Design of communication primitives for satellite networks management

ZHANG Wenbo, TIAN Ye*, SUN Peigen, XU Haifeng

Abstract—According to the mobility of the satellite network nodes and the characteristic of management domain dynamic partition in the satellite network, the login and logout mechanism of the satellite network dynamic management domain partition was proposed in the paper. In the mechanism, a ground branch-station sends the packets of login broadcasting to satellites in view. After received the packets, the SNMP agents on the satellites adopt link-delay test to respond. According to the mechanism, the SNMP primitives were extended, and the new added primitives were as follows: broadcasting, login, login confirmation,delay_testing, test responses, and logout. The definition of primitives, which followed RFC1157 criterion, could be encoded by the BER coding. The policy of the dynamic management domain partition on the basis of the login and logout mechanism, which was supported by the SNMP protocol, was realized by the design of the extended primitives.

Keywords—Satellites Network; network management; communication primitive; SNMP

I. INTRODUCTION

WITH the development of computer and communication technology, The network technology is extending into the space, satellite networks have become the forefront issue of current researches. Satellite network [1] is an interconnection group of satellites, which is composed of satellites of different orbits, different types, different uses and different performance and constellations, together with the corresponding facilities on the ground, and which is connected by the links between satellites and the links between satellite and the ground. As an important establishment which is the access to space systems, ground systems seamless. Satellite network is playing an extremely important role in fields such as the defense and economic construction of the nation. But to make such a highly complex, dynamic heterogeneous network operate effectively and credible. The satellite network must be effectively and efficiently managed to ensure that the network resources and information can be correctly regulated and configured. It should adapt to changes of the application tasks, oneself and the external condition and deal with complex emergency situations.

As for the network management, a clearly division of management domains [2] contributes to enhance the scalability of the system and avoid the duplication operations. In the traditional network management, the division of management domains is usually by the geographical or structure due to most of the network device nodes is fixed. That is to say, firstly determine the location of the station manager, and then do topology configuration according to the geographical location of the network nodes and designate a management domain corresponding to the station manager. Once the management domain is identified, the nodes inside the domain can not casually move to another management domain. This management mechanism is able to ensure that the network management applications won't be overlapped, and because of the relatively fixation of network nodes, network topology management is also relatively easy to be implemented. However, this management domain partition method can not be applied in satellite networks.

Referring to the satellite network, the mobility of the satellite (or constellation) and frequently dynamic changes of the network topology [3] due to provisional of the links, so the network management domain must have a clear division of ownership in order to avoid overlapped management operations. At present, researchers have proposed the management domain splitting strategy based on the delay tests and management domain splitting strategy based on delay and hop counts. The basic idea of these strategies is to make the proposed algorithm can reduce the negative impact that link delay brought about to the satellite network management. In order to achieve a dynamic division of management domains, the satellite nodes must be able to dynamically register to the management domain and logout from the management domain, this paper proposed the alteration mechanism of satellite network management domains based on login and logout, and designed the communication primitives. It is noted that this paper assumes that the satellite network will use SNMPv3 as its management protocol in the future[4].

The login and logout mechanism of the satellite network dynamic management domain

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World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:4, No:2, 2010

In the initial state, all satellite network sub-station managers located on the ground periodically broadcast the login packets to satellites within its ken. Such a broadcast packet provides a chance of validation when the satellite joins the management domain. The role of the broadcast packet is similar to the public access channel of mobile communication systems[5]. The login and logout mechanism provide a good flexibility and scalability for the satellite network nodes to access.

The satellite registers to internal initialization sub-station manager after entering the orbit. When the satellite goes through another sub-station manager[6] and receives the registered packets, it records the information of the sub-station manager and sends the delay test information. Then it compares the communication delays to different station managers according to the delay test results and determines whether to move to another management domain. The delay test process can reduce the impact of the communication delay on network management. The login and logout mechanism can improve the effectiveness and accuracy of the network management.

The management domains of the sub-station manager are a collection of all the registered satellite nodes, which is dynamically updated and can be flexible to accept new satellites. When a new satellite node joins the network, it does not need to know the distribution of the station managers in the network. With its own orbit operation and doing a certain degree of security authentication, it can register to the sub-station manager flexibility. This login and logout mechanism of the satellite network ensures that the satellite nodes do not depend on a specific management of the sub-station manager. Especially when a few of the sub-station manager are paralyzed due to the failure, it is still able to effectively manage the satellite[7] nodes. But the temporary satellite launched for the specific tasks do not have to notice all of the station managers before the launch.
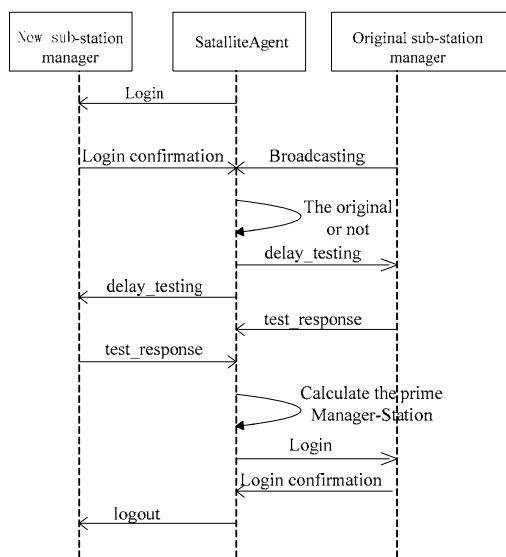

Fig. 1 The timing diagram of the login and logout mechanism

Having the synchronization data between the sub-station managers and the central manager, network managers can be kept informed of launching a new satellite into orbit because of an emergency situation. At the same time, this login mechanism can be easily expanded. Because it is a long course to establish and operate the satellite network, the size of the initial network construction will be limited. The dynamic division of the management domains and the way the network elements (including satellite and the station manager) join the network will not impact the whole network management systems and can maintain stability of the system to some extent. The timing diagram of the login and logout mechanism is shown in Figure 1.

II. THE EXTENDED SNMPV3 PRIMITIVES

Currently, the primitive operation of SNMPv1 ~ v3 management structure can not support this dynamic change mechanism for management domain, in order to achieve the login and logout mechanism need to add new primitives to support this dynamic division management domain in the SNMP communication primitives. The login and logout process of SNMP agent is accomplished through six primitive primitives, and they are:

Broadcast：broadcast

Login：login

Login confirmation：login confirmation

Delay_testing：delay_testing

Test_response：test_response

Logout：logout

We use abstract syntax (ASN.1)to describe the six primitive primitives.ASN.1 is a formal language, which describe a unified data that is usually used to define the abstract syntax of application data and the structure of application protocol data unit. The management information system structure and management information base of SNMP management structure is defined by ASN.1, and is the same as the other operations in SNMP primitives, these expansions of primitives exchange information in the form of including the protocol data unit (PDU) message. The expansion of the primitive language of the message is structured as follows:

```
Message::=SEQUENCE{
    Version INTEGER{version(1)},
    Community OBJECT STRING,
    Data ANY
}
```

Similarly, in order to support these expansions of primitives, we need to increase the corresponding managed object, such as the IP of current station manager, radio layout in MIB.

A. Broadcasting primitives

Sub-station manager broadcast the login packets to the whole satellites at a certain time interval that is to assert the current sub-station manager to the SNMP agents on the satellites. The broadcasting time interval value should be within a reasonable range, it can't be too small because a high frequency broadcasting will increase the nodes loads and can't too large because the large time interval can make the satellite

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nodes difficultly and timely to join the dynamic management domain of the satellite networks. The interval time should be expected to coincide with the time of the network reconfiguration. As to the sub-station manager, it's broadcasting time interval value can be configurable. The sub-station manager broadcast the packet which should include the PDU type, station ID, and other station information. The PDU is defined as follows:

```
PDU ::=SEQUENCE {
    pdu_type  INTEGER,
            -- denote the login broadcasting message
    broadcast-id INTEGER,
    variable-bindings VarBindList
            -- the information of station manger
}
VarBindList ::=SEQUENCE{
    IdBind,
    positionBind – relevant information such as:ID and
position
}
IdBind ::=SEQUENCE{
    Id  ObjectName,
    Value  ObjectSyntax
}
positionBind ::=SEQUENCE{
    position ObjectName,
    value   ObjectSyntax
}
```

B. Login primitives

The login primitives language packet should be sent when the SNMP agent on the satellites initialize or to login a new sub-station manager, The SNMP agent on the satellites provides the basic information, such as the node type, the node name, the node identifier, the current location when it login to sub-station manager. The node types illustrate the agent node is a computer, switch or router. The PDU is defined as follows:

```
Login-PDU ::=SEQUENCE {
    pdu_type INTEGER,
            -- denote the login message
    log-id  INTEGER,
    variable-bindings VarBindList
            -- the basic information of the SNMP agent on the
satellites
}
```

C. Login confirmation primitives

When the sub-station manager receive a login massages, it should read the contents of the message and put the current agent into the agent list, and then send a confirmation message to the SNMP agent on the satellites. For some reasons that make the sub-station manager not to accept the login request of the SNMP agent on the satellites, it should explain why it does not accept the login request for the SNMP agent on the satellites in the login confirmation message. The corresponding PDU is defined as follows:

```
LogResponse-PDU::=IMPLICIT SEQUENCE
{
    pdu_type INTEGER,
        -- denote the Login confirmation message
    log-id  INTEGER,
    error-status
        --0：login succeed，1：reject to login
    INTEGER  {Success(0), Fail(1)}
}
```

D. Delay_testing primitives

When the SNMP agent on the satellites receives the login broadcasting packet, it should verdict the sub-station manager whether it has registered or not. If not, it should send the delay testing message to the new sub-station manager and the original sub-station manager. Because of the processing time, network congestion and other reasons, the one-way delay testing can not accurately determine the size of delay. The SNMP agent on the satellites send the testing package to sub-station manager and need to consider the time information between sending and receiving, so the current time stamp message should be banded in the package. The sub-station manager add the current time stamp to the testing package and return to the SNMP agent on satellites, The SNMP agent on satellites decide to login which one after calculating the weight based on the sending delay and receiving delay when it receive the test response packets and, the calculation formula is:

$$Delay = sendTime*s\ endright + receiveTim\ e*receiveR\ ight \tag{1}$$

The'sendRight' and 'receiveRight' respectively refers to the weight of the delay of sending packages and the weight of the delay of receiving packages.

$$sendright + receiveRight = 1 \tag{2}$$

The PDU is defined as follows:
```
TestResponse-PDU ::=SEQUENCE {
    pdu_type INTEGER,
            -- denote the delay testing message
    test-id INTEGER,
    variable-bindings VarBindList
            --include the time of SNMP agent on the satellites
send the packet
}
```

E. Test responses primitives

When the sub-station manager receives the delay testing message from SNMP agent on the satellites, it need to add the current timestamp to the basis of the primitive message and returned the message to SNMP agent on the satellites. The PDU is defined as follows:
```
test_response::=SEQUENCE {
    pdu_type  INTEGER,
            -- denote the delay test_response message
    test-id  INTEGER,
    variable-bindings VarBindList
            -- include the time of SNMP agent on the satellites
```

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send the packet
```
  }
VarBindList::=SEQUENCE
{TimeStampBind,TimeStampBind2}
Logout primitives
```

When the SNMP agent on the satellites receives a successful login message, it modify the corresponding configuration, and send a logout message to the primitive registration of the sub-station, the PDU is defined as follows:

```
Logout-PDU::=IMPLICIT SEQUENCE
{
pdu_type  INTEGER,
        -- denote the logout message
logout-id  INTEGER
-- denote the satellite agent ID
variable-bindings VarBindList
}
```

In the management architecture of SNMP, the integrated format of primitive language operation information is shown in Figure 2.
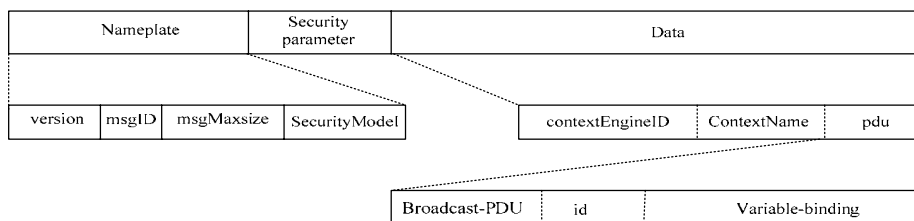

Fig. 2 The SNMP information format of the primitive language of expansion

To cope with the dynamic login and logout mechanism of the satellite network management system require increasing the definition of management information in MIB. For example, the current sub-station manager which the SNMP agent on the satellites registered defined as follows:

```
Current Manager OBJECT-TYPE
SYNTAX  DisplayString (SIZE (0..10))
ACCESS  read-only
STATUS  mandatory
DESCRIPTION
"A textual description the current manager which belongs to"
::= { system 14 }
```

III. CONCLUSIONS

According to the characteristic of management domain dynamic partition in the satellite network, the login and logout mechanism of the satellite network dynamic management domain partition was proposed in the paper. According to the mechanism, the SNMP primitives were extended, and the new

added primitives were as follows: broadcasting, login, login confirmation, delay_testing, test responses, and logout. The definition of primitives, which defined by BER and followed RFC1157 criterion

REFERENCES

[1] E. Papapetrou, S. Karapantazis, G. Dimitriadis,etc. Satellite handover techniques for LEO networks[J], International Journal of Satellite Communications and Networking. 2004, 22(2), pp. 231–245.

[2] S. Kiani, G. Oien, and D. Gesbert, Maximizing multicell capacity using distributed power allocation and scheduling, in: IEEE Wireless Communications and Networking Conference (WCNC) 2007, pp. 1690-1694, Mar. 2007.

[3] J. Cho, Y. Chang and S. Chong, .Joint Network-wide Opportunistic Scheduling and Power Control in Multi-cell Networks,. *IEEE InternationalSymposium on a World of Wireless, Mobile and Multimedia Networks 2007*, pp.1-12.

[4] AW Jackson, et al. Active Network Monitoring and Control: The SENCOMM Architecture and Implementation [C]. Proceedings of the DARPA Active Networks Conference and Exposition, San Francisco, California, IEEE Computer Society, 2002,2, pp. 118–132 .

[5] Verikoukis, C.; Alonso, L.; Giamalis, T. "Cross-layer optimization for wireless systems: a european research key challenge," IEEE Communications Magazine, 2005,43(7), pp. 1 – 3.

[6] Ibrahiem M. M. El Emary, Salam A. Najim1, and Musbah Aqel. Towards Designing and Implementing an Expert Network To Manage the Computer Communication Networks. Journal of Information and Computing Science. 2007,2(3), pp. 228-234.

[7] E. Feltrin, E. Weller, E. Martin and K.Zamani. Design, Implementation and Performance Analysis of an On Board Processor-Based Satellite Network. In proc. of International Conference on Communications 2004,6,pp.3321 – 3325.