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ATM Customer Network Management Using WWW and CORBA Technologies

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Abstract

In this paper, we present a framework for managing ATM customer networks using WWW and CORBA technologies. The WWW technology may provide network management operators with platform independence, location independence, friendly and/or consistent management behavior as well as secure management operations. The main problems in a Web-based network management system may include limited management capabilities of HTTP operations and lack of supporting mechanisms for trap or event notifications. These problems are, in this paper, solved by the integration of Java and CORBA technologies. We extend the current Web technology which is being used for transferring various information on Internet to those which can be used to transfer management requests and replies as well as event notifications. A Web browser is used as a universal user interface for monitoring and controlling the activities of the ATM customer networks. We have developed an integrated customer network management system which can manage SNMP-enabled or CMIP-enabled network devices and provide ATM CNM services. In particular, we applied the CORBA technology to accommodate several management protocols such as SNMP, CMIP and other management protocols. Through the CORBA IDL-to-Java mapping, complex management operations as well as event notifications are supported without modification of the current WWW systems.

Keywords: ATM Customer Network Management, Web-based Network Management, CORBA, Java, Integrated Network Management.

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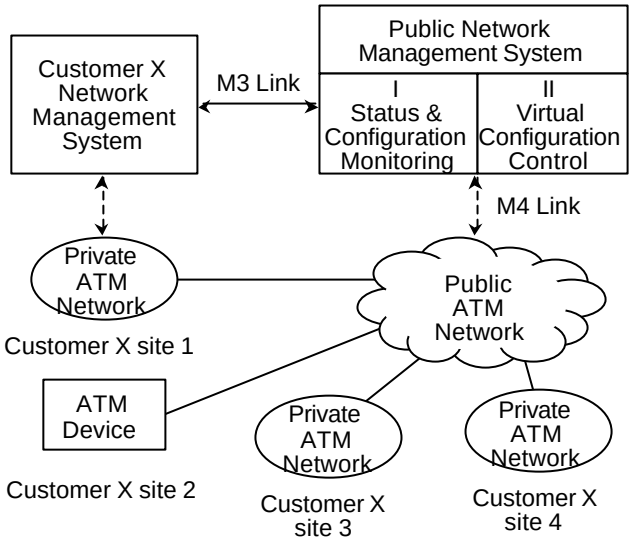
- Customer's Requirement
  - easy, uniform and consistent management user interface
  - support of multimedia information
  - platform and location independence
  - interworking with public network management systems
- Provider's Requirement
  - provide customizable NM view to customer
  - provide diverse service classes to customer
  - integration of management protocols
  - security mechanism
  - easy maintenance and operations



The ATM technology provides seamless connections between public ATM WANs and enterprise LANs. This enables enterprises to construct global high-speed virtual private networks (VPN) connecting their private network to public backbone network. Network administrators of private high-speed communication networks would like to monitor and manage their VPNs which may be realized by connecting both public and private ATM networks. In this case, the public network operators must provide capabilities for the customer network managers to be able to monitor and understand the activities of the public ATM networks. The ATM Forum and ITU-T have been working on a management framework which allows such capabilities. The framework is intended to provide the customer network management (CNM) for ATM public network service [1, 2].

SNMP (Simple Network Management Protocol) is specified in M3 interface [3] for the exchange of management information between a customer network manager and public network manager. Both CMIP (Common Management Information Protocol) and SNMP are specified in M4 [4] interface for public ATM network management. These imply that an integration of CMIP and SNMP is needed for the management of ATM customer networks at PNMS (Public Network Management System) and CNMS (Customer Network Management System). Both M3 and M4 interfaces are defined by ATM Forum.

The visual illustrates the relationship through the M3 interface between the customer network management system (CNMS) and public network management system (PNMS). M3 interface should support two classes of CNM services, Class I and Class II, to allow public network operators to provide modular, incremental capabilities for the satisfaction of different levels of customers needs. The Class I provides monitoring capability only whereas the Class II provides controlling capability as well.

Customer's and service provider's requirements for ATM customer network management are described below. Customers may require an easy, uniform and consistent management user interface. They want to manage networks no matter where they are and which platform is used. On the other hand, service providers need to offer restricted NM views which might be controllable or customizable. They may also require diverse classes of quality of service to customers to be offered, which may be concerned with reliability, security, service quality and so on. Since there are existing many different management protocols, proprietary or standardized, they want mechanisms for the flexible integration of these protocols for easy maintenance and operations of their CNM systems.

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FEATURE COMPARISONS OF SNMP, CMIP, HTTP AND IIOP

Feature	CMIP	SNMP	HTTP	IIOP
Information Model	Object-Oriented	Limited OO	Hypermedia	Object-Oriented
Language	GDMO	ASN.1	HTML	IDL
Architecture	M/A, M/M, Cascaded	M/A, M/M	Client/Server	Client/Server
Operations	M-Get, M-Set, M-Create, M-Delete, M-Action M-Event-Report	Get, Set, Trap	Get, Post, Head	Request, Response, CancelRequest, LocateReply, CloseConnection, MessageError
Communication Mode	Transaction-Oriented Request/ MultiResponse	Request/ Response	Asynchronous Request/Response	Request/ Response
Addressing	MIT with OID Scoping/Filtering	MIT with OID at end nodes of the tree	URL	Object Reference
Standardization Body	ITU-T, ISO/OSI	IETF	IETF	OMG

The table above shows the feature comparisons of CMIP, SNMP, HTTP and IIOP (Internet Inter-Orb Protocol). Currently, most of the network management systems use either CMIP or SNMP as their management protocol. SNMP is relatively simple and widely used to manage the computer communication equipment mainly. CMIP is a standard network management protocol to transmit transaction-oriented management information. The benefits of SNMP are simpler than CMIP and it has been widely used, so there are a lot of developed systems. The benefits of CMIP are that it is a standard adopted by ISO and it has powerful functionalities such as the scoping, the filtering and the linked replies in addition to its system management capabilities.

The well-known problem of HTTP, the communication protocol of WWW, is that a new TCP connection has to be opened at each request and the connection has to be closed if the response is done. This makes the utilization of systems and network resources bad and is one of the factors to degrade the whole transmission speed. On the other hand, IIOP is designed to be able to get multiple requests in a connection and to allow requests to be overlapped. This makes a connection setup costs to be reduced. In other words, many requests can be transmitted without waiting and with any sequence in the same connection. In CORBA, ORB (Object Request Broker) provides the connection and session management to use available resources efficiently.

In our system, CORBA IDL has been used to integrate various network management protocols. The OMG Telecom Special Interest Group is working to manage the telecommunication network using CORBA [5]. The work of NMF and X/Open JIDM (Joint Inter-Domain Management) attempts to manage the network in a unified way with integration of standard network management protocols and CORBA.

The integration of CORBA with WWW enables users to explore the CORBA-based system with Web browser. In this case, various network management information and network management services can seamlessly be manipulated through Web browsers.

INTEGRATION OF WWW AND CORBA USING JAVA

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- Integration Methods
  - Without Modification to current WWW systems
    - CORBA-to-CGI gateway
    - Java with CORBA ORB(CORBA IDL-to-Java mapping)
  - With Modification to current WWW systems
    - Web Browser Modification
    - Web Server Modification
    - Both Web Browser and Web Server Modification
- Feature Comparisons of Java with CORBA ORB and HTTP-CGI

Feature	**Java with CORBA ORB**	**Java with HTTP-CGI**
State across invocation	Yes	No
Dynamic invocation	Yes	No
Callbacks	Yes	No
Security	Yes(via CORBA)	Yes(via SSL or s-HTTP)
Transaction	Yes	No
Performance	Fast	Very Slow
Parameter marshaling	Yes	No
Interface description	Yes(via IDL)	No
Server salability	Yes	No

The integration of CORBA and WWW enables users to access information resources of the CORBA-based system through the Web browser. The implementation methods for the integration of CORBA and WWW are described below.

● CORBA-to-CGI gateway

It is a typical and the easiest way used in WWW, but suffers from the performance bottleneck of CGI. The CORBAnet Project of OMG (Object Management Group) is using this approach.

● Java with CORBA ORB

Through CORBA IDL-to-Java mapping, Java applet is treated as a CORBA client and a CORBA server is located in the HTTP server side. This method may overcome the bottleneck of CGI. In contrast to the limited HTTP operation, Java applet can perform various operations through the IDL interfaces. This method does not require any change of the current WWW system for the network management. The management operations can be defined in CORBA IDL. We adopted this method to develop an ATM customer network management system.

● Web Browser Modification

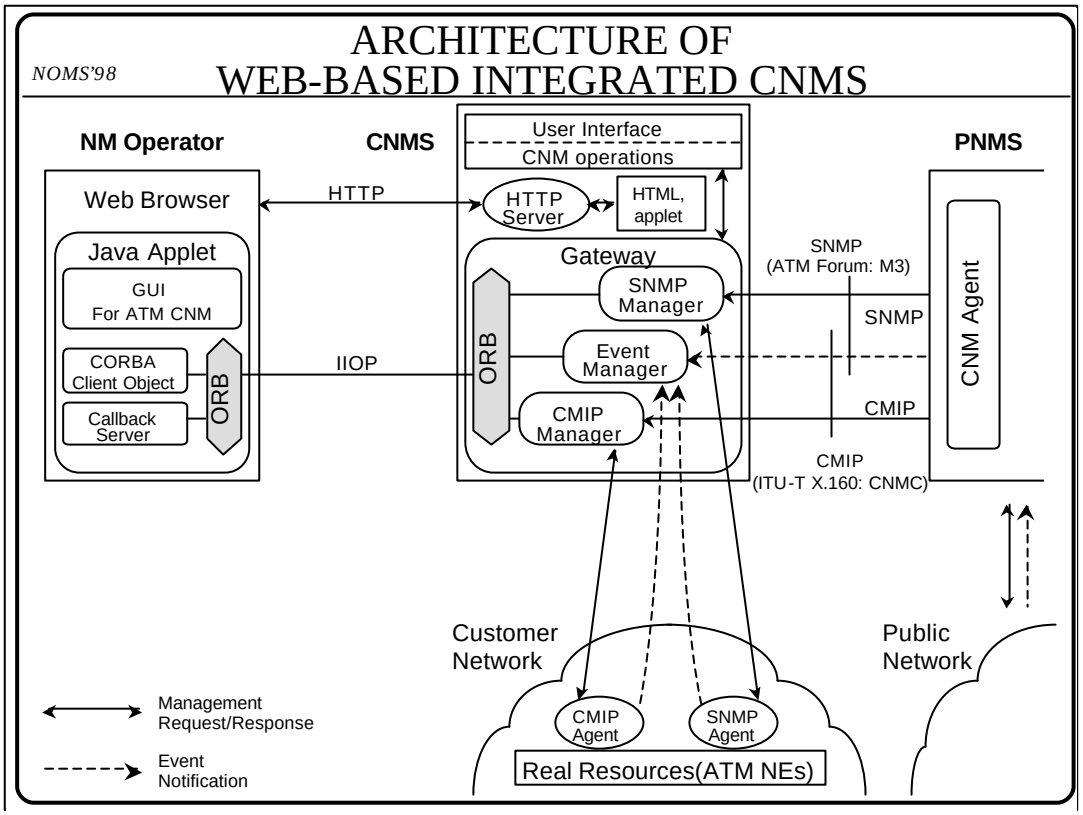
The Web browser may directly access the CORBA server using the IIOP such as Netscape's ONE(Open Network Environment).

● Web Server Modification

The Web server may directly access the CORBA server using a techniques such as VisiBroker for Java.

● Both Web Browser and Web Server Modification

This approach is used in the project by ANSA and in the project by Oracle. The current Web browser and Web server are respectively substituted with a CORBA client and a CORBA server both of which can support IIOP and HTTP. This method seems to be ideal, but practically it is very difficult since it should fully modify the current WWW systems. The table above compares the features of the Java with CORBA-to-CGI and the Java with CORBA ORB which is the approach used in this paper.

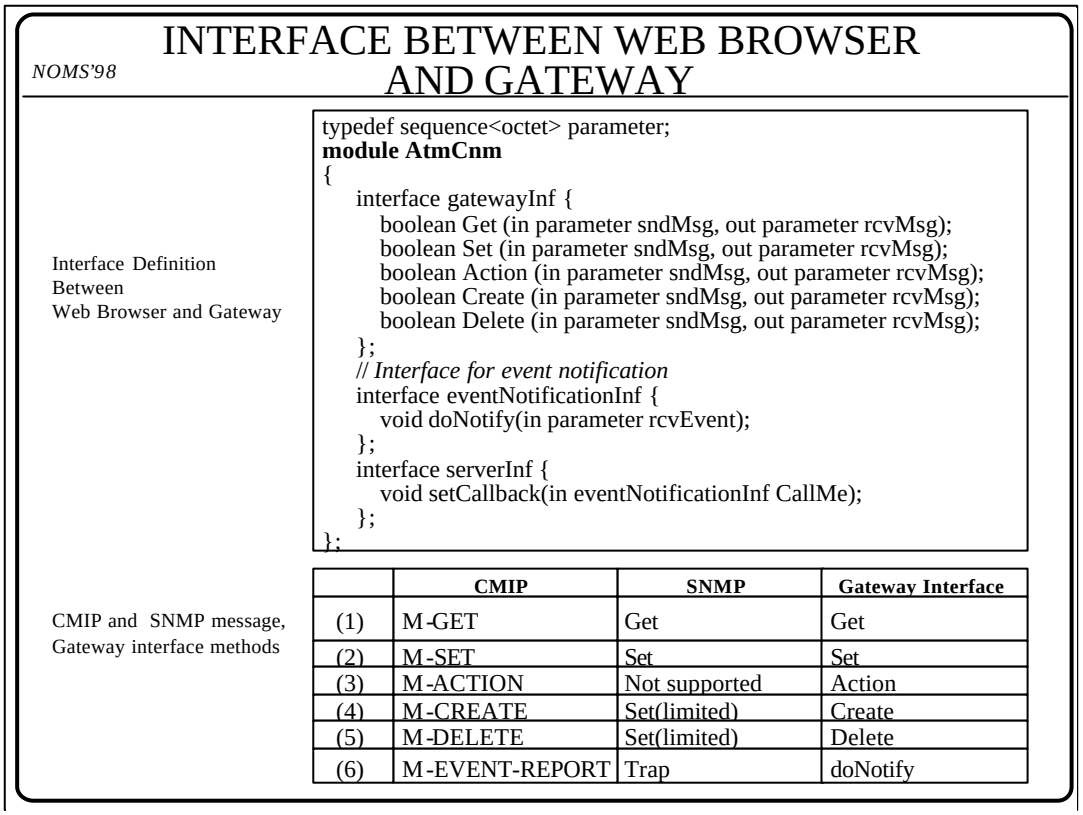


The figure above shows the architecture of Web-based integrated CNMS (Customer Network Management System). The CNMS consists of a HTTP server, a Java applet and Gateway which performs real network management operations.

The Java applet which is loaded into the Web browser is corresponding to a CORBA client and can transmit a user request to a manager, which can be either a CMIP Manager or a SNMP Manager. In this case, dynamic binding mechanism is used for linking a proper manager in Gateway. Resources of an ATM customer network are modeled with abstraction of a service name only. This makes the management operation efficient and consistent. In Gateway, there are three CORBA servers. One is CMIP Manager for OSI's CMIP and another is SNMP Manager for IETF's SNMP. The other is Event Manager to handle asynchronous events from CMIP or SNMP agents.

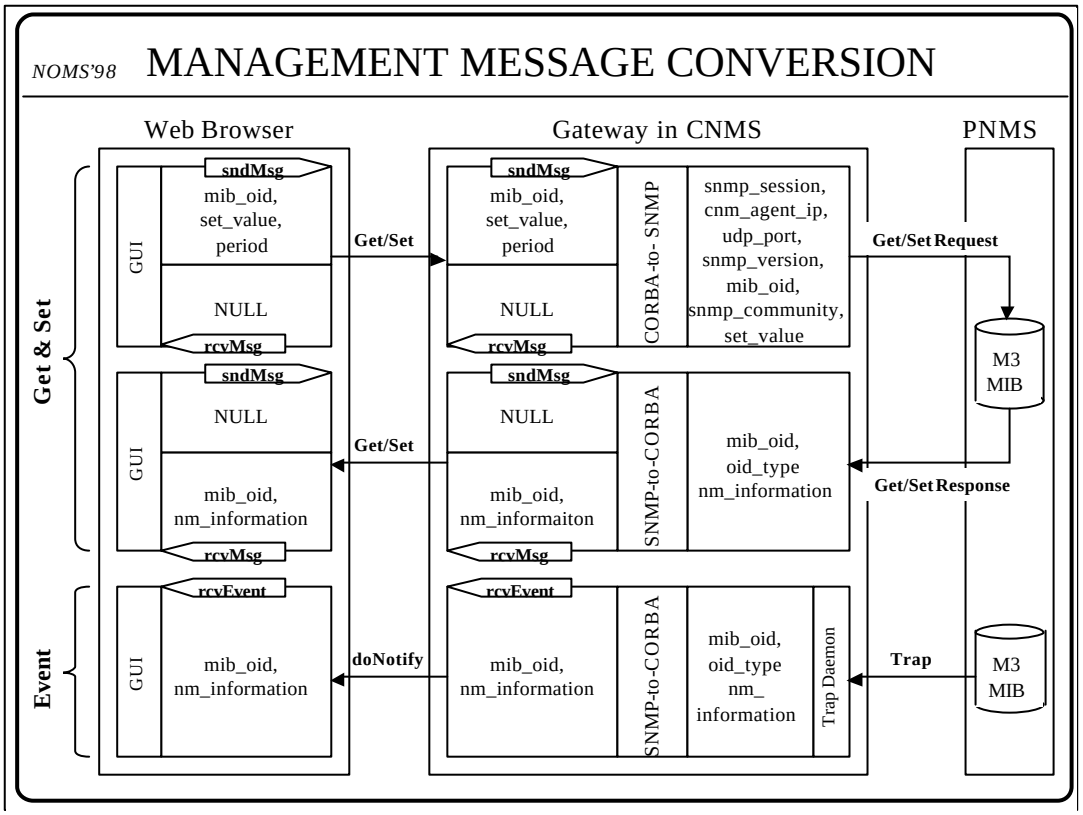
The callback mechanism is used to send events from agents to the Java applet on the Web browser. Through the callback mechanism, the Java applet which is the CORBA client does not need to poll periodically Event manager in Gateway. In other words, if the agents send events to the Event Manager in Gateway, Event Manager can immediately send it to the Java applet on the Web browser using callback mechanism. The callback mechanism is realized by implementing the eventNotificationInf and serveInf interfaces using IDL whose definitions are described in detail at the subsequent slide. Here, the client is interacting with the server on a peer-to-peer basis. Each is acting as each other's client and/or server.

In the proposed architecture, the network management system and user interface are separated, so that the NM operator can download the Java applet and manage the private network if the NM operator can access to the WWW browser, no matter where he is. A management system can be accessed though the several Web browsers. A management system can provide customized views to the users with security mechanism so that the architecture is suitable for the CNM services. In particular, in case that new management protocol is introduced, all you have to do is developing a new protocol manager in accordance with pre-defined IDL interface specification. This makes our architecture efficient enough to support new management services.



There are two types of network management operation in our management system: a manager's operation to an agent and an agent's operation to a manager. A manager sends a request to an agent using Java applet: (1) to get values of MOs in an agent, (2) to set values of MOs in an agent, (3) to perform an action to an MO in an agent, (4) to create a new MO, (5) to delete an MO in an agent. An agent sends an event to a manager using Java applet when users want (6)to be notified of the events. Both CMIP and SNMP are allowed to provide the network management service primitives to support the above functions. Other proprietary network management protocols may also be allowed to provide their management service primitives. The table shows the mapping between the methods in the gateway interface and the primitives which are provided by CMIP and SNMP management protocols. The gatewayInf, eventNotificationInf and serverInf are the interfaces defined between an Java applet and Gateway. The gatewayInf which have six methods is defined for the generic management operation. The eventNotificatioInf and serverInf each of which has only one method is defined for the event notifications. The IDL-to-Java mapping of the interface between Web browser and Gateway using VisiBroker for Java is given below:

```
package AtmCnm;
public interface gatewayInf
   extends org.omg.CORBA.Object {
   boolean Get(parameter_var sndMsg, parameter_var rcvMsg);
   boolean Set(parameter_var sndMsg, parameter_var rcvMsg);
   boolean Action(parameter_var sndMsg, parameter_var rcvMsg);
   boolean Create(parameter_var sndMsg, parameter_var rcvMsg);
   boolean Delete(parameter_var sndMsg, parameter_var rcvMsg);
}
public interface eventNotificationInf
   extends org.omg.CORBA.Object {
   void doNotify(parameter_var rcvEvent);
}
public interface serverInf
   extends org.omg.CORBA.Object {
   void setCallback(AtmCnm.eventNotificationInterface CallMe);
}
```



The figure above describes the management messages and protocol conversion. It is necessary to map CORBA operations to SNMP messages or SNMP messages to CORBA operations for the exchange of management information. The way of how the CORBA operations are mapped to SNMP message PDU is dependent on the specific implementation.

In SNMP Manager, the CORBA-to-SNMP module converts Get/Set operations in CORBA-IDL interface to SNMP request messages and the SNMP-to-CORBA module converts SNMP response messages to return values of the Get/Set operations in CORBA-IDL interface.

In Event Manager, the CORBA-to-SNMP module converts the SNMP trap messages to the doNotify operation in CORBA-IDL interface when the trap daemon receives the SNMP trap messages from agents.

The model conversion procedures which are specified in JIDM may be applied for the mapping of CORBA IDL to SNMP messages, and vice-versa.

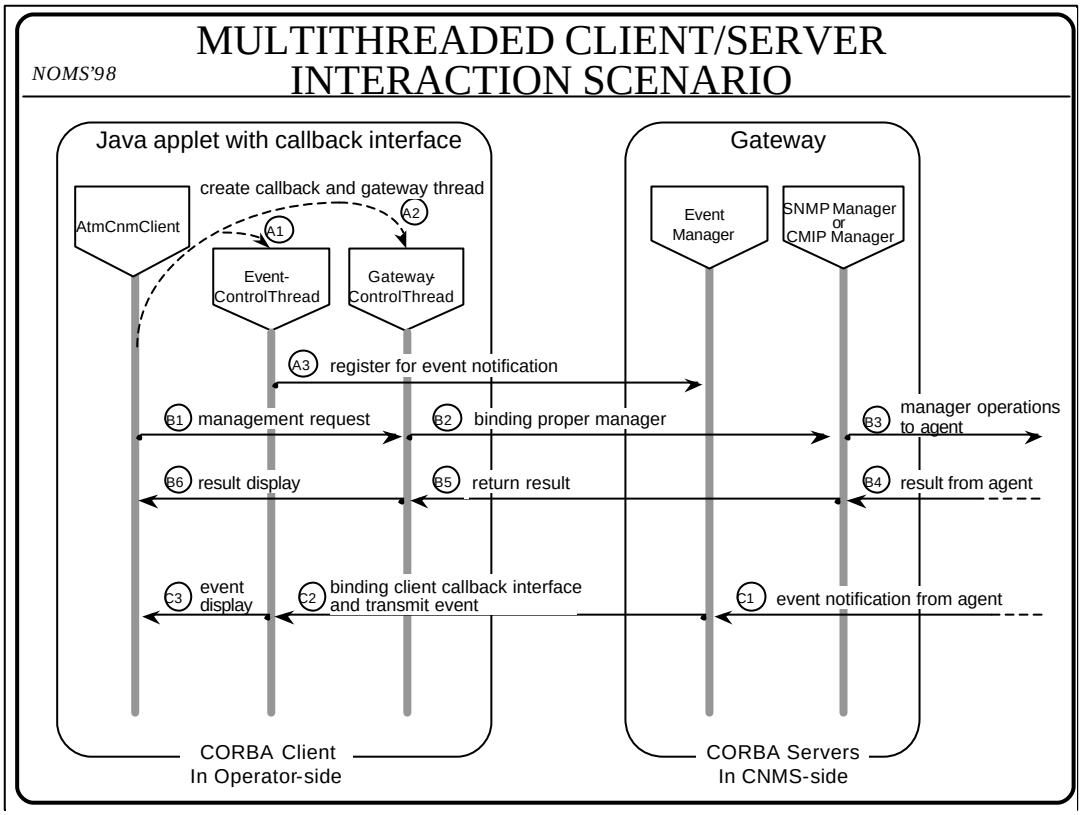
When CORBA Set operations are performed to atmVclAdminStatus in VclTable which controlled by M3 agent, the corresponding contents of CORBA and SNMP messages are shown below.

● Java applet for NM in Web Browser

```
mib_oid  = atmVclAdminStatus        // MIB OID
set_value = "up"                    // set atmVclAdminStatus to "up"
period = NULL                       // only need for monitoring service
nm_information =  "up"              // after Set operation, the value is changed to "up"
```

● SNMP Manager in Gateway

```
udp_port = 161                      // default UDP Port number
snmp_version = SNMPv2               // SNMP version
snmp_community = public             // SNMP community
cnm_agent_ip = 155.230.12.109       // IP address of the CNM agent
mib_oid = atmVclAdminStatus         // MIB OID
set_value = "up"                    // set atmVclAdminStatus to "up"
nm_information = "up"               // after SNMP Set request, the value is changed to "up"
```



(1) Initialization

During the initialization phase, two additional threads, EventControlThread and GatewayControlThread are created in addition to AtmCnmClient. EventControlThread registers its object reference pointer to Event Manager in Gateway to receive the event notifications from the agents. The initialization steps are summarized below.

(A1) create an EventControlThread thread
(A2) create a GatewayControlThread thread
(A3) register to Event Manager in Gateway through the setCallback method

(2) Generic network management requests

Generic NM procedures are described below.

(B1) receive a management request from a user and send the request to GatewayControlThread
(B2) bind proper manager and send the user's request
(B3) send the actual management request to an agent
(B4) return the result of management request
(B5) send the result
(B6) send the result to display

(3) Event notifications

Event Manager notifies the event asynchronously to the client using the object reference registered during the initialization phase.

(C1) asynchronous event notification from agent
(C2) invoke doNotify method in the callback interface to send the events
(C3) send the events to display

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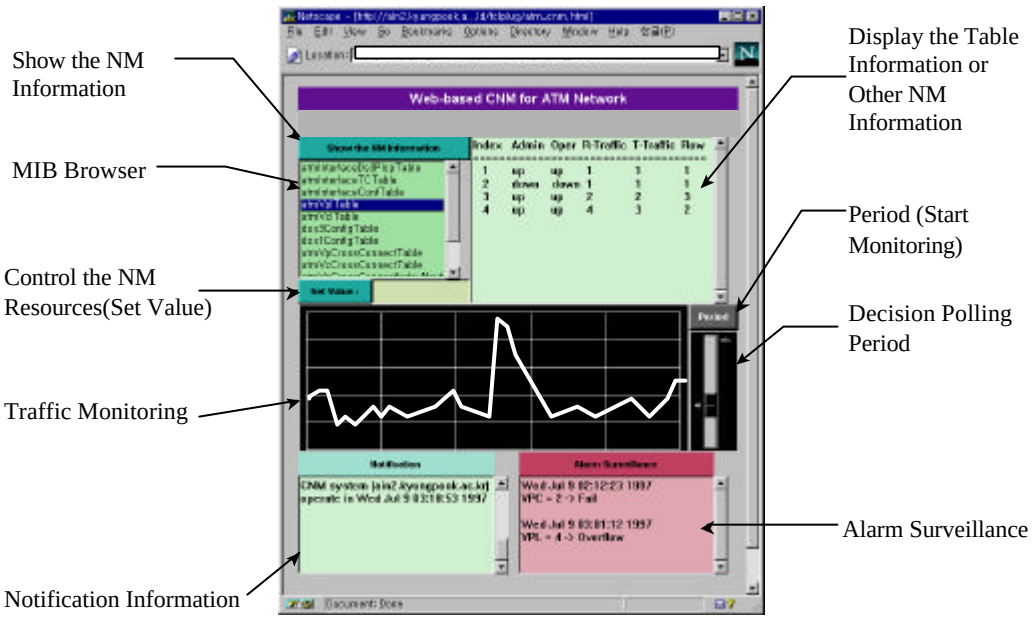
PROTOTYPE IMPLEMENTATION



We have developed a prototype of Web-based ATM customer network management system to validate our concepts. ISODE 8.0 is used on a Sun Solaris 2.4 platform and a managing system is implemented to support both CMIP and SNMP protocols. OSIMIS 4.0, developed by UCL is used for CMIP. SNMPv2 contained in ISODE 8.0 is used to implement the ATM UNI ILMI standard and M3/M4 interface specifications defined by ATM Forum. VisiBroker for Java is used as a CORBA integration platform to implement the Gateway and network management applet.

The figure above shows the Web-based management user interface for ATM customer network management. It consists of six parts and each part is explained below.

- Show the NM Information : After selecting an item in the MIB browser, text box shows the NM information to the operator.
- MIB Browser : This shows M3 MIB information in the CNM agent.
- Set Value : The value of resources can be changed using this button.
- Monitoring : A polling interval can be selected and traffic information is displayed. For example, this figure display the traffic of M3 interface. OID used for this monitoring is pathGroup.pathTable.pathEntry.PathCells in Fore ATM switch.
- Notification : This part shows asynchronous events which are notified to Event manager in the Gateway.
- Alarm Surveillance : This part shows filtered alarms.

The list of implemented M3 MIB is described below.

(1) CNM Class I MIB

- ATM Level Configuration : atmInterfaceConfTable, atmVpl/VclTable (RFC 1695)
- Physical Level Configuration : dsx3ConfigTable (RFC 1407), dsx1ConfigTable (RFC 1406)
- ATM Level VPL/VCL Configuration and Status : atmVplTable, atmVc lTable (RFC 1695)
- VPC/VCC Configuration and Status : atmVpCrossConnectTable, atmVpCross Connect-IndexNext, atmVcCrossConnectTable, atmVcCrossConnectIndexNext (RFC 1695)

(2) CNM Class II MIB

- ATM Level Configuration : atmInterfaceConfTable (RFC 1695)
- VPC/VCC Level Configuration : atmVpCrossConnectTable, atmVpCrossConnectIndexNext, atmVcCrossConnectTable, atmVcCrossConnectIndexNext (RFC 1695)

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CONCLUSION AND FUTURE WORK

- Describe ATM CNM model and requirement
- Suggest Web-based management architecture for supporting CNM services in ATM networks
- Features of the proposed architecture
  - NM operators need not to know what management protocol is used
  - Be capable of event notification without modification of current WWW technologies
  - Support complex ATM CNM services through CORBA and Java technologies
  - Mechanism for the ATM CNM services
  - Provides extensibility for adopting new management protocol via CORBA technology
- Present the implemented prototype of the proposed architecture
- Future work
  - Analyze performance of the entire system
  - Extend the same technologies to other types of networks
  - Extend the same technologies to the management of systems and applications

In this paper, we design and implement the network management system to provide an ATM CNM services using the WWW and CORBA technologies. The architecture can manage complex networks in the effective and consistent way using Java network management applets.

The Web-based network management provides the platform independence and common and uniform access to NM resources. The problems in a Web-based network management system include limited capabilities of HTTP operations and lack of supporting mechanisms for event notifications. We solved these problems using CORBA and Java technologies. Through the CORBA IDL-to-Java mapping, complex management operations as well as event notifications can be supported without modification to the current WWW systems, comprising of Web browser and servers.

The proposed architecture provides the remote management interface with distribute processing functions, so that the NM operator is not constrained to his location, as long as he can download the Java applet using the Web browser. A management system can provide customized views to the users with security mechanism so that the architecture is suitable for the provision of the ATM CNM services.

For further work, we plan to analyze the performance of the system and extend the same technologies to other types of networks. We envision that this should be fairly simple since the ground work which is the most difficult part has been already done.

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