Cloud to Cloud: A Framework Model For Next Generation Network Management

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Abstract: With the rapid growing of the network scale and its capacity, the traditional peer-to-peer (P2P) network management model is not suitable. In this paper, we present a novel network management framework model called "Cloud to Cloud" (C2C). In this model, a number of management services are deployed on geographical distributed servers to form a management service cloud, and NMS uses services provided by this cloud to manage the underlying physical network cloud. This paper describes the general characteristics of the C2C model, and then introduces its architecture, information model, communication model and functional model. In the end, we give an implementation framework of C2C model in the wireless access network management.

Keywords: C2C, Services Cloud, Framework Model, Management Service

1. Introduction

In the past decade, there were dramatic shifts in the structure and role of computer networks and telecommunication networks. Especially, with the application of IP technology, the networks have become an indispensable part in the daily life of the public. Yet the technology still advents its way. The next generation network (NGN) is coming to us.

From the functional perspective, NGN is a broadband multi-service network, which can provide integrated and personalized services (such as data service, voice service, video service and etc) to the wired or wireless intelligent user agents. This implies that there will be drastic developments in network technologies, infrastructures and services. In such circumstances, the present OSI-based or SNMP-based network management system cannot satisfy such requirements. The traditional management systems are a kind of precise management system. And with the increasing of the network scale and the number of new services, the complexity of NMS (Network Management System) will be exponentially increased. This leads to the results that network management and network maintenance will be too costly to be supported. Therefore a new efficient network management paradigm for the NGN is required.

This problem has already received serious attention in both the telecommunication and network industries. Much work has been carried out to provide a management framework and technologies for networks and services. (E.g., Consortium of Telecommunication Information Network Architecture (TINA-C [1]), Telecom Operation Map (TOM [2]), Common Information Model (CIM [3])). More recent research mainly focuses on service management. Although [4] presents a very detailed model for service management, it doesn't consider service hierarchies. [5] proposes an architecture that uses contracts based on SLA (Service Level Agreement) to share management information across different boundaries. [6] presents a generic service model, however it is too sophisticated.

In this paper, we present a novel network management framework model called "Cloud to Cloud" (C2C). Cloud is defined as a set of functions provided by distributed servers or a group of physical entities. During the implementation, we deploy plenty of management middleware on many geographical distributed servers across the network to form a management service cloud. With the aid of management services hosted by this cloud, it is convenient for NMS to manage the underlying physical network cloud. C2C adopts an open service model, which is loosely coupled and

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dynamic with the system migration. In the following parts, we will introduce its main features in detail.

2. General Requirements of the Next Generation Management Model

Most of the traditional network management models are centralized and closed, and they are commonly in the Manager/Agent paradigm. Such paradigm can only perform limited management functions. Furthermore, in the future open service environment, it cannot execute effective management of new services. So new network management models should be established to cater for the requirements of the next generation network.

First, the model should evolve from the human-driven or element-driven style to the network-driven [7] style. In the early, most of the management tasks were carried out by human beings themselves. Later, with the development of NMS, the element-driven model got widely used. NMS can receive the events sent from network equipments once the fault occurs. Then NMS will report them to the operators directly without further treatment. It is the operator's duty to localize the fault and recover the network. During this period, network services may be suspended. In order to guarantee the service quality of customers, NMS must manage the network actively. Once faults happen, NMS are able to adjust the network and carry out certain management tasks by itself to assure normal network operations. The rescue tasks mentioned above include routing reconfiguration, root-cause fault diagnosis, fault recovery and etc. We call such style "Network-driven style", which means that the networks drive NMS to accomplish tasks, not just send alarm events to it. The similar idea has been realized in telecommunication networks, but its application in IP networks is still limited.

Secondly, the model should be distributed, rather than centralized. Compared to distributed management, centralized management is less efficient, especially the network may get out of control after failure of a single manager. But the question is: how to design a practical distributed management model? Our answer is management middleware. We will deploy plenty of management middleware over the network. The high-level management applications accomplish their tasks through the coordination of kinds of middleware. By middleware, the complexity of underlying network is transparent to the applications.

Thirdly, the new NMS model should be an close loop system with stable feedback, rather than a open loop system. With the feedback information, NMS could automatically carry out certain management tasks to make the network running normally. There is only a little human intervention in this process.

Besides the aspects described above, the management model should also satisfy the requirements of scalability, heterogeneity, data consistency, service integration, interoperability and etc. All these factors will greatly increase the complexity of today's management applications. Considering these new challenges, we propose C2C (Cloud to Cloud) network management model.

In the following sections, we will describe the whole management architecture of the new C2C management model in five aspects: management architecture, information model, communication model, functional model and management service platform.

3. Characteristics of C2C Framework Model

3.1 Management Architecture

For either CMIP-based TMN or SNMP-based Internet management system, their architectures are both relying on ITU-T Recommendations G.700 and G.701. The essence of such kind of architecture is application-centric. It means that the manager interacts with the agents in the devices directly, while the networks themselves do not provide any special service. With the increasing quantity and complexity of business services and networks, such paradigm looks evidently no longer suitable. In order to achieve more efficient network and service management, a great deal of distributed management services should be deployed on the networks. The network itself can provide support for NMS to make it more powerful.

Under such scenario, network control model should also be changed from P2P (Peer to Peer) to C2C (cloud to cloud). There are kinds of clouds, such as management application cloud, management services cloud and physical network cloud, as shown in Fig 1:

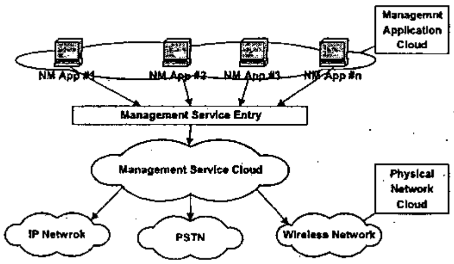

Fig 1. C2C (Cloud to Cloud) Model

Management applications can access the services provided by the management service cloud through the service entry. Management service cloud looks like a middle layer, which make the complexity of underlying heterogeneous networks transparent to the up-level applications. The management applications invoke these services to accomplish management tasks, without interaction with agents directly (Fig 2).

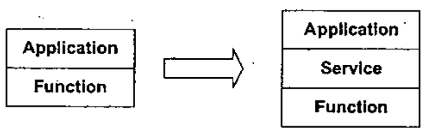

Fig 2. Migration of the management invocation style

Furthermore, we can also abstract C2C model into four layers: computing layer, management component layer, management service logic layer and management service entry, as shown in Fig 3:

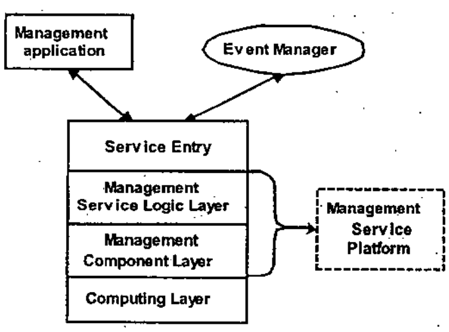

Fig 3. Abstract model of C2C

Among them, the computing layer is the foundation of all above layers, which provides distributed computing capacity for the up levels. The management component layer and management service logic layer together form the management service platform, which is a cloud that hosts a number of management services. The management service platform spans across the whole network and is the fundamental part of the whole system.

Above it is the management service entry. Both the operators and applications can invoke certain management service through this entry. Such entry is not only a simple directory, and it also hosts several specific services of its own, such as relationship service, authentication service, naming service and etc. Meanwhile, the service entry provides an open interface for the event manager, which can collect events from the network and trigger NMS to do some adjustment.

The whole model is loosely coupled and scalable. Within such framework, management applications will be much easy to develop.

3.2 Information Model

Traditional OSI-based management systems adopt an object-oriented information model. In such model, MO (Managed Object) is an instance of MO class. Its proprietary interface specifies the attributes, operations, notifications and behaviors abstractly. GDMO [8] (ITU-T X.722) is one kind of model, which is a modeled by object-oriented method and mainly used in TMN. But its complicated definition limits its application.

In contrast with GDMO, SNMP-based Internet management information model is too simple. It is data-oriented instead of fully object-oriented. Due to lacking OO features (such as inheritance, allomorphism, containment), such model is hard to be reused. From the telecom operators' perspective, it is difficult to operate on telecom equipments. However, MIB-II, one kind of managed object model, has got widely used in IP networks for its simplicity.

Neither of them is satisfactory enough. Practically, it is unrealistic for us to define a generic template for all the MOs. Different MOs have different management characteristics, considering its attributes, activities and relationship with other objects. So we propose a function-oriented (FO) information model with OO features, as shown in Fig 4.

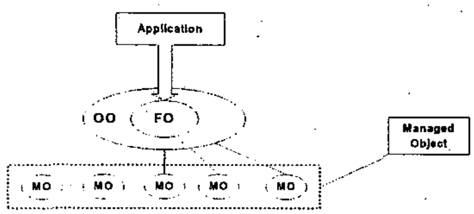

Fig. 4. Function-Oriented object and relationship description

Such model allows two types of management operations. From the perspective of management applications, it is function-oriented, which simplifies management invocations. On the other hand, from the view of MOs, the model is object-oriented. In this way, it is easy to describe the behaviors and relationship of MOs.

3.3 Communication model

In the communications model, there are three kinds of entities, which are management service requester, service registry and management service provider. Their activities include service publication, service query, service invocation and etc, as shown in Fig 5.

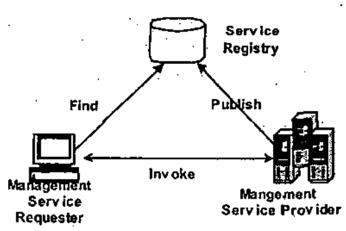

Fig 5. Entities in the Communication model

Normally, management service provider is the owner of the management services. From the architecture perspective, it is the platform that hosts the services and publishes the management service description and invocation information to the service registry. Service registry maintains the information about management services, and provides query and authentication functions to management service requesters. The requester can retrieve a management service's description (or invocation information) directly or by querying the service registry for such type of service. After that, the requester can initiate an interaction with the provider to accomplish certain management tasks.

The data structure and communication protocols are defined based on XML (eXtensible Markup Language) format. XML will simplify the exchange of information between different entities. The entities can use their common DTDs to exchange information with each other, regardless of their internal format. It is not necessary to revise the interfaces of NMS when new functions are emerging. Such features of NMS greatly improve its capability of supporting dynamic services.

3.4 Functional model

The functional model of C2C includes not only the five traditional OSI management areas (FCAPS), but also many common functions.

The architecture of the functional model is a multi-level hierarchy structure, where services at a higher level are built from lower level component services. We identify four levels of these services: System Services, Infrastructure Services, Application Services, and Integrated Services [9], as shown in Fig 6.

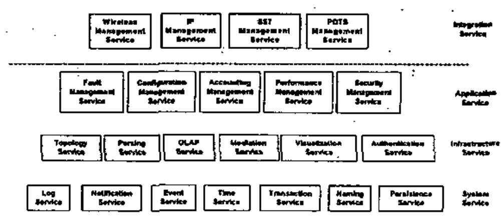

Fig 6. Functional model of C2C

System Services layer includes services such as Log, Notification, Event, Time, Transaction, Naming, Persistence and etc. These services form the core set of distributed services that are used for building the next level of services. Infrastructure Services layer contains significant management services, such as topology, parsing, OLAP, mediation, visualization, authentication and etc, whose functionality and implementation are oriented toward specific network management tasks. Application Services layer includes not only FCAPS services, but also QoS management service and testing service. They are built from the Infrastructure Services. At the top level of the service hierarchy, Integrated Services are formed by instantiating and combining Application Services. They can also invoke the underlying other services.

3.5 Management Service Platform

Management service platform is the core part of the whole system, which can be divided into two layers: management service logic layer and management component layer. The two layers can collaborate together to provide management services to the above layers. Management applications can invoke required management service to accomplish their own tasks through the service entry.

Considering a single management service, it is composed of two parts:

(1) Management Components, which are the functional elements of the platform. They can be coordinated together to provide specific management services.

(2) Service Logic description, which defines the running sequence and state transition of management components.

If needed, the management component also can invoke other functional components by links. The relationship between the two parts is shown in Fig 7.

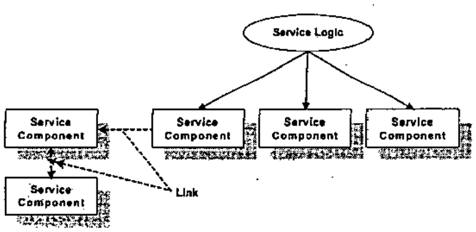

Fig 7.Service logic and management components

Meanwhile, by the separation of the abstract description of service logic and management component from their corresponding implementation, providers are able to realize their management services according to their local environment without restricting or implying a particular implementation. Considering the requirements of scalability and robustness, the implementation of management components and service logic is totally distributed. They can be deployed on several different servers, and run on another server.

In such framework, with the increasing of new management components, the management service platform can provide more and more management services to the up layers.

4. An Implementation framework of C2C model in Wireless Access Network Management

To demonstrate the advantages of C2C model, we propose a new implementation framework for wireless access network management using C2C.

One of the most important issues in wireless network management is Access Network Management, which is difficult because of the diversity of its equipments. In order to solve it, we deploy many servers on the wireless core network and the access network. By adding distributed middleware, these servers form a huge management service cloud. The up level management application can invoke the management services in the cloud through service entry to accomplish management tasks about the equipments in the access network. The framework is shown in Fig 8.

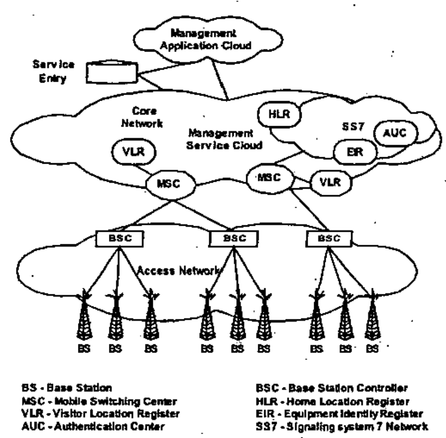

Fig 8. Wireless access network management using C2C

5. Conclusion

This paper proposes an innovative network management framework model "Cloud to Cloud" and describes its architecture, information model, communication model and functional model individually. This kind of management model aims at solving the management problem of NGN. It can migrate dynamically with the network upgrade and facilitate the development of NMS. However, by now, C2C model is incomplete and need further consideration.

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