administration to control users' operation authority and their access to network resources. It has the log management function to keep track of users' logins and operations. It supports the Security Socket Layer (SSL) protocol to guarantee security of NM data when it is transmitted in a public network. Furthermore, all login accounts and passwords are transmitted and stored in the cipher text mode.

(8) Platform Independence

The system can adapt to sorts of hardware platforms and software environments as Operation System (OS), Database (DB), and more. It uses JAVA and related specifications and structure, including JDBC, JSP, and J2EE. It should adopt the middleware and third-party product that support various platforms, such as IPv4/IPv6 SNMP DB.

3 IPv6 NMS Design

Here we propose an IPv6 based network management and operations support system. Figure 2 shows its functional structure[14]:

The system consists of 3 logically independent functional subsystems: network monitoring management, fault intelligent analysis, and SLA management.

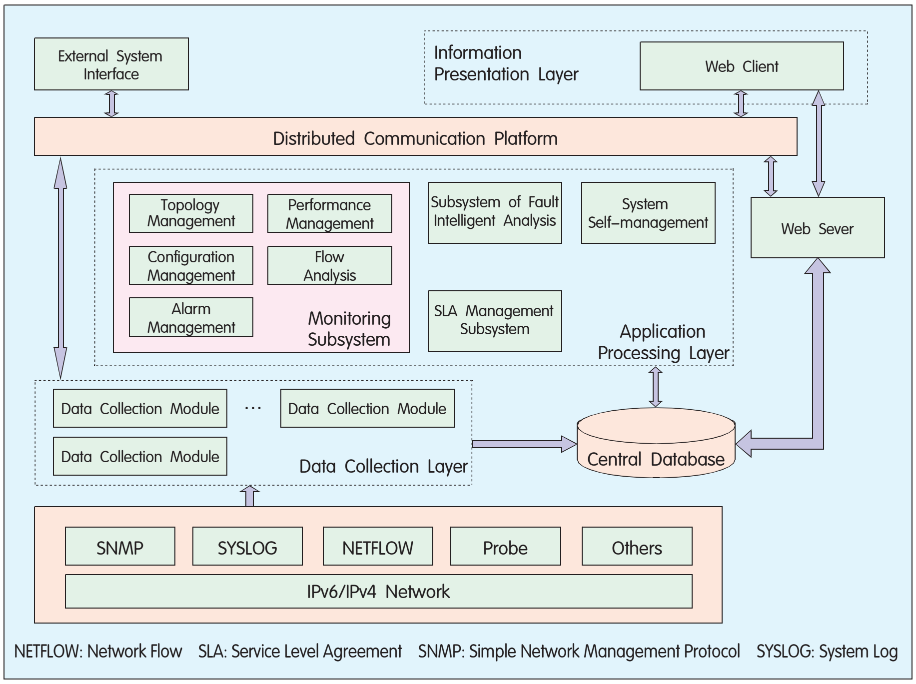
The network monitoring management monitors the configuration, performance, and faults of the IPv6 network[15]. The intelligent fault analysis analyzes the alarm relevance and locates the fault. The SLA management manages the service layer of IPv6 network and provides means to evaluate the general network status.

Besides the 3 subsystems just described, the system also delivers some common or supportive functions such as data collection, system management, network emulation, and connection to outside entities.

Figure 3 shows the software structure inside the system.

The system delivers functions from 3 layers: the data collection layer, application processing layer, and information presentation layer.

The modules on all layers are connected via the data bus and message bus. The data bus adopts



▲Figure 3. Software structure of IPv6-based network management and operations support system.

robust relational database while the message bus adopts the Common Object Request Broker Architecture (CORBA) platform. The data bus transfers non real-time data and mass data while the message bus transfers real-time data and interactive commands. The two transmissions are combined to promote the system's performance and efficiency. In addition, the distributed processing communication platform supports plug-and-play software modules, which further adds to the system's expandability and openness. That is to say, with more functions enabled in the system in the future, the system structure will just remain unchanged.

To help with the system's function expansion and integration, the system connects to other related systems via standard interfaces. Figure 4 shows the system interfaces that connect to external systems.

The interfaces are:

(1) Southbound Interfaces

The southbound interfaces connect the system to the network devices to collect information. They are SNMPv1/SNMPv2 and RMON1/RMON 2 interfaces. Such auxiliary interfaces, as NETFLOW, SYSLOG, and FTP are also southbound ones. However, the system may use a probe to collect the network's flow information if devices don't quite support the NETFLOW protocol.

(2) Northbound Interface

The northbound interface connects the system to the upper-layer NMS for information interaction. It provides the upper-layer NMS with the configuration data, alarm data, and performance data. It adopts CORBA, Extensible Markup Language (XML), Web SERVICE, and DB to fulfill its function.

(3) User Interface

The user interface connects the system to the users for interaction purposes. It uses B/S interfaces for display.

(4) X Interface

The X interface connects the system to other systems (such as the resource system and office automation system) to exchange information. It is customized to meet user information integration needs and uses XML, DB, and messages.

4 IPv6 NMS Deployment

The IPv6 NMS obtains management information from the network devices in either out-band or in-band modes. The out-band network management means the NMS uses a separate Data Communication Network (DCN) to obtain network management information from the special network management interface of the network devices. The in-band network management, however, means the NMS uses the service channels of the network devices to obtain network management information.

With the out-band mode, the network management information is independent from the service information but the required separate DCN incurs high network management cost.

Interestingly, with the in-band mode, the network management information and service information are mixed together but no separate DCN is needed.

Presently, the in-band mode is employed in the trial networks. Figure 5 shows the system deployment. Since most IPv6 devices support IPv4 SNMP, the network management and operation support center adopts IPv4-based networking.

Physically the system keeps all servers and collection devices in the network management and operation support center. The clients access the center via the Web.

The system has two servers, one for

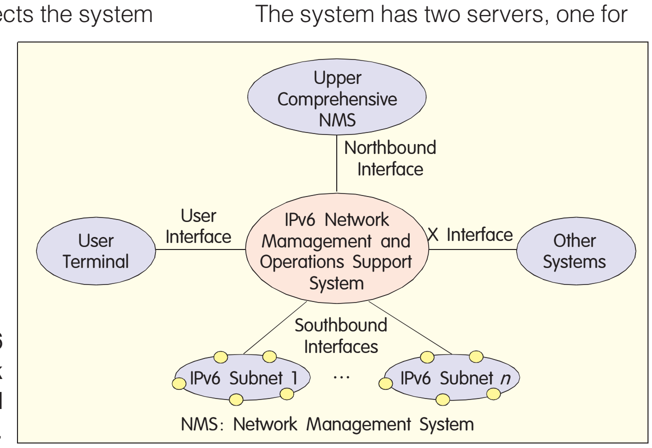


Figure 4.▶ External interfaces of IPv6 based network management and operations support system.

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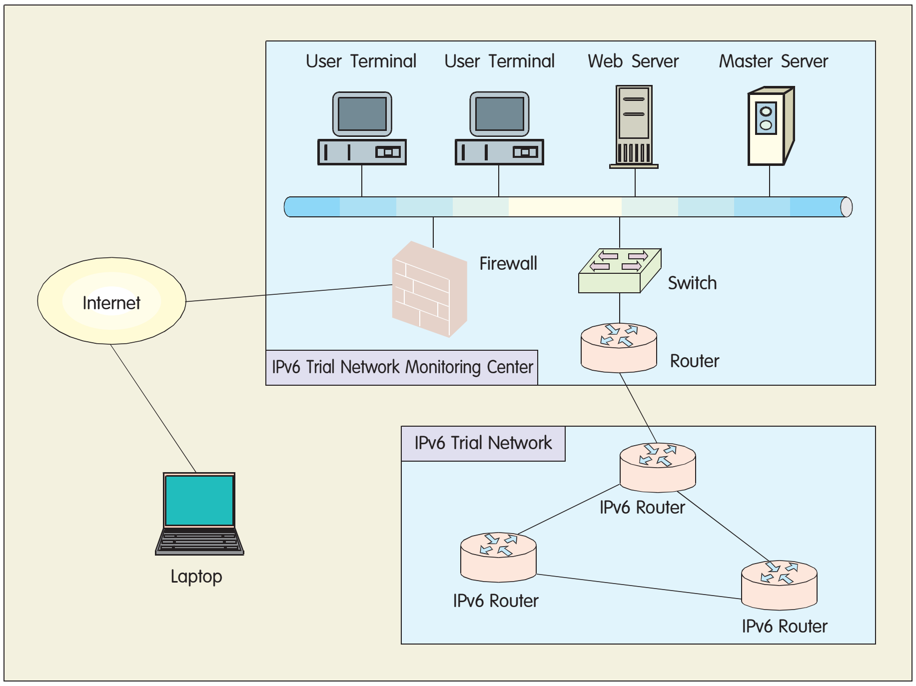

▲Figure 5. System deployment with in-band network management.

applications and one for the Web. The application server keeps all collection modules, application processing modules, and the database. It collects processes and stores network management information. The Web server accommodates the network management Web applications and provides B/S interfaces and processes user operations. For a small-scaled IPv6 trial network the server may be a workgroup UNIX server, for example, SUN V240. However, a PC server or other types of server are also possible.

5 Conclusions

In this experimental phase of the IPv6 network, the industry standards are yet to take shape and network applications are being tested. We hereby recommend the network-layer NMS. The NMS is supposed to manage the network with mixed devices from different vendors, in aspects of network resources and topology, the end-to-end performances, network failures, and customer SLA.

Most IPv6 networks of today use both IPv4 and IPv6 devices and the connection is made through tunnels, Network Address Translation (NAT), and more[16]. Therefore, the NMS has to include not only IPv4 but also IPv6 devices. As the IPv6 technology advances, the specifications of system and device interfaces become perfected. Therefore, the IPv6 network scales up, the NMS will only have to manage a pure IPv6 network with improved functions. The system architecture, modular design, and hierarchical design of the recommended NMS all ensure smooth transition from IPv4+IPv6 to pure IPv6 network management[17].

As the IPv6 technology, application, and NMS move forward, the research work has to focus on coordinated IPv6 network and NMS in order to popularize the applications. In turn it will be translated into large-scale commercial IPv6 networks and a new level of Internet technology.

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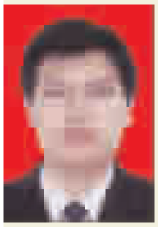

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