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A Framework to Mobility and Interactivity for Convergent Technologies

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Abstract: - Nowadays there is more acceptance of the concept of the Next Generation Networks (NGN) as a result of the integration between fixed and mobile telecommunications with data networks, in order to provide service delivery of multimedia contents. This means that many different types of end-systems, access platforms, backbones and services must interoperate and respect some agreements to deliver services with appropriate quality and affordable prices. However, there are many issues about the convergent technologies, such as the control of the data flow when it is crossing networks with different technologies, or how to maintain the appropriate Quality of Service for a specific application. The objectives of this work are drawing a scenario about the convergent environment, establishing a framework which is comprised of issues of mobility, interactivity and convergence, and discussing the concept of QoS Broker as a way to comprise many questions related to QoS.

Key-Words: - convergence, mobility, multimedia services, vertical handover, Quality of Service, QoS Broker.

1 Introduction

Since the early times of the Internet both telecommunication and data network environments have many interfaces in order to provide access to some types of services, such as e-mail. The continuous evolution of the telecommunication infra-structure, information services and the types of content take into account the possibility of supporting global services from any type of access network, in any place of the planet. [1] The actual mobile access technologies, such as Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), and any other wireless networks, such as Wi-Max or Wi-Fi are present in people daily activities through mobile phones, Personal Digital Assistants (PDA) or even notebooks. The same occurs with the Internet.

In order to provide any type of service, over any communication platform, the integration between telecommunication systems and computer networks is an essential task. However, it is not only about connecting infrastructures, but also about considering that this integrated network will transport different types of traffic. As these integrated infrastructures will handle several types of content, such as phone calls, multimedia traffic and content interaction, it is necessary to consider issues about Quality of Service as a way to guarantee the usage of the applications provided to the end-user. It is also important to consider how to tariff the traffic and what are the appropriate business models for such heterogeneous environment [3].

This paper presents a framework for convergent technologies. It considers a platform for mobility, interactivity and integration between different types of communication networks. It also discusses the convergence focused on services over this framework. The paper is organized as follows: in section two it is discussed and defined what convergent technologies are, as well as the aspects of convergence. In section three both the framework and the different aspects about integration between different types of communication networks are presented. Section four initiates a discussion about quality of service aspects related to the framework. At last, section five brings some related works and section six some considerations about this work.

2 Convergent Technologies

In this scenario, convergent technologies can be defined as the integration between telecommunication infrastructure, distributed computational systems and computer networks, in order to provide the use of all kind of contents and flows into the network, including multimedia content, independently of the terminal or the access network used by the end-user when connected.

The convergence of technologies has at least three different aspects: the network convergence, the convergence of services or medias and the convergence of end-user terminals.

Network convergence is an integrated infrastructure composed by several types of network

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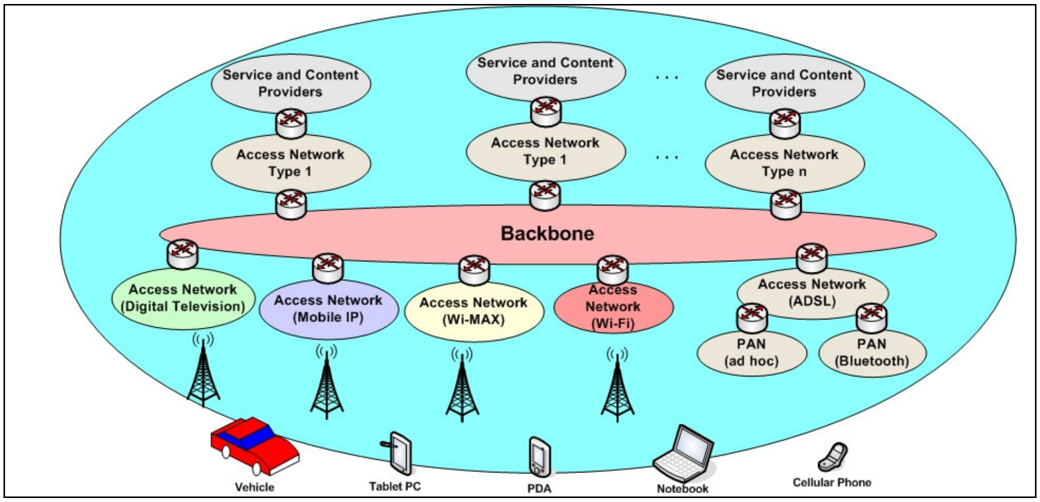

Fig. 1 – Framework for Convergent Technologies

technologies, supporting different types of flows and services, such as audio, video and data (or any other type of multimedia traffic) simultaneously. This is very similar to the definition of the Next-Generation Networks (NGN) or the concept of 4th generation networks. However an important aspect of this infrastructure is the support of the appropriate Quality of Service aiming multimedia traffic [1], [2], [3], [4], [7].

The convergence of services implies to have the same service in more than one communication network, or the same dataflow crossing different types of telecommunication systems. As an example, some multimedia traffic could be delivered by using the PSTN (Public Switch Telephone Network), a mobile or digital TV networks. It could be even the Internet. The service must be prepared to use the most appropriate network technology available for the user. An important issue presented in the framework is how to control the resources and make then available for the services in a heterogeneous network environment. As the last aspect of the convergent technologies, the convergence of the end-user terminal means both to access different types of access networks using the same device and to interact with several types of services and contents.

As a general way, in the convergent structure different types of data flows originated from many types of networks, providing diverse services, are crossing the convergent platform and will be accessed by an end-user terminal via more than one access-network.

3 A Framework for Convergence

A framework of convergent technologies must support the content and services providers, the telecommunication systems operators and all kind of access networks in only one infrastructure. Three layers compose the heterogeneous environment of the proposed framework: the Content Delivery Systems (CDS), the Backbone and the Access Networks. These layers are presented in the figure 1.

The service and both the content generators and the content providers compose the CDS that is at the superior layer in the framework. The types of content to be transmitted by this layer are video and audio streaming, multimedia content and data. The multimedia content differs from only audio and video because it may comprise interactivity content. Some examples of service that the CDS layer could provide are:

- Instant multimedia messages;
- Business transactions;
- Interactive services, such as online games or virtual stores;
- Video conferences;
- Information services, such as Internet banking.

An important feature of the CDS layer is to produce content and services in several formats, each one with its own specific Quality of Services (QoS) requisites for its appropriate use.

Another issue of the CDS is the possibility of the applications work with different technologies of end-user devices, since there are great differences of available resources between them. A simple example is the difference between a PC and a PDA, or between a PDA and a mobile phone.

The second layer of the framework is called Backbone, which is responsible for the interconnection of all access networks (when users become connected) and the CDS. The main feature of the Backbone is to provide support for the systems interoperation and the management systems of the telecommunication operators in order to provide end-to-end QoS control and management; and support to billing and security mechanisms.

When the end-user accesses the service and content providers, he will do it by using the Access Network layer. A quite important feature of this layer is the changing of the access network technology during the transmission of the data flow in a transparent manner for the user. This means that if the user is receiving a data flow from a GPRS network and for any reason he must start receiving the data flow from a Wi-Max network, this operation must be smooth and transparent for the user. This operation is called "Vertical Handover".

3.1 Vertical and Horizontal Handover

According to [5], the handover is defined in the mobile environments as the process of changing the data flow of one base station (BS) to another one, in order to maintain the communication process. It happens when the signal of and adjacent BS is stronger than the BS that is under use. The handover can also happen nearby the cell boundary, when the quality of the service decreases [6]. In this work this type of handover is called "Horizontal Handover". This name indicates that the handover process occurs between cells of the same network technology.

However, the framework considers that one data flow can change from one type of access network to another one. For this reason, another type of handover must be considered: the "Vertical Handover". This is more than simply change the cell that is under use; it implies the change of the type of cell under use. For example, one traffic flow can start the transmission from a DVB core and for any reason the GPRS network will further continue the transmission.

In the vertical handover, some issues must be considered:

- How to guarantee the quality of service necessary for the service operation;
- How to maintain the connection during the change of network technology;
- How to determine what path and what network technology is the more appropriate in order to provide the service;
- How to manage and inform to the billing processes of all telecommunication operators what resource was used in any network.

According to [7], the vertical handover will be used in the wireless access-networks, and its use will be associated to the user device, which will be able to or access these several mobile networks, or it will be reconfigurable [8].

The vertical handover brings some challenges if it takes into account the continuity of the application sessions. One of the matters is related to the Quality of Service necessary for a specific application. As it is possible to have more than one access-network available, it is a difficult task to decide what network must be used. An excessive vertical handover could interrupt the service or cause delays during the running application [9].

Although, [7] suggest a model to heterogeneous wireless network and considers the vertical handover process between wireless networks, this paper suggest that the vertical handover may occur not only the wireless environment but also may occur in wired and wireless network, in order to use the backbone as the way between two wireless networks, or even the vertical handover between a wireless network and a broadband network as xDSL, it is necessary taking into account the differences between the different technologies, mainly in the cases when the traffic will change from the backbone (probably a wired network) to the access-network (wireless in several cases), where the resources are lower than in the first case.

4 Quality of Service Issues

When it is considered a heterogeneous environment, as shown in figure 1, it is quite clear that all these networks have their own resource controls in order to deliver any type of service to the end user, and these control mechanisms may be incompatible between them. For instance, on one hand the QoS mechanisms presented in IP networks, such as Diffserv or IntServ, are not appropriate for the heterogeneous scenarios, since they not consider other protocols different from the IP [10], [11]. On the other hand, in the telecom networks all management is done by using an out-of-band network for signalling and network control (in a general way the used protocol is SS7) [12], which is incompatible with the IP QoS systems. In order to build a common QoS mechanism that controls the whole convergent framework, the concept of Bandwidth Broker from DiffServ technology ([13], [14]), associated with QoS administrative domains, may be used to handle not only the difference between networks, but also the restrictions presented in the legacy systems.

Although the DiffServ does not guarantee end-to-end QoS, it can be successfully used in access networks such as MNO (Mobile Network Operator) or DVB because these infrastructures have methods for pre-allocation of the resources, at least in the Layer 2. It means that there is available bandwidth for any established channel and the delay or jitter has no representative effect in the communication (when it is considered only the backbone) [15]. The same does not happen in an IP Backbone infrastructure.

However, it is important to have in all these infrastructures an admission control. According to [17], it is vital to establish a resource reservation mechanism, since the traffic flow of any user should follows the subscribed service requirements (SLA-Service Level Agreement). The admission control mechanism must verify the possibility of an ingress service flow going across the infrastructure. For that, it might consider both the prediction of the subnet resources allocation and the classification of traffic according with predetermined traffic classes (similarly as the DiffServ traffic classes).

In order to demonstrate the necessity of the any application follows the appropriate QoS parameters, it was simulated video stream propagation into a mobile network using the CONE tool [18]. For that, some parameters of the MNO were translated to QoS parameters of the IP network. The test was composed by a MPEG 4 transmission over RTP (Real Time Protocol) without caching or buffering. In the figure 2 can be observed the transmission results where the network packet drop was 0.1%, the delay was 1.5 ms and the jitter was 0.025 ms. The MNO network did not have enough resources to transmit such video. An efficient admission control mechanism should not permit this transmission, and other network, such as DVB, should transmit that video.

Taking into consideration the proposed framework and the properties of its components, it is proposed a QoS analysis for a similar scenario related with the INSTINCT architecture [16], as it is depicted in figure 3. In the proposed scenario, more than one Content Creation Subsystem (CCS) could exist. These contents are sent to the Service Creation Subsystem (SCS), and these portions of the structure are responsible to format all contents in an appropriate manner to the end user terminals. Therefore there is another vital component of the scenario, which is called Network Manager (NM). It receives and manages QoS information from the probes and all other network equipments. The NM is capable of building the network statistical model behaviors used by the QoS Broker in order to handle the network resources. However, the NM receives information, but does not provide any support for QoS control, which means that the NM will not handle any QoS limitation suffered by any service. Instead, the NM sends alerts and other relevant data to the QoS Broker evaluate the network states and perform QoS control based on statistical models stored in a database controlled by the QoS Broker.

Fig. 2 Video transmission over a MNO network

The QoS control is not essential when considering only the DVB or the MNO backbones, since the structure and operation of the network guarantee some resources when a service is under transmission. When considering the Metropolitan backbone or the radio transmission itself, the effects of the delay, jitter and bandwidth becomes critical. In the metropolitan backbone several types of traffic will compete for the available resources. For the radio transmission, the resources could be limited by the effect of several types of interferences, such as rain and electromagnetic signals. In this moment the QoS control is vital for maintaining the quality in the whole network. A possible solution for that scenario is the use of QoS Broker.

According to [15] it is possible to build a QoS Broker that could handle the IP protocol in different network technologies, such as between UMTS and Ethernet networks. This QoS Broker will handle the QoS parameters of the network that it belongs, and inform all necessary information to establish a connection between two or more QoS administrative

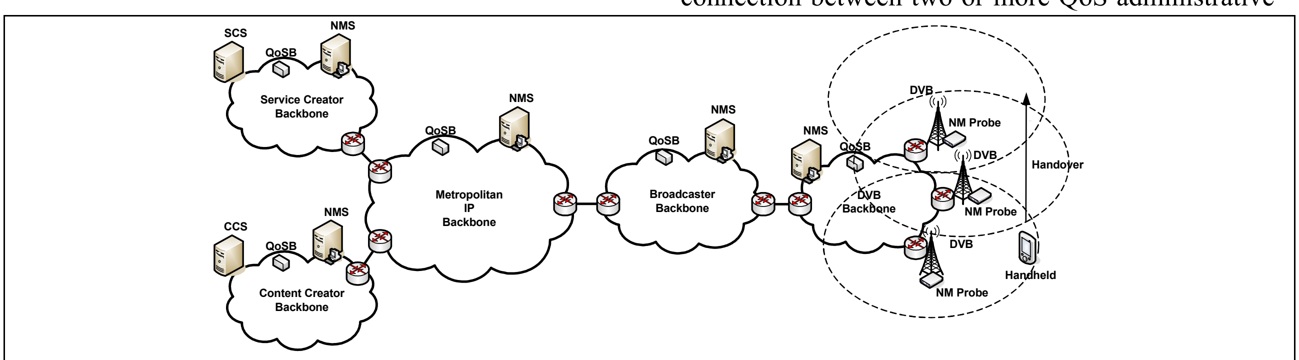

Fig. 3- Infra-structure for QoS Analysis

domains. This concept is very similar to what the Bandwidth Broker does in the DiffServ architecture. However, for a truly heterogeneous environment some issues must be taken into consideration, especially the protocols of each network infrastructure. In the proposed scenario, the QoS Broker is composed by:

- **NM Module**: receives data of the network statistical model behaviors (such as delay, jitter, available bandwidth, packet loss);
- **Core Module**: receives data for all modules and processes how to handle the traffic and sends the appropriate parameters to configure the network equipments by Virtual Router Module [15];
- **QoSB Database**: stores the data from network statistical model behaviors;
- **Virtual Router**: sends control parameters to the network equipments ([15]), and creates a relationship between parameters used for each network technology and the respective protocols, as a way to map similar resources.
- **QoSB Interface**: receives and sends information between QoSB.

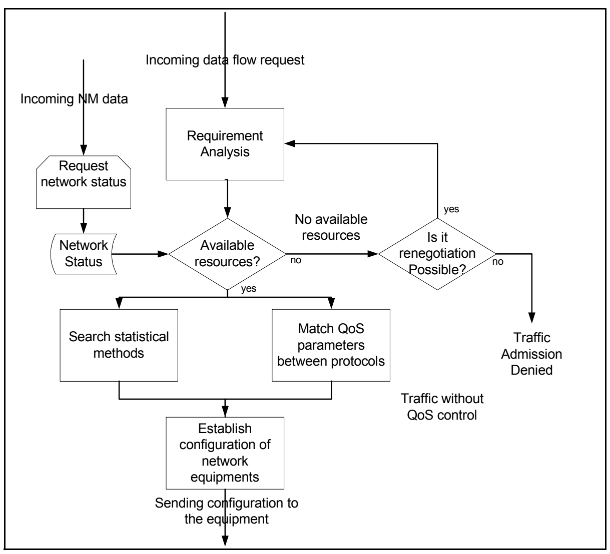

Fig. 4- QoS Broker Operation

Any traffic originated in the SCS that must cross two QoS administrative domains to reach the end user device should have its resource allocation negotiated by all QoS Broker in the traffic path in order to allow a new traffic flow inside each QoS Broker network domain. For this, the QoS Broker analyzes if there are the necessary resources available in its network and selects the appropriate type of channel for the transmission of the content, as it is depicted in the figure 4.

As in the heterogeneous environment it is possible to have several types of protocols in use at the same time, the QoS Broker have the task of informing the configuration for the network equipments for mapping the characteristics of all protocols involved in the transmission of any content. For instance, if content should be transmitted from a mobile network to the DVB infrastructure (crossing the IP backbone), a mapping between the parameters of QoS of all involved protocols must be done in order to the network equipments of the traffic path interoperate respecting the SLA requirements.

When taking into consideration an IP backbone it is an interesting approach that the routers use the DiffServ QoS mechanism. These equipments will use the configuration data from QoS Broker to adjust the classes of services in a way to better control the traffic flow in the network.

5 Related Works

References [19] and [20] propose end-to-end QoS architecture frameworks for heterogeneous networks. The EVEREST project discusses the deployment of a QoS control for mobile environment and the quality of service improvement from the point of view of the user terminal. It is a solution based on IP DiffServ technology in all domains and utilizes the hierarchical BB (Bandwidth Broker) concept to provide scalability. It also presents the WQB (Wireless QoS Broker) that assumes BB functions concerning the mobile environment. DAIDALOS project discusses the QoS control for intra and inter-domains, aiming the integration of multiple access technologies: wired and wireless networks, broadcast media and cellular technologies. DiffServ is used in DAIDALOS for supporting QoS in core network and the QoSB (QoS Broker) concept is the main element of the architecture, which is the responsible for controlling the access network routers in order to match the QoS requirements of the applications.

The main contribution of our QoS framework is towards the qualities found in both projects. As EVEREST, we consider not only the QoS control from the point of view of the user terminal in a mobile environment, but the other types of networks (wired, broadcast and cellular networks) as well as DAIDALOS does. The concept of QoSB presented in DAIDALOS is also used, however the proposed framework consider a QoSB capable to handle with several protocols, instead of the IP-based QoSB proposed in DAIDALOS.

6 Considerations

The framework for heterogeneous networks addresses several questions of the convergent environment such as quality of service, security and handover procedures. The distribution of QoS tasks between the components of the proposed architecture is necessary due to the complexity of the environment. We believe that QoS Broker will use statistical methods to determine models of the network use. The Network Manager will know the possible available services in order to identify the best available types of channels for each transmission. These two components control a subnet of the QoS administrative domain.

This paper describes an ongoing work. We are applying the method described here and we are designing some network modules, such as the QoS Broker, in order to develop experiments using network simulator as a way to assess the proposed architectures usefulness for the Instinct Project [16] partners.

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