Chapter 2

II. REQUIREMENTS FOR THE MANAGEMENT OF ACTIVE NETWORKS

Section II.1 – Introduction

From the previous chapter we have gained the basic knowledge about the objectives of this thesis as well as about the main technologies involved. Although the project objective is the management of heterogeneous networks formed by active, programmable and passive nodes, it is the management of active and programmable nodes the one that has a bigger influence on the management system design and implementation. The reason is that the particularities of these technologies motivate a set of requirements that must be handled by the management system.

Along this chapter we are going to analyse and enumerate which are these requirements imposed by the management of active and programmable networks and why are they needed. Later on the chapter, we will also describe other requirements not related with the management of active and programmable networks but with management itself, with the thesis objectives or others. Finally, the chapter is concluded with some final remarks about the chapter content.

Section II.2 – Requirements derived from the management of active and programmable networks.

Active and programmable network technologies focused on the synergy of three concepts: network virtualisation, open interfaces and platforms, and intelligence in the network. The network is no longer an entity providing basic connectivity but rather is treated as a service-enabling platform, which is open, intelligent and offers a variety of virtualised facilities under the authority of different communities. Consequently, the management of such network has to take into account a whole new range of problems and complexity. To this end, it must support co-existence of different management strategies thus facilitating customisation, interoperation with different vendors' equipment, and dynamic extension of its functionality to support new services and their deployment.

Active networks technology impacts network management functionality in different ways. First, as an enabling technology, it offers new ways to achieve

a more flexible, distributed and efficient management. In contrast, it puts additional burden on the management of the network, which now has to account for the additional complexity introduced by this technology. This results in an increase of the management logic complexity and the tasks, some of them new, that need to be performed.

The first requirement introduced by active and programmable networks is derived from its inherent dynamic extensibility. In active and programmable networks the functionality of network elements, and thus from the network itself, can be modified at run-time. This allows the introduction of new active applications, network services or the modification of the network behaviour. In this way, the network functionality can evolve at run-time as soon as new requirements appear. If the management system is not capable of extending dynamically its management functionality to cope with these new applications and services it will soon become obsolete and useless. Thereby, it is a major requirement from the network operator's point of view that the management system can update its management functionality at least at the same rate of change as the active and programmable network that it manages. Otherwise, the network operator would not be able to take full benefit of the new functionality added in the network. The figure below schematises the dynamic extensibility requirement. We can appreciate in the figure how the management system must be capable of extending its functionality to cope with the MPLS service dynamically installed in the active network.

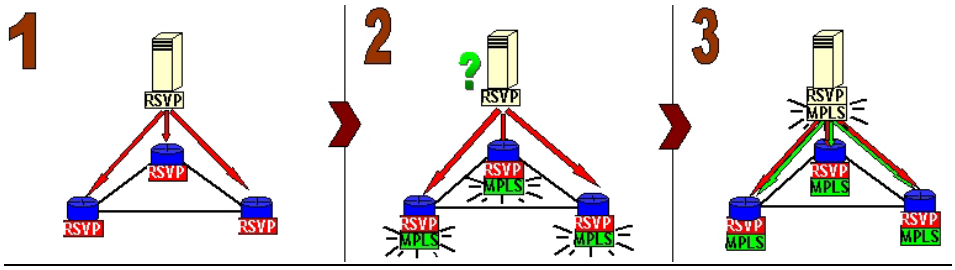

Figure 2 - 1. Dynamic extensibility requirement

Moreover, we introduce some concrete requirements to the extensibility mechanism so that it is capable of handling efficiently the objectives of the thesis:

i) New management functionality must be installed automatically when its need is detected.

ii) Components implementing new management functionality must be selected not only based on the functionality they implement but also taking into account the devices where this functionality applies. This property is closely linked with the support for heterogeneous networks.

iii) The complexity added to the management system because of including the extension mechanism must be minimised.

iv) Dynamically installed components containing management functionality no longer used must be removed from the system to reduce the computational load.

v) The network operator decides what functionality might be potentially added to the management system.

vi) Dynamically installable components must be MANBoP components. That is, they must implement the corresponding MANBoP interfaces.

Linked with the need of dynamically extending the management functionality, it might be the case that a service provider and a network operator achieve an agreement by which the service provider is allowed to use the network operator's management system to manage his active applications. This will require, not only that the management system is capable of dynamically installing the corresponding active application management functionality when required, but also that the service provider obtains delegated access to the management system.

Such an agreement benefits both the service provider and the network operator. The service provider saves costs by using an already available management system. Moreover, he can dynamically customise the active service to the business needs. On the other hand, the network operator takes additional profit from his own management infrastructure by selling to service providers restricted access to the management functionality. Furthermore, the network operator also saves costs by outsourcing service management tasks to service providers [FAIN01].

Hence, the management system must include a flexible delegation mechanism in order to meet increasing requirements for customisation that consumers impose on networks. The acceptation of the term delegation that best defines the requirement set by active networks is the one used within the context of Policy-based management [Damianou01]: the transfer of access rights between subjects by means of delegation policies. Nevertheless, the concept of delegation as initially devised, a transfer of the management logic from the central management system closer to the managed entity [Goldszmidt95], is inherent in the capabilities of active networking technology itself.

The figure below represents the delegation requirement concept we are considering. The figure shows how the network operator creates the user access rights by means of delegation policies. Afterwards, when the user introduces his policies to manage his resources and services, such policies will be validated against his access rights.

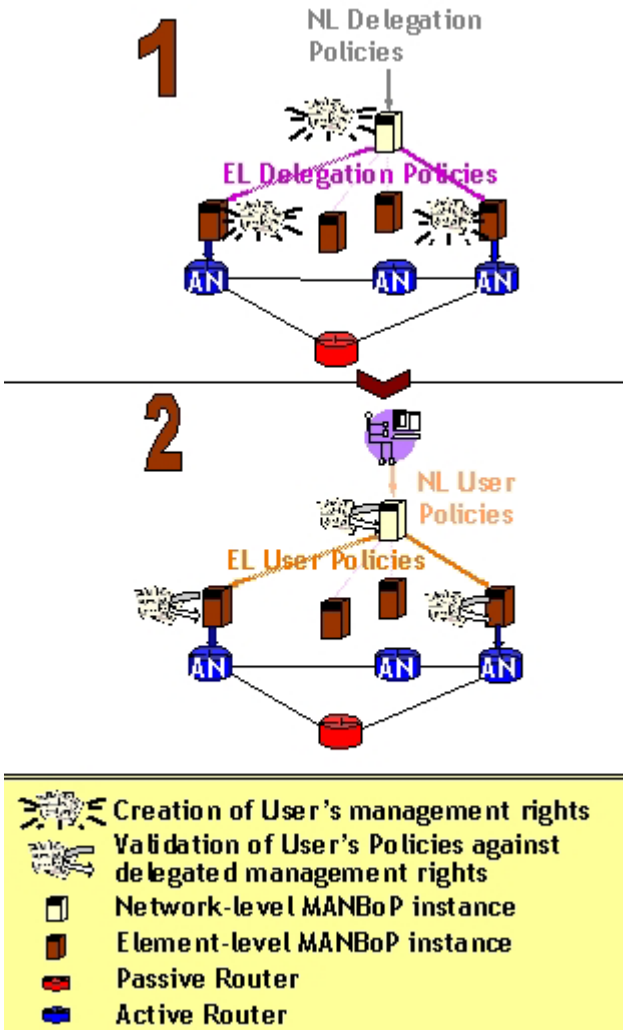

Figure 2 - 2. Delegation requirement

The delegation mechanism that has to be designed and implemented in MANBoP must include some concrete requirements to fulfil the expected functionality:

i) The mechanism must be capable of delegating the whole range of management functionality available in the system.

ii) The granularity of delegation must be small enough so that the network operator can clearly establish what management tasks the service provider is allowed to do.

iii) The delegation mechanism must be as lightweight as possible, particularly the authorisation checking process.

iv) The delegation mechanism should permit iterative delegation of resources. That is, the service provider can be allowed to delegate

to his customers part of the management functionality he has obtained through delegation.

The third requirement that active and programmable networks impose over the management system is related with the managed resources. Active and programmable networks offer much more resources to be managed than passive networks. These resources are related mainly with active services themselves and the computational resources they are consuming, such as CPU, memory, disk size, type of EEs where they run, etc.

A management system for active and programmable networks must be able to monitor and configure all these resources, since they are basic in the behaviour of the network. Service providers obtain a certain amount of these resources when they run their active services. Thereby, an efficient management of these resources is fundamental to assure the correct behaviour of the network and to obtain the maximum profit from the network exploitation.

Furthermore, the number of management requests (in our case policies) that the management system must handle is proportional to the number of resources that must be managed within the network. Thereby, this requirement could potentially jeopardise the scalability of the management system. Hence, the framework must not only manage these resources but also manage them in a scalable way.

Summarising, the management of these new resources in active and programmable networks imposes a set of requirements over the MANBoP framework:

i) It must manage CPU resources on those nodes that offer such possibility.

ii) It must manage memory resources on those nodes that offer such possibility.

iii) It must manage disk resources on those nodes that offer such possibility.

iv) It must be capable of installing and removing active services in active and programmable nodes.

v) It must be capable of configuring Execution Environments (EEs) and the node OS to meet the active services necessities (e.g., assigning incoming and outgoing channels to EEs and active services).

The likely progressive deployment of active routers in today's IP networks introduces two important requirements in the management plane. These are that it has to be able to cope with heterogeneous network technologies both passive and active, and that the management system must support the addition and removal of devices from the managed network. The reason for

the first requirement is obvious, as during a period of time is foreseeable the coexistence of passive, active and programmable nodes on the managed network. The explanation for the second comes from the fact that, if the managed network is evolving from a passive network towards an active or programmable network, passive nodes will be progressively replaced by active nodes. Therefore, if the management system is not able to cope with these changes the network operator would be obliged to re-start the management system every time this happens and, what is worse, re-introduce all policies that dictated the entire behaviour of the network. It is likely that, often, the network operator would desist from substituting an old device, if he has to reset the entire management infrastructure.

In relation with management of heterogeneous networks the concrete requirements are:

i) The MANBoP framework must be able to seamlessly manage all types of active, programmable or passive devices included within the managed network.

ii) The management mechanism must take advantage of the facilities offered by the managed device to enhance the management efficiency.

In relation with the addition and removal of managed devices into the managed network the concrete requirements are:

i) The management framework must support the dynamic addition of a new device within the managed network.

ii) The framework must support the dynamic removal of a device within the managed network.

iii) The addition or removal of a device from the managed network must be transparent for all policies installed in the system. That is, the processing of all policies previously introduced in the system should not be affected by the addition or removal of a device into the managed network.

Up to here we have enumerated and described requirements that active and programmable networks impose over the management system increasing its complexity. However, active and programmable networks, as enabling technologies, offer new mechanisms that should be used to ease or enhance the way the devices are managed. For example, the use of active packets or management services inside active or programmable routers to realise certain management tasks can reduce management traffic as well as to reduce the computational load inside the management station. The figure below exemplifies this requirement. We can easily observe how the management of an active node with an active service (box 2) significantly reduces management traffic when compared with the management of the same node directly from the management station (box 1).

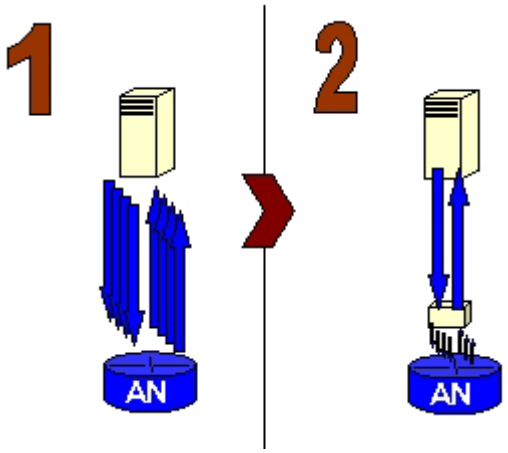

Figure 2 - 3. Use of active and programmable technologies for enhancing management

The concrete requirements for the use of managed device facilities are:

a) The management system must take advantage of facilities offered by managed devices to enhance the management efficiency.

b) The way management is made over a particular device must not compromise the efficiency in the management of other devices.

Section II.3 – Other requirements

In addition to the requirements derived from the fact of managing heterogeneous networks formed by active, programmable and passive routers, the management system must cope with other requirements. Along this section we are going to describe the more relevant ones among them.

One of the project goals is that the MANBoP framework can be used to create different management infrastructures. Such property provides a lot of flexibility to network operators in a cost-effective way. They can create the management infrastructure that best fits their needs just owning a single piece of code: the MANBoP framework. This capability allows network operators to always create the most appropriate management infrastructure according to their managed network, the services they are offering, the number of users, etc. Furthermore, this property helps to make the entire MANBoP framework more scalable, as the management infrastructure can be adapted to the size of the network. The figure below exemplifies this concept by showing two of the multiple management infrastructures possible. The first one is the simplest management infrastructure consisting of a network-level management station that manages all network elements (both passive and active). The second management infrastructure is formed by a network-level management station working over many sub-network-level management stations. Each sub-network-level management station interacts with several

element-level management stations. Finally, each element-level management station will manage just one network element.

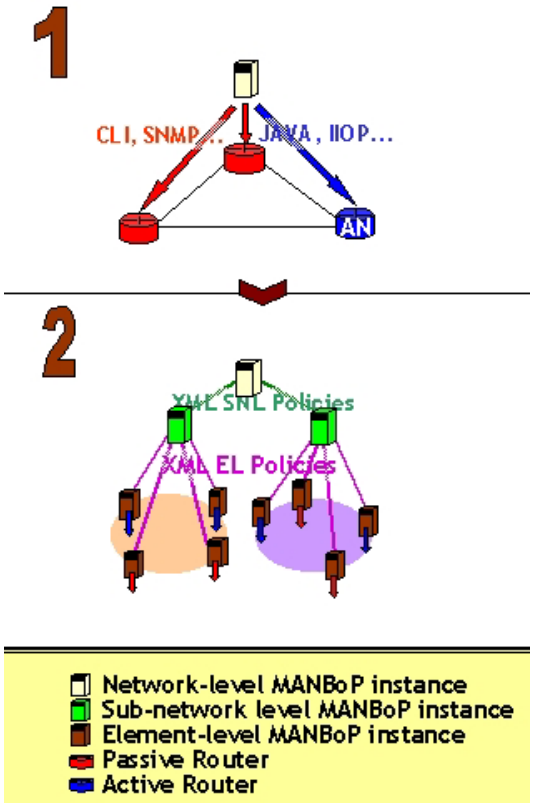

Figure 2 - 4. Different management infrastructures example

The fulfilment of this goal sets a number of concrete requirements on the design and implementation of the management framework:

i) The management framework must support its instantiation at different management levels.

ii) Each MANBoP instance running at a particular management level must be able to work together with other MANBoP instances forming the management infrastructure.

iii) Each MANBoP instance must be capable of establishing what is the exact dynamically installable component it needs at each particular time; based on the management level where it has been instantiated, the requested functional domain and the underlying devices.

iv) The management framework must support the dynamic addition and removal of new managers to the management infrastructure. This requirement is linked with the one of supporting the dynamic addition or removal of devices to the managed network.

Finally, the MANBoP framework must also handle a number of requirements related just with its expected functionality. That is, although the management functionality supported by the framework depends largely on the functional domains being used, there is a common set of functional requirements that a management system must consider.

i) The management system must be able to configure all managed network resources.

ii) The management system must be able to monitor all managed network resources

iii) The management system must be capable of installing, configuring and removing active services within the network.

iv) The management system must be able to establish, modify and remove network connectivity services with particular QoS requirements

v) Linked with the above, the management system must be capable of determining the best route for a connectivity service based on the requested QoS.

vi) The management system must contain the necessary fault and performance management functionality to guarantee the QoS of a service (e.g. network connectivity service, active service,...).

vii) The management system must facilitate its use and its interworking with other systems. This should be done by offering clear, open interfaces as well as using, whenever possible, standard technologies.

viii) The management system must be fully portable so that it can be instantiated on any machine as long as it offers the minimum amount of computational power required.

Section II.4 – Conclusions

Along this chapter we have analysed all the requirements that the management system must handle. First of all, we looked at those requirements that arise from the fact of dealing with heterogeneous active, programmable and passive networks. More specifically, a network management architecture for active and programmable networks has to account for the additional complexity introduced by these technologies, e.g.: handling mew services dynamically installed in active routers and handling

increasing requirements for control and customisation of resources that consumers impose on active and programmable networks. Liaised with these control and customisation requests, is the necessity of delegating management functionality to customers.

Furthermore, the progressive deployment of active and programmable routers in nowadays legacy networks imposes two new requirements. The first one is the support for different types of managed devices (active, programmable and passive). The second one is the support for the dynamic addition and removal of network elements. The intention of this requirement is promoting the migration of legacy networks.

Besides, we have also reviewed those requirements related either with the thesis goals or with the expected functionality from the management system. Among these, the most relevant requirement is the possibility of easily creating the management infrastructure that best suits the network operator needs.

On the other hand, active and programmable networks as enabling technologies offer new mechanisms that should be profited to achieve a more flexible, distributed and efficient management framework. The use of active packets or the capacity for dynamically adding management services in the active nodes are clear examples of these mechanisms.

Policy-based network management technology eases the handling of some of these requirements. The use of policies is particularly adequate for delegation of functionality that enables further customisability of network resources. Also the 'abstraction' property of policies, which makes them independent of the underlying managed device, is suitable for the management of heterogeneous network technologies.

All requirements listed in this chapter must be adequately supported by the management framework proposed to satisfy the Thesis objectives. Indeed, the requirements have been obtained from analysing the needs that impose the attainment of the objectives.

One of the most remarkable conclusions that can be extracted from the chapter is the number and complexity of the requirements that the management of active and programmable networks impose over the management architecture. The challenge is to design and implement a management framework that handles this complexity as simply as possible.

In the following chapter, we will describe and comment different approaches proposed to cope with these complex requirements.