Computer Engineering and Intelligent Systems
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol.4, No.8, 2013

Multi-Agent Based Network Monitoring and Management using Jade

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Abstract
The most difficult area in any implementation of a successful network is the monitoring and maintenance of such a network. The network management solutions available today use the Simple Network Management Protocol (SNMP), which uses a centralized management approach. The drawbacks of such an implementation over-weigh the advantages . SNMP provides excellent statistics on the macro level but does not provide the level of details that is often required to completely resolve many network issues . Unlike SNMP the Multi Agent System (MAS) works in a distributed computing paradigm. This paper discusses a MAS solution to certain real world requirements of any network administrator. A real world problem domain is also discussed.
Keywords: SNMP , MAS , Network monitoring

1. Introduction

The users of network, have high expectations of reliability and quality of service that the network offers. Most of todays organizations rely on the network for their day to day activities and thus lay, a huge reliance on them. A few hours of network breakdown would incur huge losses to the organization.
In, (William Stallings,1999), network management is described as an activity of monitoring and controlling the connected devices in a network by collecting and analyzing data from the devices. Collection of data from the devices becomes difficult as the network is made up of heterogeneous computing environments.
In, (Sidnie Feit,1993), discusses the conventional network management which makes use of SNMP, to manage large networks. The administrator has an advantage of managing the whole network from a single place. But this advantage of SNMP brings with a list of disadvantages. Its drawbacks include chances of information bottleneck in the network, lacks scalability, huge information processing at the management console, high usage of network bandwidth and centralized management intelligence.
(Decker K S ,1987) brings out a solution to the problem by suggesting a Distributed Problem Solving(DPS) technique where a number of relatively smaller systems or agents are used cooperatively to solve a problem.
In section 2 of this paper the concept of agents and its importance is discussed, section 3 the network and service details are discussed, section 4 the description of a real world scenario of a network problem is discussed, section 5 the solution to the problem using MAS is discussed, section 6 the implementation details of the MAS solution using JADE is discussed and in Section 7 the conclusion and possible future work is given.

2. Agents

(Russell et al., 1995) defines agents as anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors.
(Chang,1998) describes intelligent agents as software entities that carry out some set of operations on behalf of the user or another program with some degree of independence or autonomy and employ some knowledge or representation of the user's goals or desires. Autonomous agents are described as computational systems that inhibit some complex dynamic environment, can sense and act autonomously in its environment and realize the designed goals and tasks.
(Franklin et al., 1996) describes the following agent characteristics:

a. Agent responds in a timely fashion to changes in the environment .
b. Agent exercises control over its own actions.
c. Agent does not act in response to the environment.
d. Agent is a continues running process.
e. Agents communicate to other agents and systems.
f. Agent can change its behaviors based on previous experience.
g. Agent can migrate from one machine to another.
h. Agent actions may not be scripted.

(Sunsted et al., 1998) describes reasons to adopt mobile agent:

a. In a client server architecture continues handshake for each request/response requires a complete

round trip across the network. This uses the useful network bandwidth available. Mobile agents reduces this bandwidth utilization problem by the client migrating to the server's machine and making requests on the server directly.

b. Mobile agents can work off-line and communicate their results when the application is back on-line, thus solving the problem's in client server architecture created by intermittent or unreliable network connections.

c. Clear idea on what problem is to be solved is a mandatory requirement for any application designed in a client server architectural model. Scope for modifications in an application is very limited or costly in this model. Problems in network monitoring is dynamic and ever changing and thus the application needs a more agile development model. Agent based model for development is most applicable since the administrator of the network can decide what an agent should do on a visit, to a managed node.

d. Networks of today work on heterogeneous environments and thus the management tool used must be able to work on such a network. Agents are well adapted to work in any heterogeneous environments.

All these offer compelling reasons to adopt agent architectural model for developing a tool for network management tasks.

3. Network and the Services

The network under consideration is an academic institutions network where students and faculty are the stakeholders. Many different services are mandated to be provided to the stakeholders of this network. The privileges provided to a student is not the same as that of the faculty. The institution has many buildings and is logically split into the academic block and the hostel blocks. The user authentication on the network is done by a LDAP service , so as to enable universal login to all the users of the network within the campus network irrespective of the location. Internet connectivity is provided to the users of the network and is guarded by the Fortinet firewall. The firewall has a efficient logging service which keeps a log of the sites visited by individual users and the firewall authentication service is given by the LDAP service that runs in the network. Storage solution in the network is provided by a private cloud implementation of the OwnCloud server and all the data of both the students and the faculty is maintained on the cloud. Moodle leaning management system is another important service used by the network users. The network in discussion has 800 nodes and the above mentioned services are provided to all the network users. The paper discusses an MAS backed monitoring and management system which would help the administrator of the network to monitor the network and thus minimizing the down time of vital services used by the users. The nodes in the network have Ed-Ubuntu operating system installed on them.

4. Problem in the network

The main problem of concern in the campus network is the quality of Internet service provided to the users with the available bandwidth. The administrator can only take note of the high network traffic on the router and is left in a state of helpless situation. The SNMP running on the router may not be able to analyze what kind of traffic are using up the bandwidth or who is responsible for the traffic. This leaves the administrator knowing what the problem is , but not knowing the cause and therefore lacks the ability to resolve the issue.

5. MAS solution

The solution to the problem discussed in section 4 is given by the use of agents in the network. Java Agent Development Environment (JADE) is used to implement the solution.

Step 1: The first step of the solution is to learn the ip addresses and the corresponding physical address of all the legitimate nodes in the network. This will be help the administrator to know the source of the internal attack well in advance, as the malicious node/user of the network would try to change the ip details before an attack.

Step 2: The monitoring agent is the central decision making node where all the sensor agents would report in an event of abnormality. The monitoring agent dispatches the sensor agent as soon as an legitimate nodes comes up in the network.

Step 3: The network administrator sets a network traffic limit for nodes in the network and this is taken as input by the monitoring agent. While dispatching a sensor agent to the node in a network the traffic limit is set to the agent.

Step 4: The sensor agent which resides in the node monitors the traffic generated by the node and informs the monitoring agent when the set threshold exceeds.

Step 5: The monitoring agent prepares the report of incidents reported by the sensor agents in the network and presents it to the administrator for further necessary action.

With this solution the network administrator would be able to isolate the malicious nodes in the network and thus the solution.

6. The implementation

Code :- Sensor agents behavior :

```
/**
 *
 * @author Pramod S
 */
import jade.core.*;
import jade.core.behaviours.*;
import java.net.*;
import java.lang.Process;
import java.io.*;
import jade.lang.acl.*;
import jade.core.AID;
import jade.core.Agent;

class pra1 extends SimpleBehaviour
{
        pra1(Agent a)
        {
                super(a);
        }

        public boolean done()
        {
           return true;
      }

        public void action()
        {
                int ch;
         System.out.println("Visiting agent  ");

                // Block the behaviour for 2 seconds

                block(2000);
         //done();

         // Find the ip and mac address  of the visiting machine

         InetAddress ip;
         try {

        ACLMessage msg = new ACLMessage(ACLMessage.INFORM);
        msg.addReceiver( new AID( "r1" , AID.ISLOCALNAME) );
        java.lang.Process process = java.lang.Runtime.getRuntime().exec("ip -s link");

        InputStreamReader myIStreamReader = new InputStreamReader(process.getInputStream());
        while ((ch = myIStreamReader.read()) != -1)
        {

           System.out.print((char)ch);
        }

                ip = InetAddress.getLocalHost();
                System.out.println("Current IP address : " + ip.getHostAddress());

                NetworkInterface network = NetworkInterface.getByInetAddress(ip);
```



```
                byte[] mac = network.getHardwareAddress();

                System.out.print("Current MAC address : ");

                StringBuilder sb = new StringBuilder();
                for (int i = 0; i < mac.length; i++) {
                        sb.append(String.format("%02X%s", mac[i], (i < mac.length - 1) ? "-" : ""));

                }
                System.out.println(sb.toString());

          // send message to reciever

          msg.setContent( sb.toString() );

         msg.addReceiver( new AID( "r1" , AID.ISLOCALNAME) );

                myAgent.send(msg);

          msg.setContent( ip.getHostAddress() );

         msg.addReceiver( new AID( "r1" , AID.ISLOCALNAME) );

                myAgent.send(msg);

          //send message to receiver ends

         } catch (UnknownHostException e) {

                e.printStackTrace();

         } catch (SocketException e){

                e.printStackTrace();

         }

    catch (IOException anIOException){}

          // find ip address ends here


                return  ;
         }
}
```

7. Conclusion

The agent paradigm provides an efficient technology of the future to solve many problems the administrator of any big network may face. As JADE can work on heterogeneous platforms the future networks may be compatible to the technology. Further JADE has progressed further into mobile platforms which would be part of any state-of-the-art network of today. Much of the research in this area is in its infancy and the reason for no network management tool that uses agents are available in the market. The authors future mission would be to build a suite of tools on agent technology and to make it open source so as to provide benefit to the society.

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