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IP Network Management System

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Internet traffic is growing exponentially, and different kinds of traffic are being integrated into the Internet Protocol. To keep up with these changes, the Operation Support System (IP-OSS) will be changed to adapt a diversification of IP services. In this paper, after describing the framework of a future IP-OSS, we discuss "negotiation," which will become a key function in future IP management. We describe a policy/negotiation-based IP management service for an enterprise network. This service realizes end-to-end policy-based enterprise networking. Lastly, we introduce some Fujitsu IP-OSS products for supporting these features.

1. Introduction

The Internet traffic volume is growing exponentially, and different kinds of traffic are being integrated into the Internet Protocol. This growth has given birth to many new Internet businesses, and the integration of traffic has made the IP network into a widespread infrastructure for business activities. Various kinds of IP services, consisting of IP management services and IP communication services, for Application Service Providers (ASPs) and Content Service Providers (CSPs) have been launched, and the public network has shifted from legacy telephony and data networks to IP packet transmission networks with value-added services. The increasing competition based on liberalization, new services, and new business models have made the IP network an important commodity.

To keep up with these drastic changes, requirements for an IP-OSS which adapts to diversification in IP services have strengthened. Increased utilization by providing various kinds of IP services is crucial to secure investment returns and win the competition. To achieve this, new services such as bandwidth trading are appearing. IP management systems should support these new services by including a negotiation function for their customers.

In this paper, after describing the framework of the future IP-OSS, we will discuss negotiation, which will become a key function for future IP management services. We describe a policy/negotiation-based IP management service for an enterprise network. This service realizes an end-to-end policy-based enterprise networking support of business activities. Lastly, we introduce several Fujitsu IP-OSS products that support the above features.

2. IP service management framework

Existing IP management systems focus on the management of Network Elements (NEs), which include routers, edge switches, and Customer Premised Environment (CPE) equipment. These systems are designed to monitor, supervise, and control the behavior and performance of NEs, thus offering basic and essential

IP management functions for network devices. These systems are based on the on-site management concept for small LAN environments. However, from on-site locations to remote locations, the evolution of the Internet is making it necessary to change existing IP management concepts in order to improve customer satisfaction, services, scalability, and compatibility with e-business management systems. The key requirements for the new IP management system are as follows:

1) Faster order handling.
2) End-to-end communication service quality management.
3) Support of network performance monitoring and planning.
4) New management services.
5) Support of e-business models.

Figure 1 shows a management framework for a public IP network. Using this framework, autonomous IP network management and multi-domain management are realized. To accommodate topologically huge and technologically heterogeneous public IP networks and to provide IP services based on Service Level Agreements (SLAs) with customers and other network providers, the public network must be managed based on the Telecommunications Management Network (TMN) five-layer framework (Business Management Layer (BML), Service Management Layer (SML), Network Management Layer (NML), Element Management Layer (EML), and Network Element Layer (NEL).[1] These characteristics of public network management must also be considered to achieve public IP network service customization with flow-through network operations.

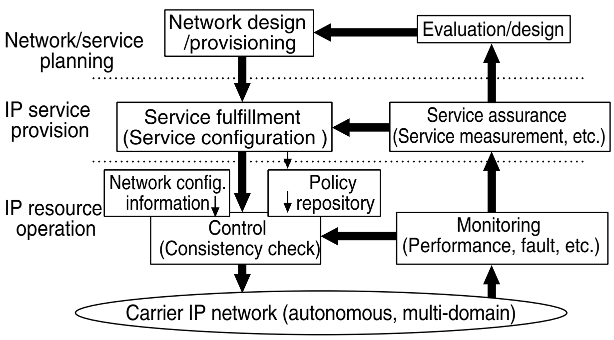

Figure 1
Management framework for public IP network.

3. Negotiation[2]

In this section, we discuss the negotiations made between an IP service provider (e.g., public IP network provider) and an end-user (e.g., an enterprise).

3.1 Negotiation model

Negotiation is one of the key functions of IP service customer care. An end-user will be able to interact with the provider's negotiation function by downloading negotiation agent software from a server in the provider domain to the end-user terminal, to finalize the SLA. The software agent is a very useful paradigm for the brokering of 1:n or n:n negotiations among participating users and providers. **Table 1** shows the features that should be included in negotiations and their timings. Of course, the timings of actual negotiations can be adjusted depending on the customers' needs and support mechanisms.

Through negotiation, end-users can select their preferred service features and price. At the same time, service providers can offer the requested service features while minimizing resource requirements and maximizing resource utilization. **Figure 2** shows the functional architecture for realizing negotiation. The figure shows that in total IP management, in contrast to legacy PSTN services, Web-enabled IT-capable terminals

Table 1
Negotiation items.

Timing	Features
• Static (long term) • Pre-assigned • On demand	• Price • QoS/CoS • Bandwidth • Delivery time • Security etc.

make easy, customer self-operation and negotiation a reality. To fully support these user functions, the provider must establish dynamic resource management databases (DBs), for example, a traffic DB, pricing DB, and CoS DB, to make more effective use of network resources.

3.2 Policy-based negotiation architecture

Negotiations and the resultant SLAs drive the execution of policies in the user and provider domains. In return, the policies in these domains can drive the content of a negotiation. Negotiation is done in consideration of factors such as resource utilization, the providing of services, and competition with other providers. These factors quickly change, and network management policies which realize negotiation results are also affected by these changes. Although policy-based management has been used in traditional telecom management systems, its policies are not separated from the rest of the system as independent components. Instead, its policies are tightly coded within the management systems, making it extremely difficult to adjust the policies to respond to dynamic user needs and provide new services according to the resource status and the competition.

The only solution to this problem is to separate policies from the management system so that the policies are realized as a set of loosely coupled, parameterizable parts of the management system. Policy management supports this by dividing the Policy-Based Management (PBM) system into a policy decision, policy enforcement, and policy repository.[3] **Figure 3** illustrates the policy-based negotiation architecture based on the loose-coupling concept.

The policy executor in the figure consists of a policy repository and policy decision function. The policies are included in the policy repository as policy rules. The rules are well-defined until a management system and/or a network element can handle them directly. A state change event of network resources triggers the policy decision function to search through the policy repository to make a policy decision. Since the policies, the mechanism which makes decisions according to the policies, and the management functions (i.e., the policy enforcement functions) which control resources according to the policy decisions are clearly separated in this architecture, the impact of policy changes on the rest of the management system is minimized. Hence, a change in the management policies to gain a competitive advantage can be easily realized. The policy descriptor provides a representation mechanism for policies, and the policy editor includes a tool for policy consistency and integrity checking. The tool is of particular importance in minimizing policy-to-policy interference when policies are modified.

The coherency of the policy is of critical importance if the PBM is to provide reliable management operations. One systematic ap-

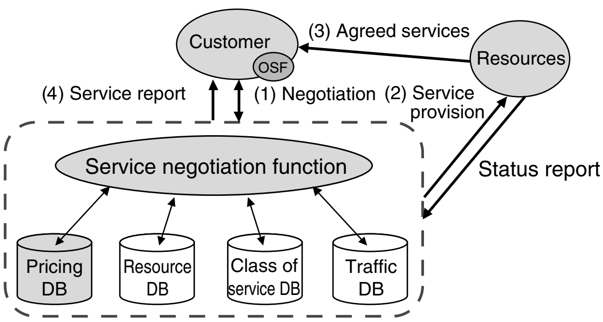

Figure 2
Negotiation architecture.

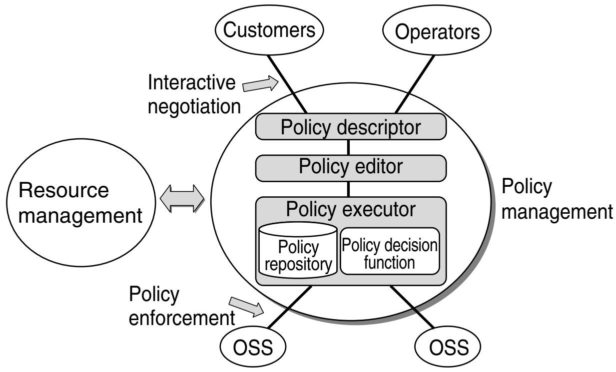

Figure 3
Policy management and negotiation.

proach to maintaining coherency is to sort out the resources by management layers and represent them as managed objects using a proper abstraction scheme.

The policy-based negotiation architecture and the loosely coupled PBM allow the policies to define and represent the relationships between service managed objects (MOs), enabling flexible and customizable negotiation and more timely IP service management. For example, a customer (end-user) negotiates with a service provider interactively, resulting in a policy modification request in the respective management domains. Changes in policy descriptions lead to changes in IP service management by the provider in areas ranging from customer service provisioning to billing. Maintaining the policy coherency before and after the negotiation and policy modification is mandatory. Although a theoretically complete checking of policy coherency is in general a hard issue, a policy consistency and integrity tool in the policy editor would enable much of the undesirable side effects to be eliminated. Underlying OSSs make the resources at and below the network management layer available as manageable resources for the policy executor.

4. Policy-based SLA[2)]

4.1 End-to-end network management based on customers' policies

In this section, we describe a new policy-based IP management service for enterprise networks that incorporates a part of the above mentioned negotiation concept. Since enterprise users will be the main customers in the early stages of a public IP network, end-to-end service management is needed if these business customers are to trust and use the public network services to establish their individual enterprise networks.

Enterprise users will require management of the quality and cost of their enterprise network assets to make them suitable for their business goals, which determines the enterprise network management policies. An enterprise network commonly consists of private networks and public networks. In the private network portion (i.e., a Local Area Network [LAN]), a policy-based management framework can be a solution for policy enforcement if the policies can be translated into refined policies (called policy rules) that the PBM policy mechanism is able to handle. In the public network portion of an enterprise network (i.e., a Wide Area Network [WAN]), enterprise users will expect public IP network service providers to be able to enforce the enterprises' policies.

To meet these requirements, we enhanced the concept of SLA and created a policy-based SLA. The policy-based SLA is defined as a set of management policies (policy rules) that are derived by refining enterprise business policies according to the assets of the information network. The concept of end-to-end network management based on policy based-SLA is shown in **Figure 4**.

4.2 Hierarchical policy enforcement architecture

Dynamic controls of IP services are specified as the policy rules. Since the controls are based on individual events involving the network resources (e.g., a state change notification) or the network/service management function (e.g., network/service fault alarm), to execute the dynamic control, different types of policy rules reside in each management layer. To handle the policy rules

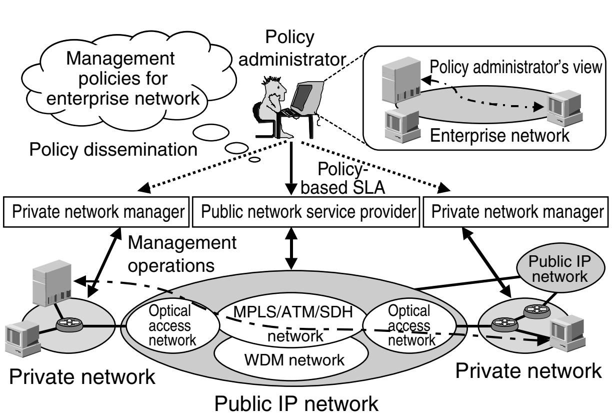

Figure 4
End-to-end management based on customers' policies.

efficiently, we propose a hierarchical policy enforcement architecture. **Figure 5** shows the architecture and three reference points: RP #1 to #3. RP #1 is for policy-based SLA negotiation, RP #2 is for event notification, and RP #3 is for issuing management operations.

The policy rules in an SLA are specified based on the management information model according to the customer's point of view, and the model is presented to the customer by a service provider. The policies are translated into a set of policies based on the TMN management information model (i.e., MOs) in the service provider. Regarding the enforcement of policies within a TMN environment, the policies can be placed into two groups: QoS policies and management policies. Since a QoS policy is a rule guaranteeing the quality of service for specified data flows, the QoS policy must be refined so that the QoS is guaranteed within the network resources (elements) in which the target data flows can be identified. A management policy is a rule for invoking management operations in certain situations. In the remainder of this section, we describe how the SM/NM policy-translation block enforces the management policies.

A management policy rule is represented by a combination of items: the Condition, Subject, Action, and Target. The Condition is the trigger event. The Subject is the manager, and the Target is the managed object. Hence, the relationship can be paraphrased as follows: "If the Condition becomes true, the Subject performs the Action on the Target."

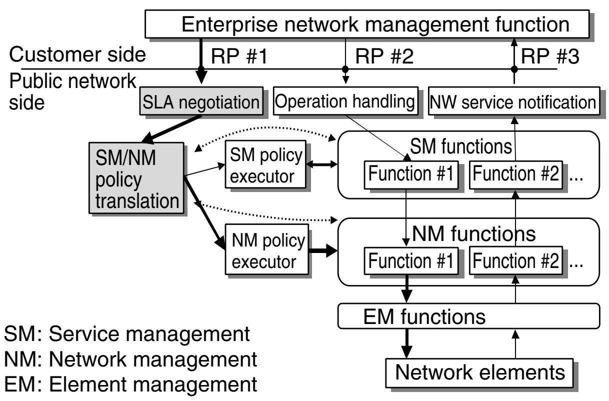

Figure 5
Hierarchical policy enforcement architecture.

Management policies can be categorized into two groups: 1) the policies that require the action of SM functions and do not require the action of NM functions and 2) the policies that require the action of NM functions and only optionally require the action of SM functions. It is necessary to translate a policy included in the SLA at SLA negotiation in order to do the following:

- To guarantee policy enforcement. When the policy requests a modification of the network configuration, the executability of the action to be taken by the NM functions should be checked based-on the network information (MOs) before the acknowledgement of SLA negotiation.
- To check whether the policy causes a conflict with the management policy of the service provider. Because the management policies of the service provider cover both SM and NM, the customers' management policies are translated into NML policies before the acknowledgement of SLA negotiation.

To maintain data consistency with the network management information in NM functions, further refinement, including translation into policies enforced by EM functions, is not allowed.

Within the SN/NM policy-translation function block, the refined management policies are classified as policies enforced by the Network Management Systems (NMSs) and those enforced by the Service Management Systems (SMSs). Some policies must be adapted to prevent lookup in the SM databases by NMSs. This enables independent enforcement of all SM policies from the NM layer and the layers under NM if sufficient information is received in event notifications from the NMSs. In addition, all NM policies can be enforced independently from the SML. This deployment improves the performance of the policy enforcement.

5. Fujitsu product architecture

In this section, we introduce Fujitsu's IP-OSS products for supporting the features described above. The Fujitsu IP-OSS architecture (**Figure 6**) is based on a TMN functional architecture (BML, SML, NML, EML, NEL). Common data sharing, load balancing, and distributed functions are realized by using CORBA. Each SML product is related by a workflow engine, and fine-grained services for users are promptly provided. In the next section, we describe the main products in Fujitsu's product map.

5.1 SystemWalker/CentricMGR and IP NetMGR

SystemWalker is a total management product family that manages all the elements (resources) of an IT system, for example, the network, servers, storage, and applications. This family supports the IP resources operating in Figure 1. Its basic concept is Policy-based Systems Management (PSM), with which all management activities are controlled. SystemWalker focuses its enhancements on the management of e-business. One of the management activities in SystemWalker/CentricMGR is a centralized operation monitoring function based on a "business viewpoint." Policy-based negotiation will be a core function in the concept. For the IP network, SystemWalker/IP NetMGR provides IP management functions based on a "service viewpoint" and has the management scalability and reliability required by ISPs and carriers.

SystemWalker/IP NetMGR can have its monitoring servers in parallel, depending on the size of the target network and the amount of information (**Figure 7**). It also gives users great flexibility, for example, it enables step-by-step addition of the monitoring menu and dynamic reconfiguration/ maintenance operations. For high-availability, it has stand-by backup and dynamic switch mechanisms for the monitoring servers. All the information collected by the monitoring servers is automatically assembled into reports. These

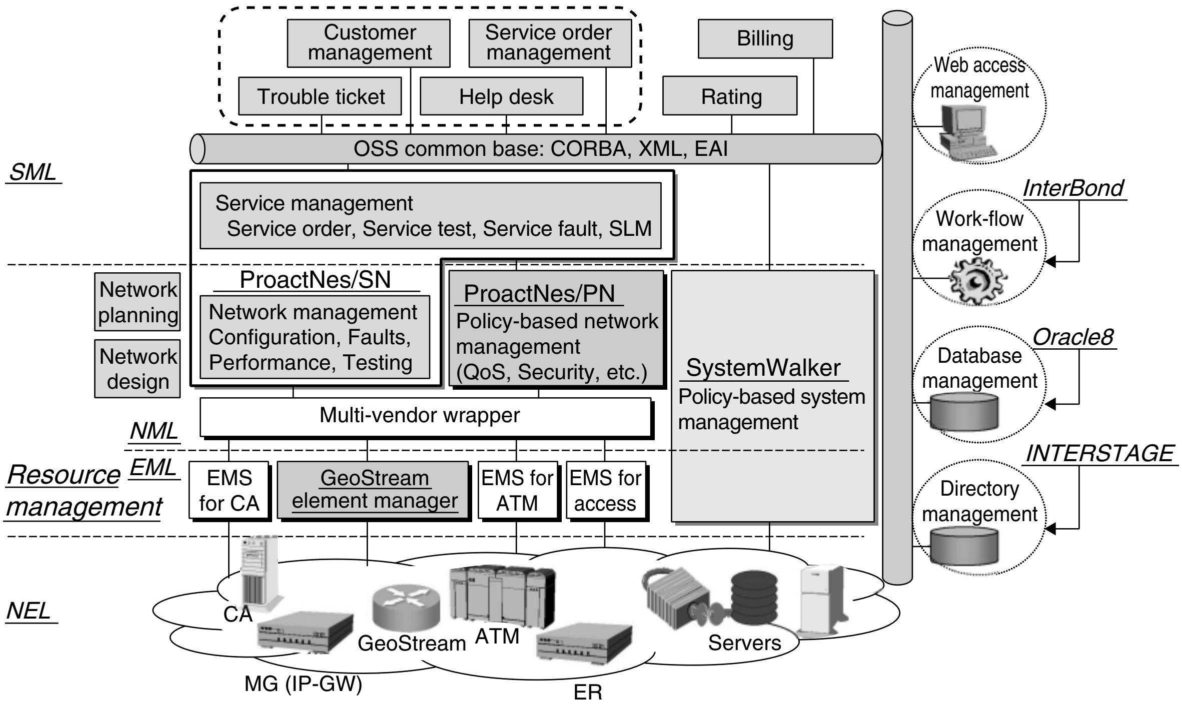

Figure 6
Fujitsu IP-OSS architecture.

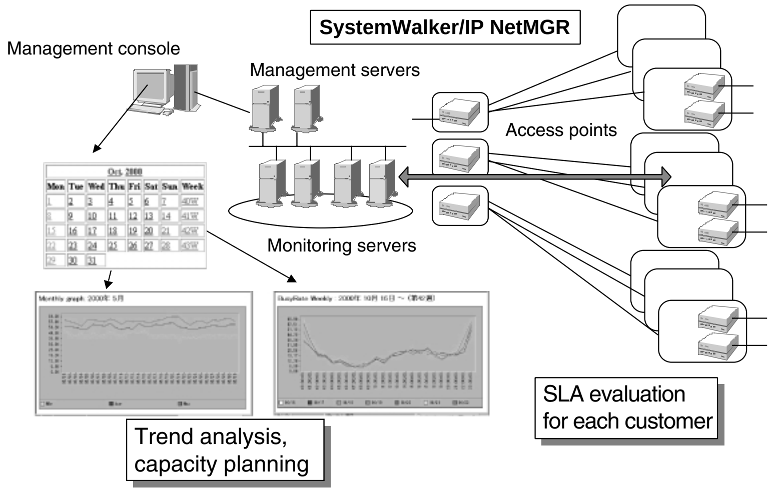

Figure 7
Example application of SystemWalker/IP NetMGR.

reports can serve as Service Level Agreement (SLA) reports for the customers.

5.2 GeoStream Element Manager

GeoStream Element Manager manages networks based on GeoSrtream, which is a next-generation, large-scale, high-performance, IP switching node. It also supports the IP resources operating in Figure 1.

For a large-scale, IP network management system, high reliability through, for example, redundancy, congestion control, access permission control, and scalability, is required. To satisfy these requirements, GeoStream Element Manager uses CORBA, Java, Clustering and other object-oriented approaches as base technologies.

5.3 ProactNes/PN and SN

ProactNes/PN provides a policy-based management function to manage the quality of communication services. This system supports the provision of IP communication services and the IP resources operating in Figure 1. To maintain the IP network quality and security, ProactNes/PN dynamically controls the Quality of Service (QoS) parameter of related network elements using unified rules (policies) according to the state of the IP network. Because managing a multi-vendor connection is a key element function for supporting end-to-end service quality management, the system supports a mutual connection network between multi-vendor network elements. This system will be used as a platform for future management services provided by a policy-based SLA. Each IP network consists of several types of network elements that have different QoS policy control mechanisms. ProactNes/PN is implemented with a modular structure to handle the various QoS policy mechanisms, and it can be applied to each grade of network and NE (**Figure 8**).

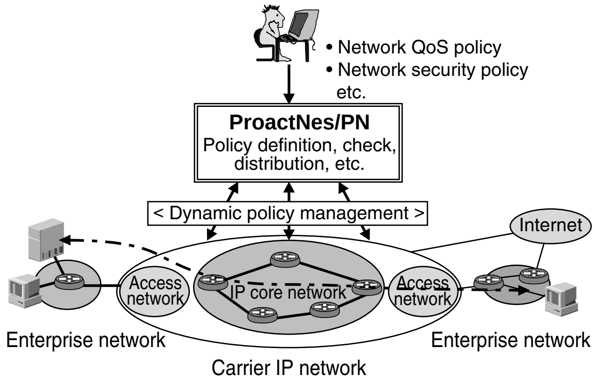

Figure 8
ProactNes/PN: policy network manager.

ProactNes/SN provides the network topolo-

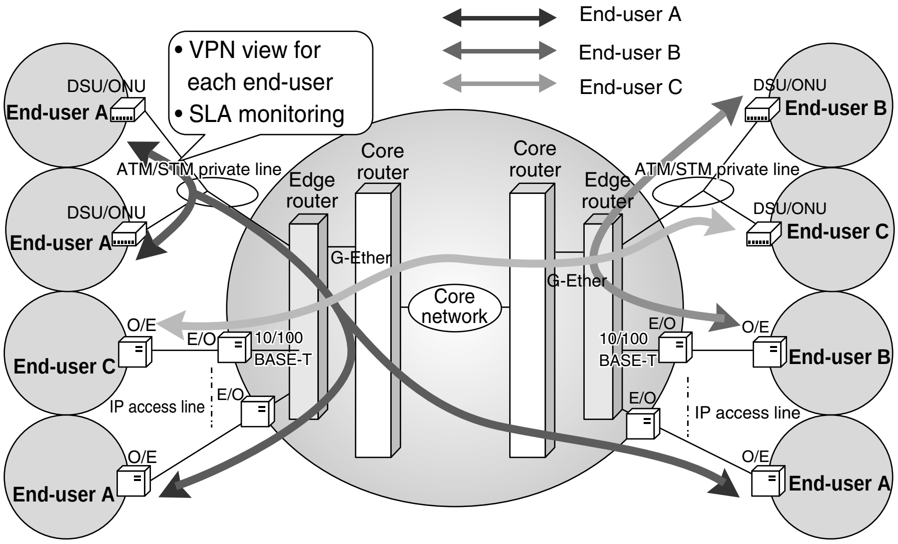

Figure 9
ProactNes/SN: service network manager.

gy view of a Virtual Private Network (VPN) service and an operator view for each end user (**Figure 9**). This system supports IP communication service provision. The term "end-user" here means not only individual users but also contract parties who use the carrier IP backbone networks, for example, ISPs and ASPs. Also, ProactNes/SN provides an SLA management function and service quality control function by inter-working with ProactNes/PN.

6. Conclusion

In this paper, we studied some of the requirements for IP management. We presented a new IP management framework which is based on the results of our study. This framework keeps up with diversification among IP services and creates added value. We believe that negotiation is the key to IP management and that the negotiation mechanism proposed in this paper will help realize high price-performance IP services, thereby winning the competition in the commercially attractive IP network field. We proposed a policy/negotiation-based management service to provide dynamic, fine-grained, IP network service customization based on SLAs, including customer management policies. Then, we described our IP management products for supporting these management services.

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