Multi-domain Policy Based Management Using Mobile Agents

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Abstract. This paper describes a new framework for the interoperability between ISP management domain for the purpose of satisfying end user requirement based on service level agreements (SLA) set up between a customer and its related ISP and also SLA set up between ISPs. The paper considers future policy based enabled equipments and management centers based on the ongoing work undertaken in the frame of the resource allocation protocol and policy framework groups of the IETF. The objective of this paper is to investigate the possibility to merge policy based management with mobile agents in order to handel QoS of communications spanning over a number of ISP domains. In this environment, mobile agents will act on behalf of users or third party service providers, to obtain the best end to end service based on a negotiation process between ISP policy management systems.

1 Introduction

Policy based management is a gaining approach to deploy management strategies. In the context of the Internet, the complexity of the composition of the Internet necessitates a close negotiation between ISP's (Internet Service Provider) in order to provide value added connectivity services. In the POTS (Plain Old Telephone Service) network, these agreements were achieved between telecommunication operators for the purpose to establish an international phone call service with guaranteed QoS. In the Internet, the number of services can be enormous and it is difficult to achieve a global agreement on the overall services. Thus ISP can negotiate cooperation on service per service base. The set of agreement ISP will agree on will be defined in ISP-to-ISP SLA. These agreements are the formal negotiated agreement between an ISP Provider and an ISP Customer for service delivery. It is designed to create a common understanding about services, priorities, responsibilities, etc. SLAs can cover many

aspects of the relationship between the ISPs such as quality of services, customer care, billing, provisioning etc. Similarly, end users connected to a particular ISP have agreed with this latter for Customer-to-ISP SLA.

When the service requested by a customer span a number of ISP, negotiation between ISP has to take place in order to assume to the customer the best deal for its request. For instance, if the ISP has connectivity with two other ISPs, there should be a process that allows searching for the best service (for instance, in term of QoS or Price) on a customer-based requirement defined by the SLA.

In this paper, we suppose that ISP will deploy in the near future, policy based management systems. Policy defines a set of rules that govern the behavior of the network depending on SLA. The purpose of this paper is to investigate the possibility to facilitate the negotiation between ISP for the purpose of satisfying a customer request. Each ISP will establish SLA with a customer and with other ISPs. When a customer apply for a service, it is necessary to set up a process that will permit to verify if the service can be assumed depending on various parameters such as, the customer, the type of service, the date/time, etc. The developed framework proposes to use mobile agents to facilitate the implementation.

The remainder of the paper is organized as follows: section 2 describes the background concepts for the purpose of this work. Section 3 presents the objectives of this work. The forth section presents the proposed framework for interdomain policy based management using mobile agents. Section 5 describes the architectures of the different components of the framework. And finally a conclusion and future works.

2 Background

In this work we have addressed a number of concepts: policy based management, agent technology; common information model which are introduced briefly in this section.

2.1 Policy Based Management

The policy based management [1] approach aims to defines high level objectives of network and system management based on a set of policies that can be enforced in the network. Policies are a set of pre-defined rules (defined actions to be triggered when a set of conditions are fulfilled) that govern network resources, including conditions and actions that are established by the network administrator with parameters that determine when the policies are to be implemented in the network. In the case of ISP, policies are defined based on one hand the high-level business objectives of the ISP and on the other hand on the SLA (Service Level Agreement) agreed with its customers and partners ISP. The Policy Working Group [2] of the Internet Engineering Task Force is chartered to define a scalable and secure framework for policy definition and administration [3][4]. The main goal is to support QoS management. This group has defined a framework for policy based management that defines a set of component to

enable policy rules definition, saving and enforcing. It identifies two primary main components by their functionality. The framework is comprised of a Policy Enforcement Point (PEP) that is a policy decision enforcer component and a Policy Decision Point (PDP) which is the decision-making component.

2.2 Agent Technologies

The agent concept has been widely proposed and adopted within both the telecommunications and Internet communities is a key tool in the creation of an open, heterogeneous and programmable network environment [5]. This trend is motivated by the desire to use the agents to solve some of the problems encountered in large scale distributed and real-time systems such as the volume and complexity of the tasks, latency, delays, and others. Generally, an agent can be regarded as an assistant or helper, which performs routine and complicated tasks on the user's behalf. In the context of distributed computing, an agent is an autonomous software component that acts asynchronously on the user's behalf. Agent types can be broadly categorized as static or mobile [6],[7]. The main motivation of the use of agent technology in this work is driven by the desire to automate the control and management processes by allowing for more programmability of the network to rapidly customize the provision of new information and telecommunication services [8],[9],[10].

2.3 Common Information Model,

The work undertaken by DMTF (Desktop Management Task Force) for the purpose of integrated system and network management has leaded to the definition of a common information model called CIM [11]. CIM is an implementation neutral schema for describing overall management information. It ha been adopted by IETF, aims to establish a common conceptual information model that captures every notion that is applicable to all areas of management including policy definition. This model is extended in this work in order to support the modeling of network and policy information as well as service level agreements.

3 Objective of this work

The ongoing panorama of networking shows a numerous number of ISP located at different geographical area. At the same time, companies are requesting more sophisticated services that permit them to connect between their sites or with sites of other companies in a personalized way.

In the context of fierce competition in open liberalized telecommunications markets, network providers are therefore currently investigating opportunities to provide their customers with differentiated service level agreements (SLAs) which state the obligations entered into by both network provider and customer

However, to satisfy the customer needs, it is mandatory to take its requirements into account in a flexible way even if the management of the end to end communication is more challenging since the service can span heterogeneous network provider domains. And yet needs to be managed on an end-to-end basis.

Thus it is necessary to enhance the PBM framework in order to take into account the multi-party process of policy based management. In fact, ISP establishes a set of agreement with others ISP in order to provide an end to end service to customer. Agreement between ISP will be based on ISP to ISP SLA that can change during time according to the business strategies. However, it is necessary to automate the interaction process between ISP Policy Based Management in order to hide the complexity of the end to end management. Interdomain PBM have to provide facilities to adapt quickly to new changing strategy regardless the relation between a particular ISP and the other ISP. For instance, ISP can have different agreement with other ISP to provide connectivity to the same destination.

In this paper we investigate the possibility to use mobile agents as flexible approach to PBM over multi-domain IP networks. We suppose that each provider has deployed a policy-based management in its own domain. Each provider has its own business objectives that can changes rapidly depending on the economic context, the economic strategy followed by the operator and agreements between the various network providers at a wide area scale.

4 Proposed framework

Because of the complexity of the policy management process in the context of multi-domain operators and its implementation and security issues, it is likely that the client/server policy based management approach will be replaced by a mobile agent approach. We call this management architecture “Mobile Agent PBM ” (MA-PBM). It can avoid scalability problems and offers flexibility to users, third party operators and network operators as it will be shown in the following sections.

The open framework defines a set of agents depending on their respective roles in the architecture:

Type	Role	Properties
Local PEP Agent Manager:	It is a fixed agent that performs local routine control/management PEP functions. It performs mainly metering and enforcement functions as well as the creation/deletion of PEP mobile agent when it needs to interact with the PDP for decisions.	Local agent, no mobility.
PEP Mobile Agents	These are used mainly as autonomous negotiator agents between PEP and PDP within the same domain. The *PEP Mobile agents* are used to obtain decisions from PDP. The PEP mobile agent carries all the information regarding the ongoing connection. It is sent by the PEP to the PDP in order to notify a particular event in the	Intra domain agent, mobility capabilities.

	network (RSVP opening request [12], QoS degradation, etc).	
Local PDP Agent Manager	It is a fixed agent that takes decision regarding the information that is carried out by the PEP Mobile Agents. It interacts with the various databases (policy rules DB, MIB, security DB, etc) in order to retrieve the rules that can be triggered. Once the decisions are identified, it gives them to the PEP mobile agent. If any configuration related to new policies are defined, it creates a PDP Mobile Agent, it send to remote PEP to perform the new configuration. It takes also into account inter-domain interactions, when a decision needs to be negotiated with remote domain PDP Agent Manager. When interacting with remote domain, it creates a PDP Domain Mobile Agent.	Local agent, no mobility.
PDP Mobile Agent	When a PDP has taken a decision it sends a PDP Mobile Agent to enforce policies directly in the PEP component in all the network elements that are concerned by this new decision.	Intra domain agent, mobility capabilities.
PDP Domain Mobile Agent	When a PDP has to take a decision related to an inter-domain connection, it has to identify the set of remote domain need for the connection and send a Domain Mobile Agent to negotiate the term of services needed by the customer.	Inter domain agent, mobility capabilities.

4.1 Domain Interaction for a service spanning two ISP domains

In the case of two ISP domains interconnecting the customers premise networks, the deployment of the different agents in the global distributed architecture is described in the following figure:

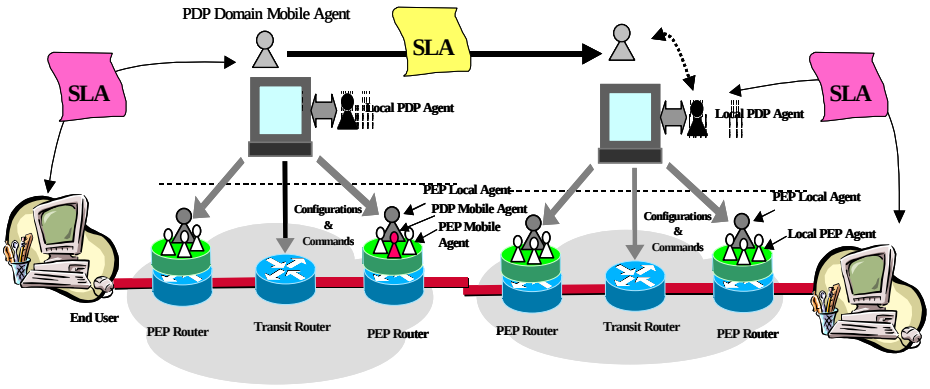

Figure 1. Architecture of Interdomain PBM

The local PDP agent is responsible for collecting information related to the entire domain. If any change occurs in the network such as an RSVP connection request, the local PEP agent running on the ingress router creates a PEP mobile agent and sends it to the PDP system. The sent agent contains all the information needed to identify the source of the request (customer) and the destination of the call (calling party) as well the parameters related to this event (for example QoS parameters for the request RSVP connection). Based on this information, the PDP local agent retrieve related information and policies from the policy DB, the MIB and the security server using different types of protocols such as LDAP, SNMP or any other protocol that permit to retrieve information from a database. Then, the local PDP agent tries to trigger any policy rule that can be triggered regarding the information carried by the PEP mobile agent. If the connection doesn't span a different ISP domain, the PEP mobile agent carries back the response to the PEP local agent. If the decision needs to interact with remote ISP, the local PDP agent, sends a PDP domain Mobile agent to remote ISPs with all information related to the requested service as well as information permitting to identify the initiating domain. The remote PDP local agent gets the necessary information from the remote PDP domain mobile agent. According to this information, it tries to trigger any policy rule that defines the ISP-to-ISP policy rules between this ISP and the initiating ISP defined within the SLA. If the service is accepted the PDP domain mobile agent, collect all the information related to the decision and move back to its domain. The local PDP agent retrieves the information and takes a final decision regarding the request service.

When the final decision is taken, each local PDP agent of each domain that intervene in the final decision has to configure its own equipment's in order to enable the customer service to be operational. This means for instance to enforce policy directly into equipment's using PDP mobile agents. Consequently PDP mobile agent will move from one equipment to another in order to enforce locally the policy by interacting with the local PEP agent.

4.2 Domain Interaction for a service spanning three ISP domains :

The described process can be complex in the case of numerous ISP that interconnect the two remote sites with different agreements. Thus negotiations have to be set up with different ISP in order to found out best solution according to different criteria's such as pricing, QoS, duration and so on. In fact, price for example, can vary according to a network operator’s tariffing policy, and according to the competition between different operators.

In case of three ISP domains as described in the figure 2, the PDP inter domain agent will move from one domain to another in order to interact with the local PDP agent manager. As in the previous example, the PDP inter domain will carry all the necessary information to trade with the remote local PDP agent for the purpose to obtaining a response for the requested service. If one of the remote local PDP agent refuse to serve the PDP inter domain agent regarding its local management policies, the PDP inter domain agent move back to it initial domain and inform its initiator

agent of the negative response. However, in case of success, the PDP interdomain agent continues its trip until the latest domain. During the travel, the agent obtains authorization to move to a different domain for the purpose of trading the end to end service.

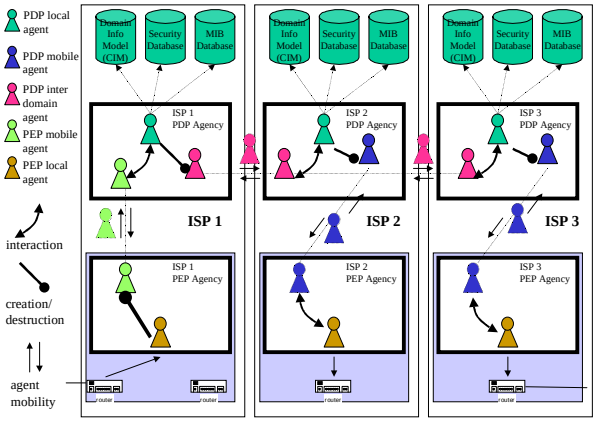

Figure 2. Agent migration during session negotiation

In case of acceptance of the end to end service, the interdomain mobile agent informs each PDP local agent in the way back to the initial domain of the final decision and collects and distributes the SAP necessary for the service initiation between ISP domains. As a matter of fact, each PDP local agent creates a PDP mobile agent and sends it towards the various routers for local configuration by the PEP local agent as described in the figure 2.

5 System architecture and information model

The system architecture comprises two main components, the PEP and the PDP environments as described below. These two environments differ mainly in term of localization. In fact the PEP environment is located at the router boundary while the PDP environment is a stand-alone system. The PEP environment has to be very light in the sense that it should not require a lot processing and memory resources and should be as faster as possible.

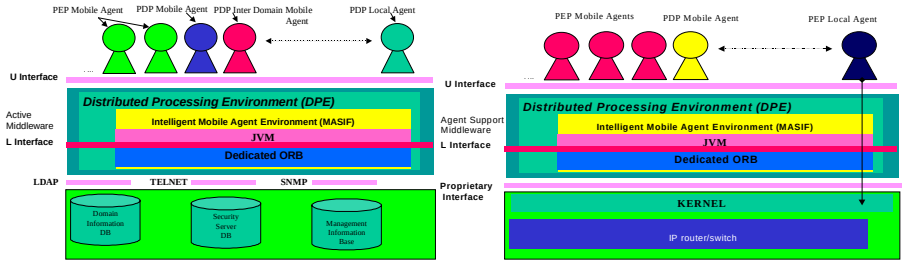

Figure 3. PEP and PDP environment architecture

5.1 Policy Enforcement Point architecture

The execution environment at the PEP point is a mobile agent agency. The agency is a MASIF like middleware located in the router. In this scheme, a MASIF like middleware based on a JVM is proposed as an technological architecture for agent execution. Based on the PDP decision, the local PEP agent assigns a policy to users' connection. In order to have a standard interface between the agents deployed on the router and the embedded hardware and software, an ORB (Object Request Broker) is used between the JVM and the Kernel. The reason for using an ORB is to provide in one hand all the support for agent management and mobility and on the other hand a standard L interface [13] to interact with router kernel, since there is a wide variety of hardware and software within routers from different vendors.

5.2 Policy Decision Point Architecture

The execution environment at the PDP point is also a mobile agent agency. The agency is based also on a like middleware located in a stand-alone system. This environment should provide facilities for policy rule directory access, security server access and MIB access. The access to the policy rule directory is performed using LDAP (Lightweight Directory Access Protocol). Access to security server can be performed using telnet or any other useful protocol. The MIB access is realized using the SNMP (Simple Network Management Protocol) as it is a standard for such access.

5.3 Interdomain Policy Management Information Model

The information model specified to capture interdomains interaction functionality is derived from the DMTF CIM (Common Information Model)[11]. For simplification reasons, the classes not used for this model are not described in the figure 4. Mainly, the information model for a particular PDP environment permits to capture the information related to the customer connected to the ISP as well as the information related to the remote ISP which a contractual relationship with this particular ISP as described in the following figure :

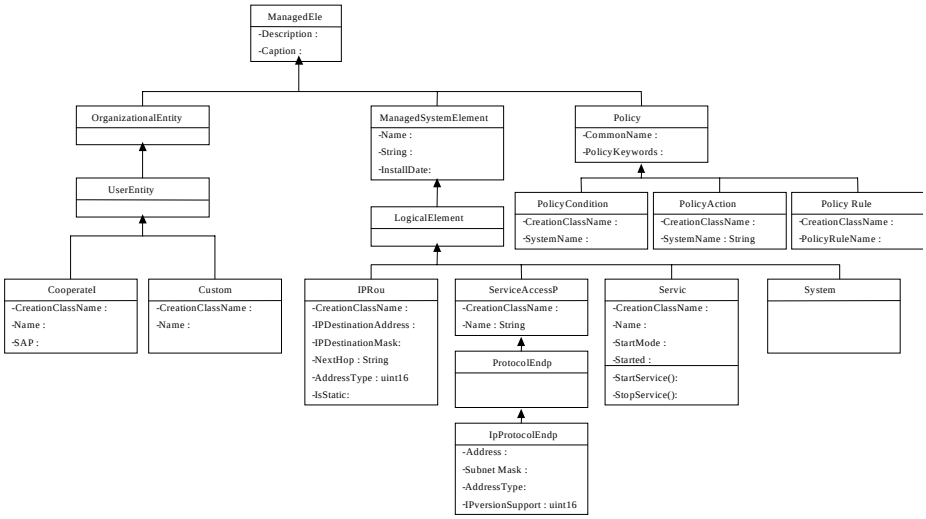

Figure 4. Interdomain PBM information model

The simplified model presents a routing table that permit to identify the route to be used for negotiation. In case of different routes for the same destination the PEP local agent creates a PEP interdomain mobile agent of each route. Each created agent will be sent in one direction with the requested parameters for the route in order to trade with the remote PDP local agent for the purpose of a customer service deployment. The routing inside a particular domain was not considered as far as we consider that it exists a local domain routing protocol that are able to identify the route inside the domain to satisfy the customer requirements.

7 Conclusion and future work

In this paper we have presented an integrated framework for interdomain policy based management based on contractual relationships between the customers and an ISP on one hand and between ISPs on another hand. These contractual relationships are described in term of policy rules in each domain. The policy defines the set actions to perform when particular events occur. The idea is to define a flexible and efficient solutions for a problem of service deployment over different Internet domains. Existing approach to offer end-to-end QoS are static and makes difficult to set up in the physical network. Hence it is not possible to react quickly to customer changes. Policy based management framework offers a good starting point to automate the process in one domain, however the issue of interdomain policy based management is still open. The proposed approach uses a set of agent with different skills. Each ISP is responsible for its domains and can change its business strategies without changing anything in the system. The interaction process between domain is performed automatically and any changes in the policies are taken into account when a

service has to be set up in the particular domain. Hence, the specified framework considers a number of key technologies to deploy the overall system. The technologies employed include mobile agent platforms, MASIF, CORBA[14]. The framework also identifies different levels for the implementation of these technologies within the network.

Many aspects of this work are not completely resolved. It is a first attempt to address policy based management in multidomain using mobile agent. The following is to go deeper in the specification of the agent interactions as well as the information model according to the recent progress in the IETF policy group.

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