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A Proxy Agent for Managing Internet-Based Systems from an OSI-Manager

Ulrich Gremmelmaier, Georg Rößler

Institute of Communications Switching and Data Technics, University of Stuttgart
Seidenstr. 36, D-7000 Stuttgart 1, Germany

Multiprotocol networks have come into widespread use over the last decade. As these networks are quite complex, network management systems for heterogeneous networks are of great importance. However, the effort spent for the management system must remain reasonable. This paper presents how proxy agents can be employed for efficient management of multiprotocol networks. An approach for integrated management of networks using OSI protocols and TCP/IP is described in more detail and the level of integration that can be achieved is pointed out. Then the functionality of the Internet Proxy Agent is described. Some remarks follow on how the directory service is used for network management purposes.

Key words: Heterogeneous Network Management; Proxy Agent; Directory Service.

1 Introduction

In today's computer networks usually multiple protocols are used above the media access control sublayer. Protocols used include TCP/IP and several proprietary protocols. Especially in manufacturing environments more and more OSI protocols can be found. In order to cope with problems from the size, complexity and heterogeneity of multiprotocol networks efficient network management is necessary.

At first, some proprietary solutions were used for network management protocols. Later, the International Organization for Standardization (ISO) started standardization efforts to provide a framework for network management in open systems [ISO7498-4, SMO]. For the management of Internet-based systems (TCP/IP protocol suite) a framework for network management [RFC1155] has been developed as well. Especially the TCP/IP-based Simple Network Management Protocol (SNMP) [RFC1157] together with the management information defined in [RFC1156] is supported by different vendors and currently implemented on a variety of network devices. Due to the fact that OSI network management provides the most powerful mechanisms it is expected that in the long run OSI management will come into widespread use. In the meanwhile, solutions for efficient management of multiprotocol networks are urgently required. These requirement mainly affect the network management architectures developed by vendors and industry consortia like the Open Software Foundation (OSF).

The focus of this paper is on an Internet Proxy Agent which is getting developed within the ESPRIT (European Strategic Programme for Research and development in Information Technologies) project Communications Network for Manufacturing Applications (CNMA) for integrated management of networks running both OSI protocols and TCP/IP.

The paper is organized as follows. In section two some aspects of heterogeneous network management are discussed. Section three gives an outline of the integrated management architecture. Section four presents the design of the Internet Proxy Agent and its implementation features. The last section concludes the paper and gives an outlook.

2 Aspects of Heterogeneous Network Management

This section is confined to centralized management architectures and therefore ignores approaches which include manager-manager cooperation as it may be found in a hierarchy of managers or a management network.

For management of heterogeneous networks, four aspects have to be considered: management information, structure of management information, management protocol, and management service. In order to reduce effort for implementation of powerful applications, a unique view of all network resources is desirable even in a heterogeneous environment. Two approaches can be distinguished how this goal can be reached. In the first approach a common platform offers a unique view to all resources [Warrier89]. The second approach is to use proxy agents which transform the view to resources. These proxy agents may be based on a simpler platform designed for a homogeneous environment. An example of a proxy agent has been presented in [Bosch90].

However, none of the approaches makes the management information uniform as it describes the behaviour of different protocols. But all management information can be presented following the same structuring principles and can be accessed using the same service interface what may require transformation to map the interface primitives onto the service primitives originally available from the underlying management protocol.

Management of OSI and TCP/IP networks differs in all aspects described above. The most significant differences concern the structure of management information. In OSI management information follows an object-oriented approach including multiple inheritance, allomorphism, and strict distinction between class hierarchy, containment and naming hierarchy, and registration hierarchy [SMI, Hegering91]. In contrast, management information in TCP/IP is structured much simpler. Although the term managed object is used, concepts like inheritance are not included. Instead, abstract data types are defined for managed objects. The same hierarchy is used for classes, naming and registration of managed objects, but they are accessed as a flat list. [RFC1155, Hegering91]. Managed objects in TCP/IP correspond to attributes within OSI managed objects. As OSI protocols and TCP/IP are different, the management information is different too.

Management protocols for OSI (Common Management Information Protocol; CMIP) [CMIP] and TCP/IP (SNMP) and the services they offer are similar even if CMIP is a connection-oriented protocol while SNMP operates in connection-less mode. Nevertheless some remarkable differences exist: while SNMP allows for accessing a single and unstructured managed object in a single request, CMIP provides for more complex operations on managed objects affecting multiple attributes using scope and filter parameters.

In the given environment (see section 3) integration of OSI and TCP/IP management is only partly feasible using the platform approach. Applications use the common platform as a common environment and share resources, but must be adapted to one of the underlying protocols. Differences concern addressing of managed object instances and classes and the management information that can be retrieved in a single request.

For this reason, the approach using a proxy agent was chosen. Integration goes further in this approach as all management information is presented in the same structure and all differences in the management protocols are hidden. In our case, the proxy agent offers all management information of the Internet following the OSI Guidelines for the Definitions of Managed

Objects (GDMO) [GDMO] and the management service is accessed in the same way as if CMIP was the underlying protocol. Consequently the proxy agent is named Internet Proxy Agent.
The approach chosen has two main advantages. First, management applications need not be adapted to different kinds of service interfaces and second, distribution of the management system is simple as one or more proxy agents can be located anywhere in the network.

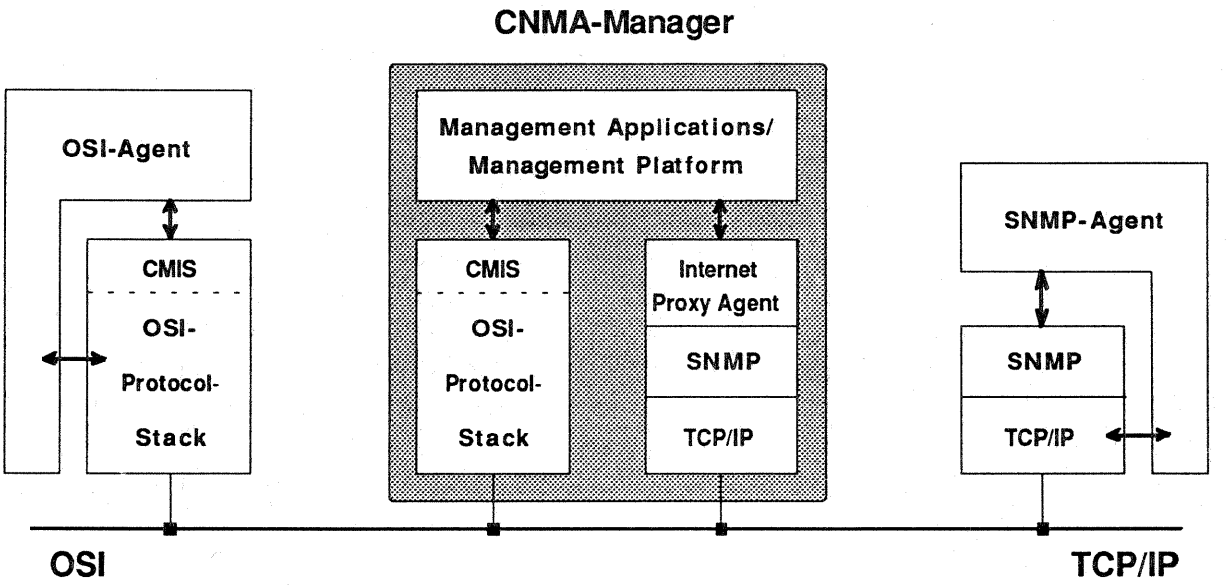

Figure 1: Architecture of the integrated CNMA management system

3 Architecture of the CNMA Management System

The Internet Proxy Agent is part of a manager architecture developed during the current phase of the CNMA project. One important work item within CNMA is network management based on the OSI management framework which covers such topics as the development of a management architecture and the definition of an application profile [CNMA]. The application profile selects the management protocol and defines the management information used by CNMA.
The CNMA management architecture comprises multiple protocol stacks and different agents (CNMA, MAP 3.0, OSI/NM FORUM, TCP/IP) administered and controlled by an integrated manager. The CNMA manager architecture mainly consists of management applications based on a common platform and the underlying heterogenous communication network comprising different management protocols and communication stacks. Due to their importance for Local Area Networks installed in an industrial environment the management applications are concentrated on Fault, Performance and Configuration Management. Figure 1 shows the management architecture with the relevant parts regarding OSI and TCP/IP management.
The management platform provides an interface similar to the CM-API which will be part of the Distributed Management Environment of the Open Software Foundation (OSF-DME). It relieves both manager and agents from connection handling for CMIS [CMIS] and addressing issues while offering all OSI management notification and operation services. Agents on the manager system locally subscribe to this interface so that requests from the manager will directly be sent to the agent. Management applications sending requests to a certain agent via

this platform only need to know the 'systemID' attribute of the selected agent which is contained within the 'system' managed object [CNMA]. The 'systemID' is a name used to identify different agents.

4 Design and Implementation of the Internet Proxy Agent

4.1 Requirements

The Internet Proxy Agent is the link between OSI and TCP/IP network management. Three main objectives had to be considered for the design of the Internet Proxy Agent:

• There should be little influence on the overall design of the CNMA manager, i.e. the management applications, for instance Performance Management, should be able to manage non-OSI systems through the proxy agent in the same way as they manage OSI systems.

• The proxy agent should be relocatable, e.g. the physical and logical location of the proxy agent should not be visible to the manager. The above mentioned properties of the management platform provide this: If the Internet Proxy Agent is located on the manager system as the other parts of the manager system it can be accessed via the management platform, as depicted in figure 1. Otherwise, the Internet Proxy Agent can be reached using CMIS of the OSI protocol stack used by CNMA.

• The Internet Proxy Agent should enhance the functionality of the management of TCP/IP-based systems. This can be reached by adding some OSI System Management Functions to the Internet Proxy Agent.

The integration of proxy agents into this architecture can be done easily because the structure of management information in the CNMA management environment is described as meta-information and thus can be extended.

4.2 Functionality

The Internet Proxy Agent provides an administrative interface via ISO/OSI management services to Internet nodes. However, the Internet Proxy Agent supports a restricted subset of these services:

- M_GET/ M_SET
- M_CREATE/ M_DELETE
- M_EVENT_REPORT

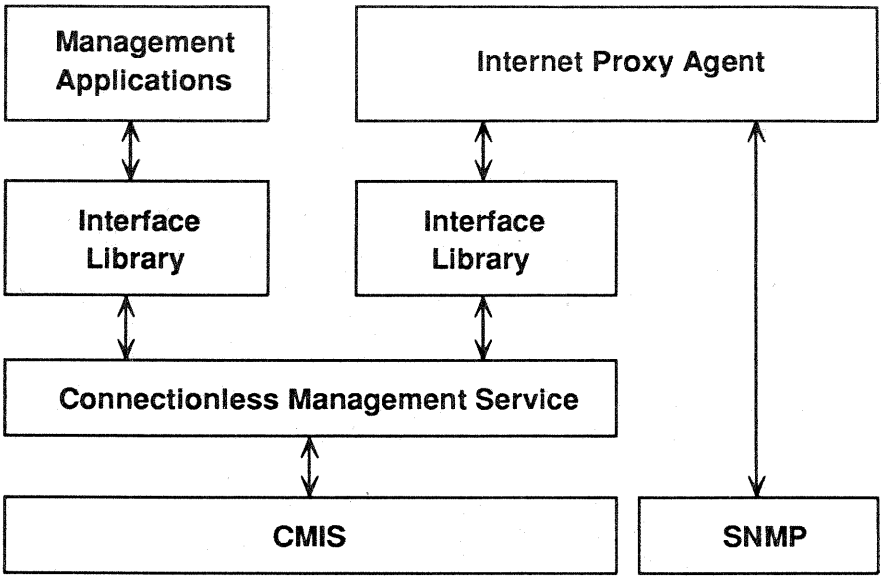

Figure 2: Internal structure of the CNMA management system

The exchange of management information between the Internet Proxy Agent and its controlled stations is done by the Simple Network Management Protocol (SNMP). Therefore the main component contains a translator function that maps management information and services between OSI and the Internet. So the essential task is to reconstruct the strictly hierarchichal structure of OSI management information to the flat one of TCP/IP and vice versa. Concerning the management protocol one CMIS request usually results in multiple SNMP requests.

Figure 2 depicts how the Internet Proxy Agent is based on the management platform in the same way as the management applications. Access to the platform services is provided through the interface library.

The Internet Proxy Agent supports MIB-I as specified in RFC 1156 [RFC1156]. These managed objects are recast into OSI template forms according to OSI GDMO providing a subtree below the 'system' managed object [CNMA]. The 'system' managed object is the top level object in the CNMA containment hierarchy. The main purpose of this managed object is to distinguish between the controlled Internet systems. Furthermore, the support of the 'system' managed object extends the functionality of the Internet Proxy Agent. For example, one attribute of 'system' notifies about the operational state of the controlled Internet stations enabling the management of station life lists at the manager.

The Internet Proxy Agent supports the Event Report Management and the Alarm Reporting Function (OSI Systems Management Functions). Event forwarding is controlled by 'eventForwardingDiscriminator' managed objects which are kept by the Internet Proxy Agent. This includes the ability to emit both SNMP-specific and OSI-specific events such as attribute value change.

However, it is not possible to add every OSI Systems Management Function to the Internet Proxy Agent. For example, the State Mangement Function dealing with the monitoring and control of the state of managed objects cannot be applied in general to the mangement information existing in TCP/IP-based systems as these managed objects do not exhibit their state behaviour.

4.3 Use of Directory Service

In CNMA the OSI directory is used as a repository for static addressing information relevant for network management. The use of the directory gives the following advantages:

- All addressing information is kept at one central site independent of the protocol used. This leads to more consistent information in the network because addressing information needs not be reentered for management purposes.
- Stations can be added or released from the directory. This is the way how managers and proxy agents learn about new stations in the network.

Proxy agents use the directory as follows: As soon as a CMIS request arrives at the proxy agent the proxy agent extracts the managed object instance. If the managed object has been requested recently the proxy agent retrieves the object owner, i.e. the agent, and its system address from a local cache held within the proxy agent. Otherwise, in order to find the station address to a given 'system' managed object the directory service is used. Then the proxy agent reads three attributes associated with a certain managed object instance from the directory. These attributes are

- the objectOwner attribute to check that the proxy agent is responsible for this object
- the systemAddress attribute to identify the station to access
- the authentication attribute if a password is required

This mechanism assists to a management view upon the network where only managed objects belonging to a certain object owner are visible. The Internet Proxy Agent makes use of the directory service. In this case, the attributes have the following meanings:

- objectOwner is the Internet Proxy Agent
- systemAddress contains the Internet address and the specific port number for SNMP
- authentication is used for the community string required with SNMP

Figure 3 shows how the Internet Proxy Agent makes use of the directory service.

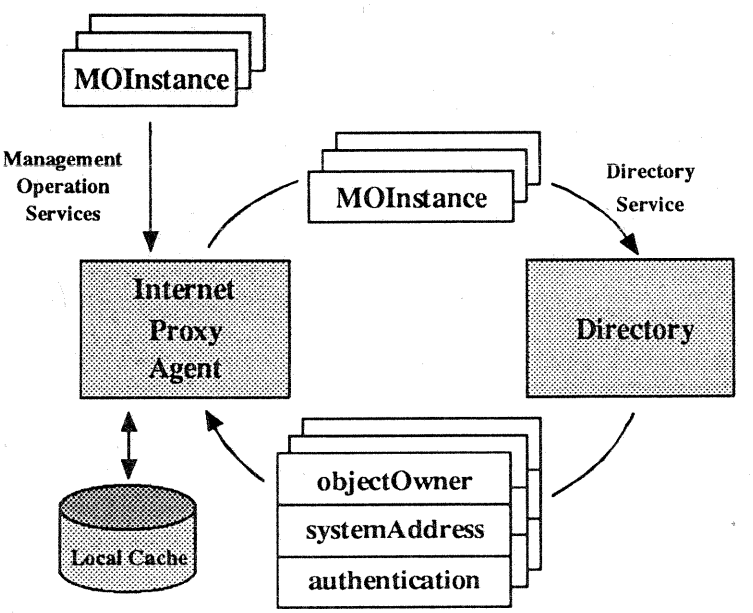

Figure 3:Use of Directory Service

4.4 Implementation Issues

A prototype version of the Internet Proxy Agent is currently implemented on a UNIX 386 system. The Internet Proxy Agent is realized by several processes. The target manager system in which the Internet Proxy Agent is integrated is equipped with two communication boards for the OSI and TCP/IP protocol stacks (see Figure 1). The Internet Proxy Agent uses the socket mechanism to pass and receive SNMP protocol data units to and from the TCP/IP protocol stack, respectively. The interface to the management platform is based on standard UNIX interprocess communication mechanisms.

5. Conclusion

This paper has presented some aspects of heterogeneous network management and a solution towards integrated management of both OSI and TCP/IP networks provided by an Internet Proxy Agent. This solution is based on OSI management standards.
This work is carried out within the ESPRIT project CNMA. It is planned to demonstrate the Internet Proxy Agent in a CNMA pilot site, usually an experimental manufacturing environment.

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Ulrich Gremmelmaier
was born in Germany in 1964. He studied electrical engineering at the University of Stuttgart where he received his Diploma degree in 1990. Since then he is with the Institute of Communications Switching and Data Technics as a member of the scientific staff doing research in the field of network management. His interests also include planning of Metropolitan Area Networks and protocols for high speed networks.

Georg Rößler
was born in 1962. He studied electrical engineering at the University of Stuttgart where he received the Dipl.-Ing. degree in 1987. Since 1988 he is with the Institute of Communications Switching and Data Technics as a member of the scientific staff. His interests include network management and efficient protocol implementation.