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A Satellite Network Management Architecture based on Mobile Agents and SNMP

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Abstract. With the application of different kinds of satellites, the satellite network will be one heterogeneous and complex system, then the satellite network management is more difficult and the classical network management architecture cannot be applied to the satellite network directly. Aimed at the new features of the satellite network, a hierarchy network management architecture is proposed and a new satellite network management system based on mobile agents and SNMP is developed, which takes good advantage of the mobile Agents and SNMP's merits respectively. The simulation results show that the new satellite network management reduces the network traffic load and resolves the problem that the satellite's moving brings.

Keywords: network management architecture, mobile agent, SNMP.

1 Introduction

In the recent twenty years, satellite technology has developed rapidly in the world. Especially, satellite application has come into constellation mode phase with the emergence of small satellites. A satellite constellation is composed of several satellites in the appointed orbits, which can provide better area coverage and longer coverage time. Constellation mode technology is maturing and has been successfully applied. Emerging constellation is the necessity of the development of space technology: because it can cover the whole earth and be affected little by geographical environment. Especially, a constellation can complete a complex mission that is difficult for single satellite. It is also impossible for small satellites to replace satellites on some functions. Therefore, the space in the future will be a complex and heterogeneous satellite network consisting of all kinds of satellites. To guarantee the reliability of such network, a new network management architecture is needed, which is just the core of this paper.

The remainder of the paper is structured as follows. Section 2 introduces classical network management protocol and a new technology in network management - mobile agent; Section 3 presents a layered satellite network management architecture based on mobile agents and SNMP; Section 4 shows the simulation platform and program implementation; Finally, the last section concludes the paper.

2 The Introduction Of Classical Network Management And Mobile Agent

2.1 Classical Network Management Protocols

At present well-known network management protocols include SNMP (Simple Network Management Protocol) used in Internet and CMIP (Common Management Information Protocol) used in ISO networks. The latter has been a formal international standard since 1990, but developed slowly as a result of

complicated implementation and high cost; On the contrary, almost all network producers support the former because of its simplicity so that it has been an applied standard.

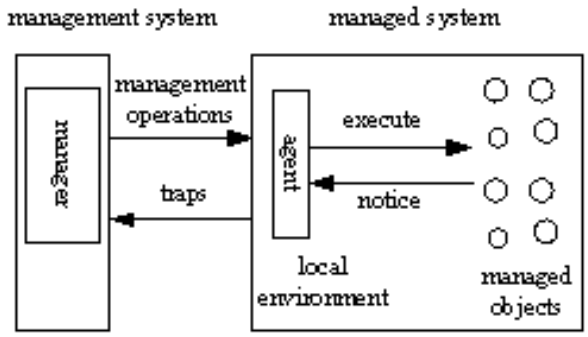

Figure 1 Classical Network Management Modle

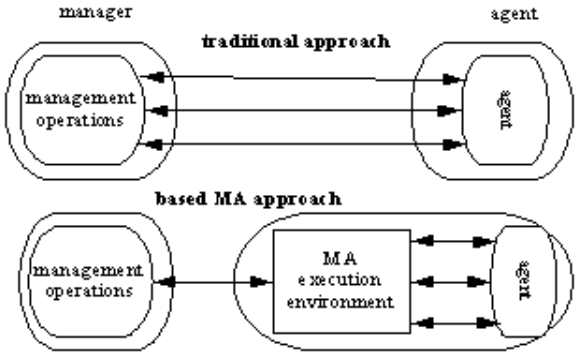

Figure 2 Moblie Agents Reduce Network Load

In Classical network management, manager-agent model is adopted widely (figure 1). In this model, the manager gathers information about managed devices from the agents that reside in managed devices and react to events from the agents; it is the agents' task to collect information of managed objects and report it back to the manager.

2.2 The weakness of classical network management

The management station is needed to handle all management information, which increases network load and makes network easier to get congested. In particular, in some large network, polling mechanism leads to delay and more network load. The network management system excessively depends on management stations, therefore once the management station fails, the whole system will collapse, which means bad reliability.

2.3 Mobile agent

The research of mobile agent originated firstly from artificial intelligence; however, it has been widely applied to distributed system, software engineering, communication and so on. The most prominent characteristic of mobile agent is mobility, and it is abstractly defined as a program that is able to finish user tasks automatically and not bound to the system where it executes, and transport its code within the network, then continue to execute on the destination system. Mobile agent differs from classical agent in three ways: (1) mobile agent (MA) is an independent object-driven application program; (2) MA can move within heterogeneous network environment according to some rule and look for proper computing resource and information resource to handle these resources;(3) MA can keep its status during moving and continue executing after moving. Now mobile agent has been applied into network management field [1][2][3]. Its advantages [5] are as follow:

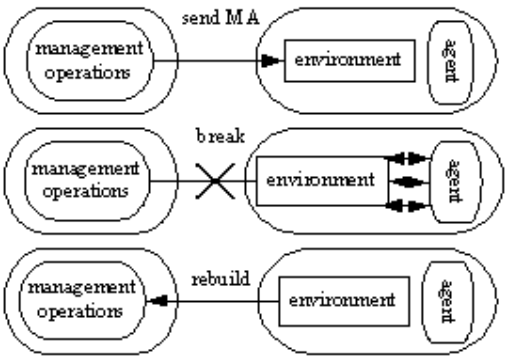

Figure 3 Moblie Agents Execute Asynchronously

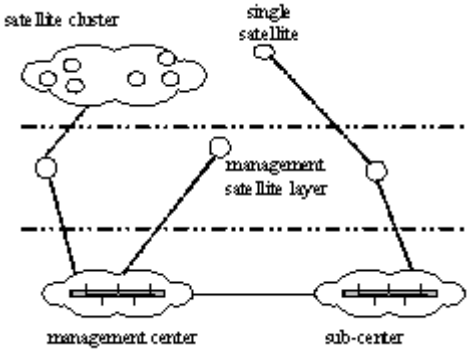

Figure 4 The Layed Architecture of Satellite Network Management

• Reducing network load.(Figure 2) In classical network management, management systems need several PDUs (protocol data unit) to finish an operation so that a lot of messages exchanges take place

between the manager and managed nodes. To finish the same operation, a MA can save bandwidth and reduce network load by being dispatched to the managed nodes, executing and retrieving the result.

• Reducing network delay. A mobile agent containing many operations is sent the managed node and executes code locally, consequently this mechanism reduces communication between the manager and the managed nodes to avoid network delay.

• Autonomy and synchronism illustrated in figure 3. In classical client/server model, network connection must keep till this service finishes using request/response model. However, after sending codes, data and status, a mobile agent executes autonomously. This makes it unnecessary to keep the connection between the manager and the managed nodes. When the execution finishes, the connection can be rebuilt.

• Platform independent. A mobile agent only depends on its execution environment, which provides a best choice for seamless system integration.

3 A new satellite network management architecture

3.1 The features of the satellite network

Compared with classical network, satellite network has many features:

•The nodes in satellite network is mobile. This means that the topology of satellite network is dynamic; consequently, it is more difficult to maintain communication links than in classical wire network.

•Satellite nodes are heterogeneous. The satellites in satellite network may be completely different. Hereby, the management architecture must be cross-platform.

•Satellite bandwidth resources are limited. The presented new network management architecture is required to try to save consumed bandwidth.

•Communication is high-delayed in satellite network. Especially, inter-satellite link lengthens the delay time, so does the communication between the management stations on the ground and the satellites.

3.2 The layered structure of satellite network management

• Satellite constellation

A constellation composed of many satellites that are designed in scheduled orbits retrieves and transmits information to provide ideal coverage to the earth. Such as, constellations of LEO small satellites, MEO satellites can cover the whole earth; The network is more invulnerable, and less satellites are broken, therefore the system can remain normal and the broken satellites can be replaced with the new ones in a short time; It can reduced delay during transmission; These characteristics make constellation technology used widely in the fields of military, government, industry and so on.

• The layered satellite network management

To avoid the disadvantage of centralized network management, we divide satellite network into several layers (figure 4).The first layer consists of satellite constellations and single satellites; The second layer consists of management satellites; The last layer consists of network management stations on the ground. Three globe Geo stationary satellites, spaced at equal intervals (120 angular degrees apart), can provide coverage of the entire globe, so the management to constellations and single satellites is fulfilled in these satellites called management satellite layer. The mechanism that a large complicated network is layered into some small simple networks and controlled layered effectively alleviates the load of network management stations on the ground.

3.3 A new satellite network management system

In view of the characteristics of satellite network, mobile agent technology is very fit for future satellite network management. But there is an experiment [4] showing that mobile agent only plays better advantage than SNMP only if the number of management nodes exceeds some amount. Whereas SNMP plays better advantage if there are less management nodes. Hence we present the satellite management based mobile agent and SNMP in the infrastructure of layered satellite network management, considering the specific characteristic that satellites have limited resources.

• The structure of management stations on the ground

The main parts included in a management station are as follows:

GUI(Graph User Interface):A user manages the whole satellite network through it.

Mobile agent generator: According to the mission type, a mobile agent is generated, which includes data, status and transferring nodes etc.

Execution environment for mobile agent: It includes a serial operation methods and modes of communication, security authorization and so on.

Communication control module: It adjusts the antennas on the management stations on the ground and establishes communication with management satellite layer.

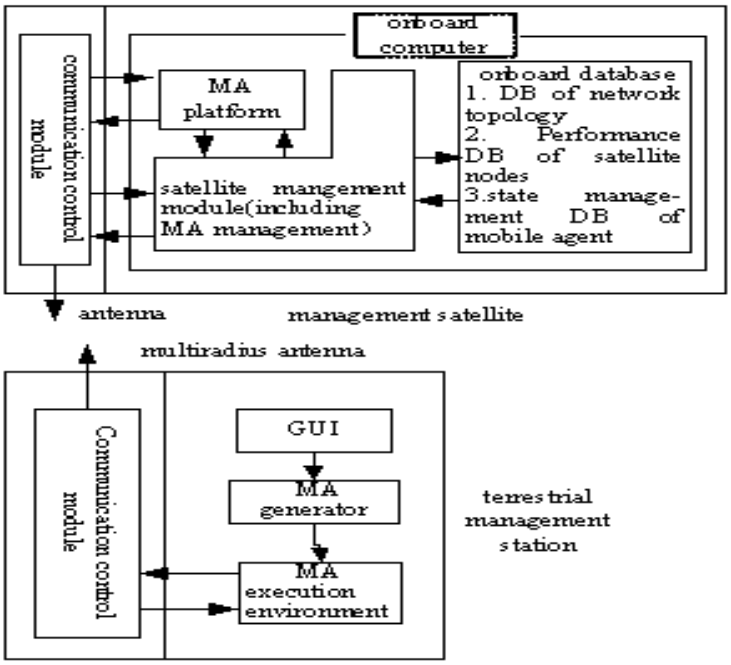

Figure 5 The Syetem Architecture of Satellite Network Management

• The structure of management satellite

The resident management program in globe Geo stationary satellites fulfills network management, mission management and mobile agent management.

The execution platform for mobile agent executes the mobile agent from network stations on the ground and communicates with satellite network management module.

The database of network topology maintains the network topology (satellite ephemeris, orbit parameters, runtime). A satellite network is a highly dynamic network, in which resource sub-networks and communication sub-networks dominated to a management satellite are always changing. In the condition of such satellite network divided into constellations and single satellites, satellite management layer is only needed to communicate with the host satellite (backuping the status of other satellites in the constellation or single satellite) in order to know the status of other satellites timely. Thus, every globe Geo stationary satellite management station is only needed to maintain all mission host satellites and single satellites within its vision range. When a constellation host satellite enters the vision range of a globe Geo stationary satellite, and authenticates, logins, writes some information such as its type, ID, login time, login location, load status (the status of mission) and orbit parameters into the database on synchronous management station, then synchronous management station loads the parameter records correlated with name identifier from authentic satellite parameter sub-database to finish the second authentication. When leaving for other globe Geo stationary satellite range, it logouts from old globe Geo stationary satellite management station. It simultaneously gathers mission execution status and transfers the mission. Consequently, network flood arosed by frequent registration and logouting in the satellite management layer is obviously reduced. Topology sub-database also maintains topology list about other globe Geo stationary satellite stations so as to relay and forward the missions (communication, data collecting) that are not in its range.

Performance database of satellite nodes contains performance parameter tables of all satellites (mission satellite, relay satellite etc.) entering globe Geo stationary satellite range. The data in these tables are updated through periodic query to all satellites. Classical SNMP is adopted to fulfill this kind of query, whereas mobile agent is adopted to finish the query to globe Geo stationary satellite from management station on the ground. Only when there are more management nodes, mobile agent will have the obvious advantage over SNMP, on the contrary, we divide satellites into several mission constellations, moreover, every constellation doesn't consists that many nodes. So SNMP will be more adaptive. But as far as management system on the ground is concerned, it is impossible for it to keep a costly satellite link to get useful performance parameters for a long time, which doesn't accord with the basic requirement of network management. In addition, satellite network is a dynamic network, so its topology always changes. Applying mobile agent for flexible network performance management exactly fulfills this requirement. The performance database table of satellite nodes consists of some contents: the status of satellite, which includes error for satellite ephemeris parameters (change of recycle), power status, communication status; the load status of mission satellites; the status of communication satellite, the quality of communication; the run pose of relay satellite and the status of link.

The status management database of mobile agent maintains the location registration tables of all mobile agents and the run status of all agents (including tasking MA, collector MA, massager MA). As for collector MA and massager MA, it tracks the situation of a mission, adds and deletes the registration of MA, receives and stores the returned results which are possibly handled and forwarded through the system on satellites of MA. As for mission MA, it is responsible for maintaining and recording the status of mission execution. When a mission satellite roams beyond the range, the database must record the status of mission execution, then transfer mission MA to another mission satellite within the range.

4 Simulation and implementation

4.1 Simulation environment

The simulated environment is shown in figure 6. In the LAN, a server simulates the management center on the ground in the satellite network, two computers simulate the satellite management layer and three computers simulate the satellites. The host in the simulated management layer is called as management host. The host deployed SNMP agent simulating satellite is agent host. Agent host1 and agent host2 simulate the mission constellation, agent host3 simulates single satellite. When some mission is needed execution, the server generates a MA, sends it to the management host. The management host executes the code of the MA to get useful information from the agent hosts with SNMP and returns the results to the server.

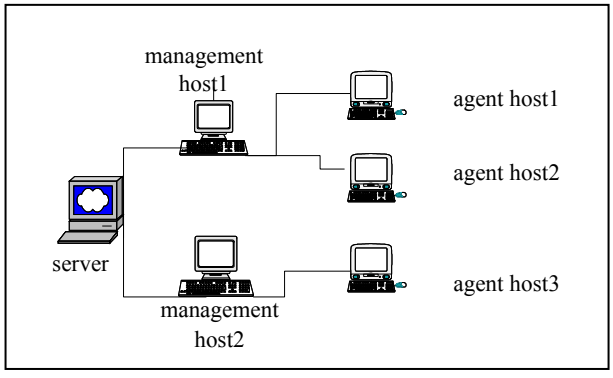

Figure6 The Simulation Environment of Satellite Network Management

4.2 Simulation results

Taking the high delay and limited resource of satellite network into consideration, we emphasize the statistic and comparison of its latency and bandwidth. One model is that we get the values of different managed objects from the agent hosts with SNMP, then compute results and record the response time and traffic. The other model is that the server generates a specific mission MA whose mission is to get the average of 10 data, transfers it to the management host, then the management host figures out the results

according to the data from the agent hosts with SNMP and returns the results to the server. Figure 7 shows the comparison between the two models in response time and traffic.

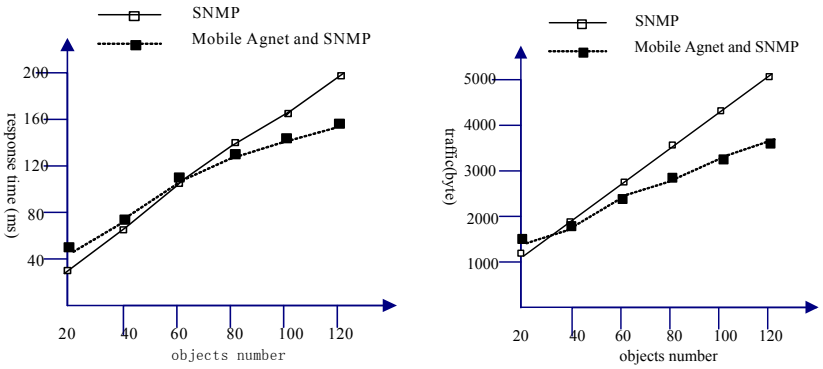

Figure7 The Comparison of response time and traffic

The result shows that the new network management leads to longer response time and higher traffic than SNMP in the condition of less managed objects (less than 60), which proves the cost of MA is higher, however, the response time and traffic will reduce on the contrary when the managed objects becomes more. Thus, the network management based MA and SNMP is fit for the complex and mainframe satellite network.

4.3 Simulation implementation

We develop an agent-based MA which provides acceptable performance and safety features inherited from Java language. The communication between the server and the management host is implemented with Java RMI (Remote Method Invocation), including transferring MA objects serially to the management hosts, then creating new objects and operating. We implement the importing, running, sending and suspending of specific MA in the simulation platform.

5 Conclusion

Classical network management has not been capable of meeting the requirement of the heterogeneous, complex and dynamic satellite network management any longer. A new network management architecture based MA and SNMP effectively balances the network load and reduces the impact of high delay between the space and the ground through the layered management .The simulation has been implemented using Java program. The further research will focus on the implementation of management functions and the security authentication of MA.

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