Resources control and QoS implementation in a NGN DSL Access Network

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1 Introduction

This paper addresses the QoS and resources reservation issues in a NGN DSL access network to deliver IP services to end-users.

A general framework to design NGN architectures is first presented with the introduction of roles, processes, and sessions. This helps us to identify functions needed to have a NGN DSL access network that supports a wide variety of services. Thanks to this model we present two different approaches to control resources in the access network : statically and dynamically. This is illustrated in the case of DSL access network. The last part of the paper deals with resources in the transfer plane, where two scenarios to deliver different types of services to the end user using DSL network are presented. These services are real time services like multimedia or voice services, and non real time services such as Internet regular data services.

2 Functional architecture

2.1 Roles

Roles correspond to trades; they provide a piece of business that is not divisible. Telecommunications actors are involved in customer–supplier relationships and provide services by holding a role. In this way actors provide services to customers while they possibly make use of other services offered by other actors that hold different roles. The services provided are subject to *contracts* including SLA. Roles can be viewed as macro components (macro objects) allowing services offers, which can be used in the *value chain* composing the final services (GII). A role *encapsulates* the realisation of the services it offers. Role approach can also be used to describe the *internal market* within a significant Telecommunications operator. Actually, a significant Telecommunications operator is composed of business units and subsidiaries that play roles. [1]

TINA introduces the Retailer role, which is business oriented. It provides customers with bouquets of services (front office). [2]

2.2 Process

The general architecture model is based upon a multi user-provider relationship scheme, which allows customers to have their services requests processed by the most appropriate services providers and the services supported by the most appropriate network resources. A specific process is requested depending on the kind of services requested and on their associated time-scale. **Processes are: before sell, provisioning, usage, after sell, billing.**

In the before sell process we can have the services planning function, the provisioning process include provisioning and dimensioning. Operations like service QoS and network performances, monitoring, accounting anomaly handling are in the after sell process. The usage process is describe hereafter.

Each process is divided into level and at each level a **session** can take place between users and suppliers. A session corresponds to a specific customer-supplier relationship. One session involves a given level and a given process. Services are related to a particular process

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(for instance billing service). It should be noted that the number of level per processes is variable and governs the nature of the delivered service. Also, the same front office could be used for service usage and management of the service.

The functional architecture is composed of 5 blocks [3] (figure2):

The access mediation, the service mediation, logic of service, the resources mediator, resource control.

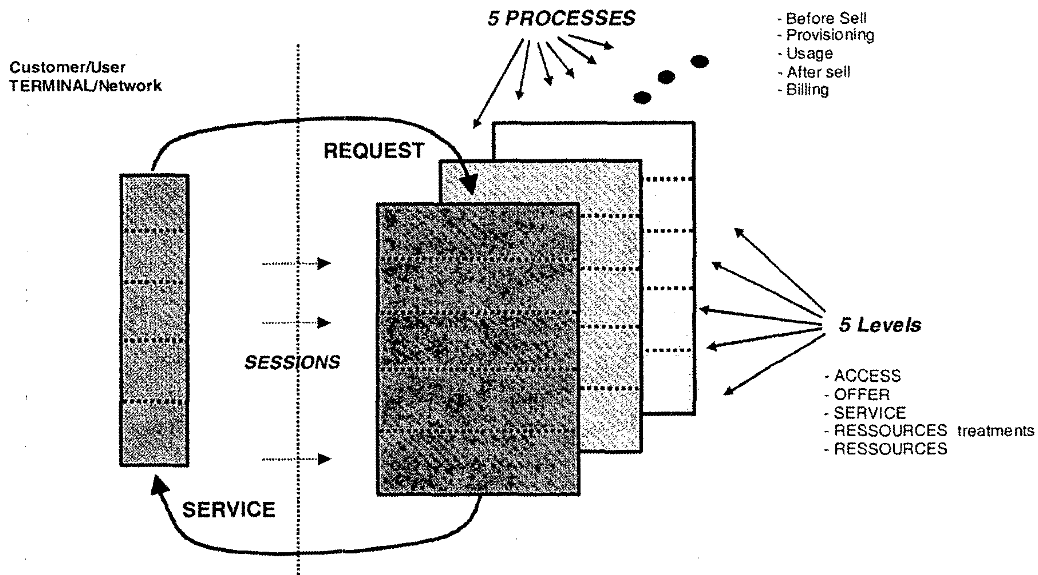

Figure 1 : General Architecture

The concept of session has been introduced in TINA whereas the concept of process is used by TMF.

It should be noted that this is consistent with the « **plane** » notion:

- the user plane covers transfer resources and data content,
- the control plane corresponds to the usage process but the resources themselves,
- the management plane gathers the 4 remaining processes, but the resources themselves.

2.3 Usage process & control plane

We first focus on the usage process that is at stake to achieve dynamic allocation of resources. As said before the higher 4 levels of the usage process correspond to the control plane.

The access mediation supplies to customers a unique access independent of technology involved at the transfer layer, it gives access to service providers, offers a yellow pages service to end users.

The service mediation provides to users (?) presentation of services, subscriptions, contracts, client (or user?) profile, and access to the unitary service when it is requested. The service mediation belongs to the business process.

The Unitary Service performs the service logic. It belongs to the service plane and is found during the usage process. It translates services requests into resources requests. Service logic corresponds to data required to carry out the service.

The resources mediation is of vital importance when one considers the multiplicity of the network resources providers and of the technologies involved at both the resources control layer and the transfer layer leading to different QoS offers.

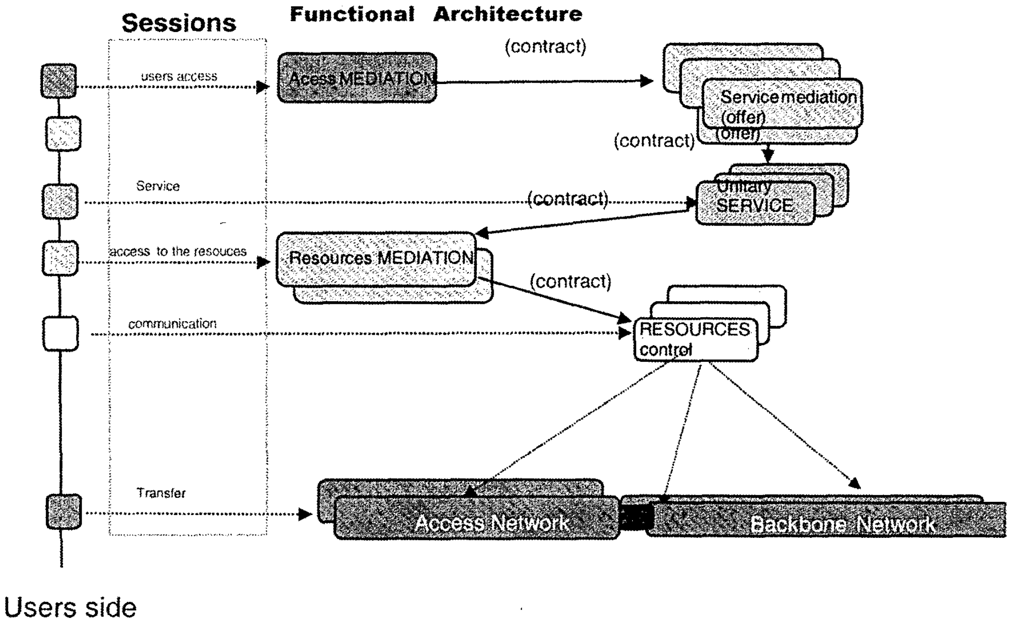

Figure 2 : Functional Architecture – Usage Process

Resources and control of the resources layers are known by the mediator. The resources mediation function has an end-to-end view (terminals to sub-networks) and identifies the sub network in accordance with the QoS needed. Adaptation between service instance and resource control is performed by the resources mediation function. The resources mediation function is required to have the service requested supported by the most appropriate resources. This function is thus relevant when service providers and/or when resource providers, and resources themselves are not yielded from the beginning.

- **Resources control** identifies flows, and controls resources involved within a sub network.

We are able to identify several reference points that separate functional blocks and represent possible client-provider relationship.

Actually when functional blocks are separated by reference points they could well belong to different actors and give ground to contracts

Several reference points are identified and they correspond respectively to the boundary between:

Clients access mediation and services mediation,

Services mediation and services logics,

Services logics and resources mediation,

Resources mediation and resources control,

Resources control and resources.

These reference points correspond to separation between functions that could lead to specific roles.

2.4 Functions and processes at stake

To deal with allocation of resources and with QoS one has to take into account 3 processes: provisioning, usage and after sell (figure 3). We will also deal with a limited set of functions which are involved in static and dynamic allocation of resources.

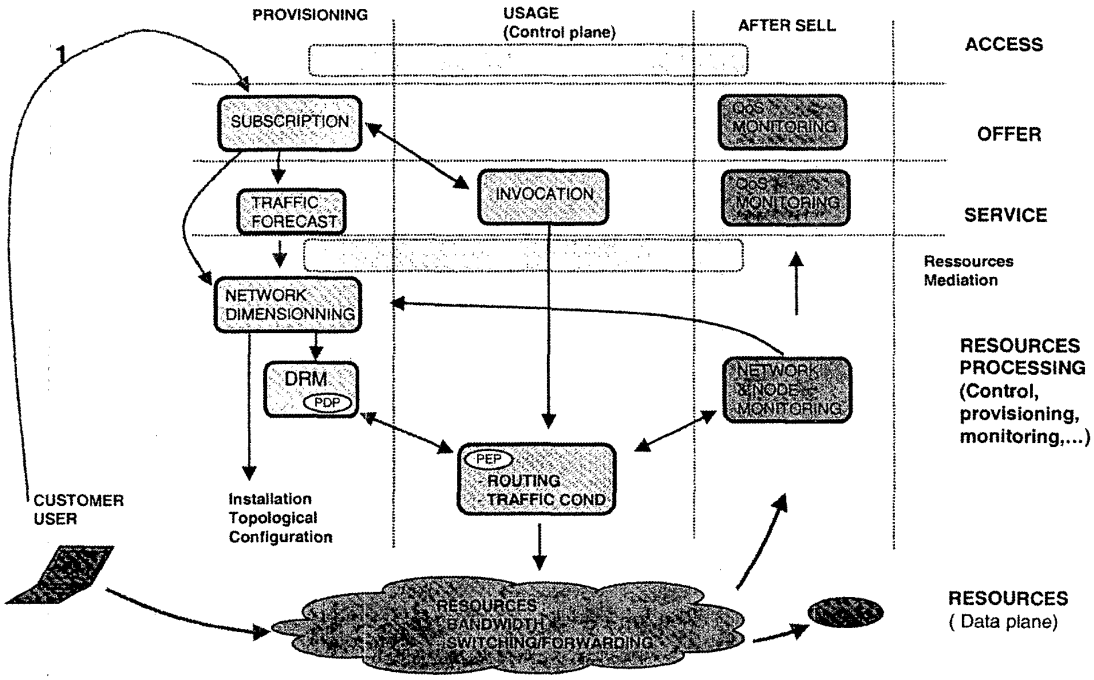

Figure 3 : Processes, Levels and Functions

The Subscription and Invocation functional blocks allows users requests to be processed respectively in the provisioning and usage process. The Network Dimensioning (ND) block enables interfaces, paths (LSP), buffers, metrics, etc ... definition and implementation taken into account subscriptions plus traffic prediction and measures. The Dynamic Resource Management (DRM) block is responsible for the resources use policies: for example LSP mode selection, metrics in use, bandwidth links, buffers space, in accordance with the general network configuration (defined by the ND function), and with on load measures (Network Monitoring and Node Monitoring). [4], [5]

The Traffic Conditioning block deals with flow control functions (flow classification, spacing, police, shaping,...) to control queues. The Routing function compute paths according to network estimated state and possibly with network element states. The monitoring and measures functions are dealt with by the after-sell process: Node monitoring, Network monitoring.

In this case no functions are available to answer to on demand requests nor to allocate resources and monitors QoS in real time. The above figure identifies functions activated, principally in the provisioning process, in answer to a provisioning request (1) (figure 3).

3 Functions and processes in a static and a dynamic allocation of resources

3.1 Static allocation in a xDSL access case

The figure (4) shows the current and short-term functions available in the 3 processes considered. Only already deployed equipments are considered to address the short term QoS improvement issue.

At the network edge, the equipments and the functions concerned can be drawn up thanks to the model. We identify the Broadband Access Server, (BAS), and the Network Provisioning Platform, (NPP) that enclose:

- BAS: Routing, possibly Traffic Conditioning, Forwarding, Node Monitoring,[1]

- NPP, a centralized platform Network Dimensioning, Network Monitoring.

[1] Routers enclose pore or less the same functions

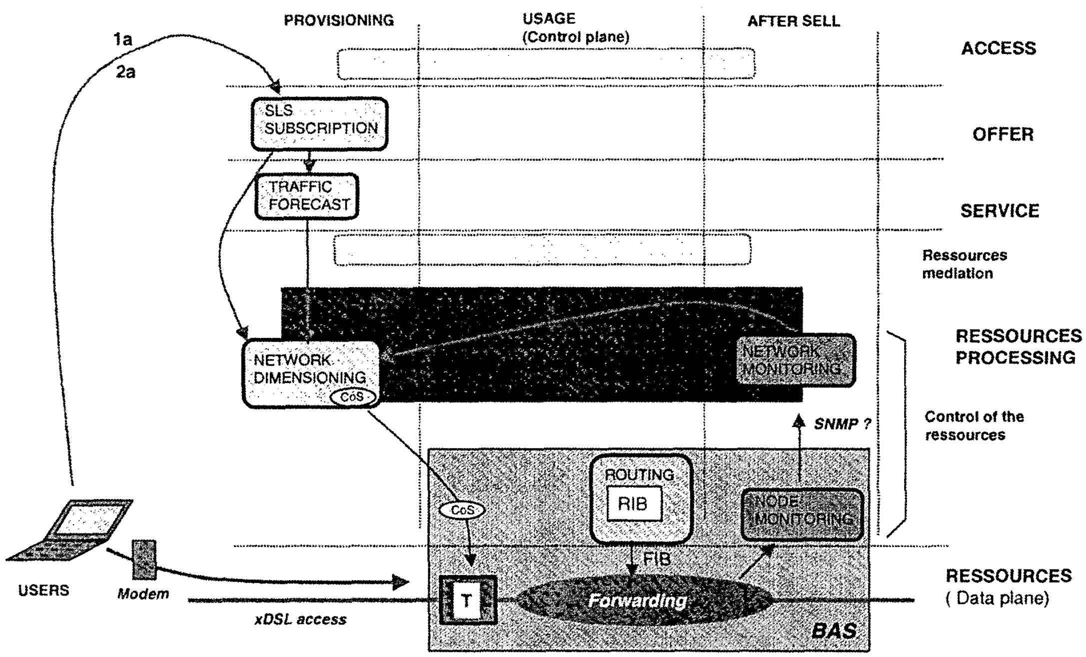

Figure 4 : static allocation of resources

One should note the restricted number of control functions available in the usage process. Only routing is found that represents one part of the network resources control function. Also, MPLS use (to handle labels and to mark paths within Label routers equipments) allows one part of the network resources control function to be found.[6], [7]

Considering this static allocation configuration improvements are expected on the following matters:

-Automation between Network monitoring and Network dimensioning functions,

-Automation between network dimensioning and termination functions,

-CoS definition and implementation,

-Implementation and improvement of termination functions such as CAR and prioritisation.

3.2 Dynamic allocation in a xDSL access case

In order to take full advantage of xDSL accesses, it is not only QoS that should be provided but also on demand services support. Consequently, more control functions and corresponding ones in the transfer plane are to be implemented in current or new equipments. Also relationships between processes are to be examined thoroughly in order to link network performance and QoS demand expressed in customers contracts.

The figure 5 illustrates the case where on demand services are requested (2a) and where real time resources allocation is performed to support these services. We are in a dynamic resource reservation case. At the network edge, the equipments concerned are labelled: Network Controlling Platform, (NCP), and Multimedia Access Gateway, (MAG). They enclose:

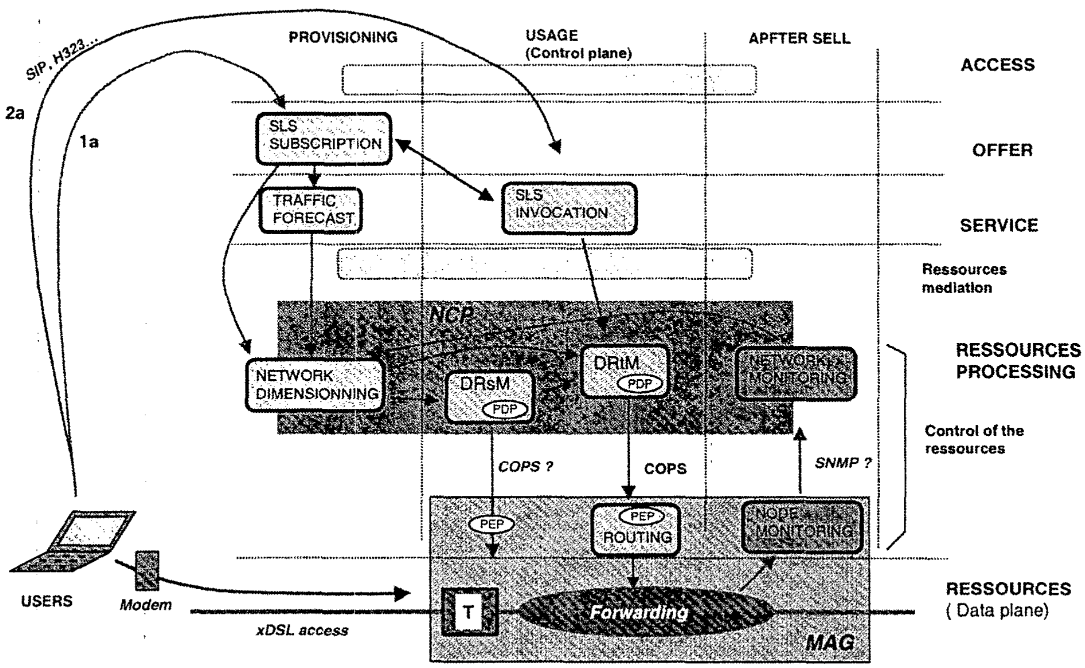

Figure 5 : On demand services – dynamic resources allocation of resources

MAG : PEP, Routing, Traffic Conditioning, forwarding, Node Monitoring functions

NCP: SLS, Network Dimensioning, DRM and Network Monitoring functions

The following protocols, H248/MEGACO, COPS, and SNFC, can be used to control some functionalities of the MAG.

Figure 5 shows the case where DRM functions are available in the control plane and implemented on a centralized control the NCP. This externalisation of part of the resource control function allows to take advantage of a NGN architecture [5], [8]. The presence of these functions in the usage process is justified in case of allocation of resources and QoS set up are needed in real time. It is not clear yet if management functions such as network monitoring or accounting could also be enclosed in this platform.

Anyhow, differences between figure 4 and figure 5 illustrates the considerable efforts remaining to be made if IP on demand services are to be offered over xDSL accesses. In order to implement and to monitor QoS:

- GCAC at the network level and CAC at the network element level within equipments

-Automation of relations between usage process and adjacent processes, provisioning and after sell,

-To set up on demand "non IGP constraints LSP" but rather according to the service they support,

- To improve QoS mechanisms in all 3 processes: monitoring, measure, flow control, QoS aware routing tables,

-Termination function in the transfer plane (police, measurement, spacing)

At last, each customer – supplier relationship should be contracted within a Service Level Agreement, (SLA).

4 Transfer plane and control of the resources

Different possibilities to implement resources were presented in the previous part of the paper. Now we describe two different transfer plane implementation for the access network (between IAD and BAS/MAG), when different types of services have to be delivered. These services can be classified roughly as real time multimedia services (like VoIP and Video on Demand) and Internet Services (non real time multimedia services), each one requiring specific network resource features and QoS level. For these two different transfer plane organisations and for each service, dynamic and static control of resources will be considered.

At the time being the QoS in the access network, cannot be managed at the Ethernet level nor at the IP level. First because, BAS/MAG and modems cannot manage the TCI (QoS) field and VLAN field of Ethernet frames. Concerning the IP level, all the services under consideration are not transported with the same encapsulation. The VoIP is transported directly in IP/Ethernet, and the Internet Services in IP/PPP/PPPoE/Ethernet. So, all services cannot be carried all together in the same IP session, the QoS differentiation cannot be made directly at the IP level.

The two proposals for the transfer plane are :

- One VC per service
- One VC for all services

In the following paragraph we will see if all the network resources (at least at the ATM and the IP layer) can be set up statically during the provisioning process, or dynamically during the usage process.

4.1 One VC per service

The objective here is to use one VC per service between the DSL modem and the BAS/MAG. That means one IP source address is required per service. QoS is processed at the ATM level, but we also have to specify some IP parameters to have the IP packets routed accordingly in the core network. The IP parameters are dealt with in the BAS/MAG and possibly in the modem if it gets some router piece of functionality.

The figure below gives an example for the option where two different services are provided to the end user.

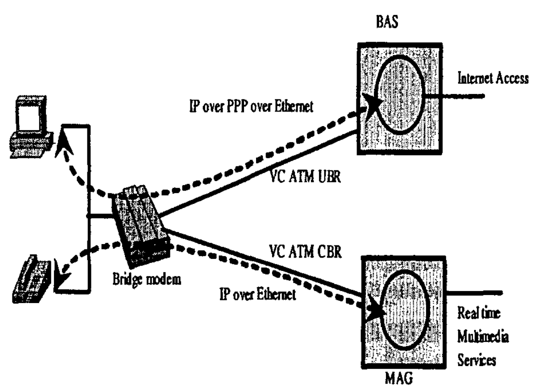

Figure 6 : Real Time and non real time services over two different VC

Given that different services are supported by resources with appropriate features, in the following we will analyse service per service how ATM and IP layers parameters are controlled.

4.1.1 Resources control for Internet Services

The network architecture that is now deployed by most network operator for Internet services over DSL has the following characteristics : PPP protocol associated with Radius for authentication , a peak rate for downstream and upstream for each service offering, the same quality of service for all IP flows : best effort.

The introduction of Diffserv mechanisms in the BAS enables the possibility to give to each IP flow the appropriate QoS. However, the activation of these mechanisms by the control plane needs to be carefully studied, since a static configuration of QoS profiles for each customer by the network manager is not satisfying.

In the PPP/Radius environment, a straightforward method of configuring QoS profiles per customer relies on specific Radius attributes sent in the authentication response. When the customer is successfully authenticated, the Radius response can bring into the BAS the appropriate information for marking, policing, queuing and shaping the IP flows of the customer. Except the lack of standardisation on these aspects (each vendor has its own set of vendor-specific attributes not compatible with the others...), this approach has an important drawback : QoS profiles can only be loaded into the equipment at session set-up, and modifications in the QoS profile forces the session to be released and set-up again to be taken into account. In order to modify QoS parameters while maintaining the session active, Radius must be completed or replaced by another protocol that will introduce this possibility, and COPS can be a possible candidate.

However, resource control at the IP level in the BAS is not the only aspect, and the ATM resources between customer and BAS should not be forgotten. What would be the QoS seen by the customer if the BAS is appropriately configured for QoS at the IP level, but with no ATM resources available? This shows that a close relationship between resource control at IP level and resource control at ATM level is absolutely necessary. QoS will be perceived by the customer only if it is offered end to end all over the network.

4.1.2 Resources control for Real Time services

For real time services VoIP service is considered hereafter. This service is delivered through a SIP architecture. It is assumed in the following, that the registration phase has been already carried out by the registrar server. Only the SIP Server or labelled "SIP call server" will then appear in the process along with an independent Network resources Controlling Platform, (NCP). Since the objective here is to deal with the resources control and not the call processing, call flows are not proposed.

For VoIP services, one signalling flow (SIP signalling), and one media flow (RTP stream) are considered. These 2 flows are bi-directional and require QoS. We also assume that the VoIP terminal equipment knows IP addresses of the Call Server and of the MAG, both are delivered during the provisioning process.

4.1.2.1 ATM Layer set up

Concerning the ATM layer we propose as a working assumption that the IAD and DSLAM (copper network side) do not support the ATM signalling. So between these 2 equipments the ATM VC that link them has to be configured during the provisioning process, and will be a Permanent VC (PVC). But between the DSLAM (access network side) and the MAG, ATM signalling could be available soon.

For the VoIP service, the ATM layer from the DSLAM to the MAG can be controlled using different methods :

In a first approach the ATM channel can be configured as a PVC during the provisioning process to support all the VoIP services subscribed by the customer. In this solution resources have to be set up and reserved, even if the service is not used permanently, which is far from ideal to optimise resources. ATM signalling can be used to set up resources.

Another option could be to use a SVC approach, which needs 2VC per customer, one permanent for the SIP signalling and one switch VC for media flow. Another main issue with this approach lies in the modem and MAG ability to route the appropriate flow (signalling and media) over the appropriate VC. In fact this approach is too complex to implement in the network compared to the expected advantages.

4.1.2.2 IP parameters set up

To deliver real time multimedia services with QoS and with a good security, the following functions have to be available at the IP layer under the control of the call server associated to the NCP :

- IP packet marking (DiffServ), or resources reservation (IntServ),
  - Here the DiffServ approach is considered. Packets can be marked on the user side (at he application level in the terminal equipment or in the routeur modem) or in the MAG.
- Opening/Closing of IP pine holes with bandwidth reservation.
  - In order to deliver VoIP service with QoS for the customer and with a high level of security for the service provider, one solution is to open, IP pin holes in the MAG with a specific bandwidth under the call server control. So without call server instruction, the MAG cannot allow the IP flow to cross the MAG, to avoid theft of services.
- Policing/filtering
  - This operation is carried out in the MAG following the SLA between the end user and the service provider
- Control Admission Connexion
  - To check during the call establishment if there are enough resources availability a CAC operation can be done in the modem, in the access network, and in the MAG. The GCAC for the core network has to be done by a specific NCP (Network resource Control Platform)
- NAPT
  - Due to the lack of IPv4 addresses, and before the availability of IPv6 addresses, it will be necessary to use some private IP addresses. This address translation can to done in the MAG. If few VoIP Terminal Equipments with dedicated IP address are connected to the DSL modem, a NAPT function has to be implemented in the modem.
- IP source address
  - We assume that IP source addresses have been delivered during the provisioning process, either with PPP approach or with a DHCP server. So this allocation is not considered in the following.

The MAG has to fulfil all these functionalities. The SIP signalling could be used to control these resources in the access network, thanks to the NCP as shown in the following figure.

If the modem is a bridge, all these functions have to be implemented into the MAG. In some conditions packet marking can be carried out at the application level in the terminal equipment, but in that case the MAG will have to check the ToS value.

With a router modem some operations could be done on the user side, like packets marking, and possibly NAPT, if few terminal equipments are connected behind the DSL modem. But this option means that the modem has to be under Call Server/Network resource Control Plateform (NCP), which is complex to manage especially if thousand of distributed modems in the network have to be controlled in real time.

During the call set up, resources control could be the following. After receiving an Invite from the IP Phone, the Call Server can perform customer identification & authorisation, checks its services profile, in order to implement QoS parameters and, to deliver the service with the QoS level subscribed. In a second step the Call

Server can control towards the Network Controlling Platform (NCP) the MAG and possibly the routeur modem. The NCP can order the MAG to mark the ToS field with the appropriate value all IP packets arriving from the terminal equipment with some specific features dedicated to real time multimedia service, here VoIP service. These features could be IP source address and port number. The NCP can also order the MAG to perform some other operations, like to perform a CAC, to open specifics pine holes with a specific bandwidth resulting from codecs negotiation, to carry out a NAPT...

In order to deliver services with the most flexibility, QoS and security, these IP features have to be controlled in real time by the call Server and the NCP. Some functions like NAPT, could be controlled statically. If only one public address is given to the MAG, all the IP flows coming from the user side will get this IP address.

In this context, the control message coming from the NCP have to transit toward a network, so they can undergo some consequences due to some network issues (lost packets, congestion...), so the call set up reliability can be low.

Figure (7) presents the different step to control the IP resources in the MAG, following an Invite SIP message coming from the end user.

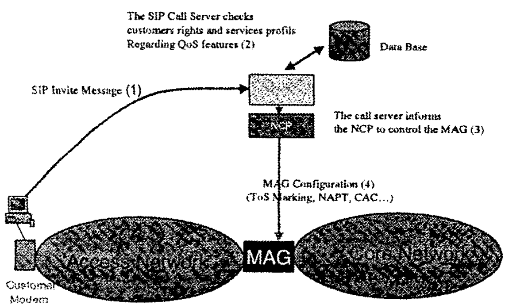

Figure 7 : Command of IP resources in the MAG

4.2 One VC for all services

In this last solution all the services are transported over the same ATM VC, but in separates sessions above Ethernet. One IP address is allocated per service.

This VC has to be set up during the provisioning process, and the same MAG will have to process all services, which can be distributed over different virtual routers if different PPPoE sessions are available.

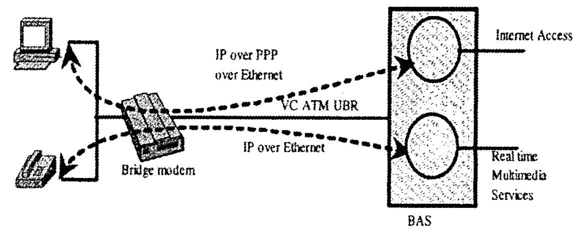

Figure 8 : One VC for different type of services

This PVC is dimensioned to transport all subscribed services. So we can assume that when services with QoS (VoIP), the Best Effort services can take specific bandwidth. But when QoS services are used, the Best Effort services could use only a smaller bandwidth, compare to the previous one.

Here operations regarding IP features in the modem and in the MAG can as previously be set up dynamically, to optimise resources implementation in the access network.

4.3 Comparison of the two approaches

With the first solution, (one VC per service), if the two different services have to be deliver, we have seen that up to 3 VC will be allocated to the customer if all the services are used simultaneously, and 2 PVC if services are not used. The option give the opportunity to use specific MAG/BAS per service, and only optimise resources, dimensioning service per service. We can imagine that the service provider gets his own BAS/MAG, so if the customer wants to change service provider, an ATM connection has to be made to go on the appropriate MAG. It is also possible for the access network resource provider to have MAG dedicated per service, through which end users could get access to all the service providers platforms. To do so the MAG has to decode SIP protocol to analyse who is the service provider, for forwarding the message to the appropriate service plat form.

With the second solution, only one VC is used and the access network resource provider can deliver access (under SLS condition) to the different service providers through its own MAG. As previously, the same MAG has to manage different type of services, some with real time constrains (VoIP), and some other with less constrains (Internet service). The approach gets the advantage for the customer to have the opportunity to change service provider easily, no change has to be carry out at the transfer plan level.

5 Conclusion

In this paper we have presented a generic functional architecture to help us to identify functions needed to deliver different type of services, with different QoS level and constraints using a NGN DSL network. This architecture throws light on relationships between management and control functions by adding a usage process to the 4 management processes.[1]

Thanks to the functional architecture it was possible to analyse the different ways to control resources in the access network. The control of the different layers can be statically or dynamically carried out either by a Network Provisioning Platform or a Network Controlling Platform. It is possible to mix these two solutions in order to have some resources controlled in a static way and some others in a dynamic way.

The last part of the article deals with resources control in the transfer plane for different type of services with specific constraints (real time services and non real time services). Two different implementations were presented, one with one VC per service, and the other with one VC for all services. For each one, we have shown that a static control of the ATM layer and a dynamic control of IP parameters seem to be the best approach to ensure QoS for end user and security for the operator. To deliver real time multimedia services, specific functions like opening of IP pine holes, NAPT, Packet marking... have to be implemented in a MAG, and controlled dynamically from Network Controlling Platform.

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7 Glossaire

BAS : Broadband Access Server
CAR : Commited Access Rate
CAC : Control Admission Connexion
COPS : Common Open Policy Service
DSL : Digital Subscriber Line
FIB : Forwarding Information Base
GCAC : Global CAC
IAD : Integrated Access Device
Architecture
LSP : Label Switch Path
MAG : Multimedia Access Gateway
MPLS : Multi Protocol Label Switching
NAPT : Network Address and Port Translation
NCP : Network Control Platform
NGN : Next Generation Network
NPP : Network Provisioning Platform
PDP : Policy Decision Point
PEP : Policy Enforcement Point
PPP : Point to Point Protocol
PPPoE : PPP over Ethernet
QoS : Quality of Service
RIB : Routing Information Base
RTP : Real Time Protocol
SIP : Session Initiation Protocol
SLA : Service Level Agreement
SLS : Service Level Specification
TCI : Tag Control Information
TINA : Telecommunication Information Networking
TMF: Tele Management Forum
VLAN : Virtual Local Area Network
VoIP : Voice over IP