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EuQoS IST project: Overview of the QoS framework for EuQoS

This paper presents a part of activities carried out by the team from the Warsaw University of Technology for the 6. FR EuQoS IST project. The investigated subject is related with a framework for providing QoS (*Quality of Service*) capabilities in a multi-domain heterogeneous network environment. More specifically, we follow the concept of introducing into the network a number of network services/classes of service for handling the traffic emitted by the applications requiring some QoS guarantees corresponding to maximum packet delay, variation of packet delay and packet loss ratio. We believe, that such approach can be effectively implemented in many kind of networks by adding adequate QoS mechanisms working on different time scales.

1. Introduction

In this paper we briefly describe our approach for providing QoS capabilities at the network layer in the EuQoS system [8]. More specifically, we will point out on associated to this layer QoS mechanisms we need to implement. We believe that the implementation of these mechanisms should be sufficient for guaranteeing the expected end-to-end QoS on the packet transfer level.

Let us start with recalling the objective of EuQoS that promised to find a solution for assuring QoS in the multi-domain and heterogeneous network environment. So, to find successful solution for this challenge we need to solve "on the way" many particular sub-problems corresponding to inter- and intra-domain aspects.

The approach we plan to force will follow the concept of establishing in the network a number of, so called, QoS network services/classes of service, like it was successfully done not only in ATM but also in IP-based networks. It is worth to mention about the results of IST AQUILA[1] project, which focused on IP-based network with an enhanced DiffServ architecture [5], [6]. For recalling, in AQUILA there was assumed and successfully tested four QoS network services, each of them oriented for handling different types of IP traffic with different QoS objectives [1], [2], [3].

Concluding, the investigated concept assumed for EuQoS is just to fix a number of end-to-end network services (NSs) differing in QoS objectives and types of handling traffic profiles. The NSs should be visible by the end-users (user applications) and should be maintained via the multiple domain network even different network technologies are on the way. However, we should be worry that the set of NSs should be carefully defined and should meet two main objectives that are: (1) to satisfy the QoS expectations from user/applications point of view, and (2) should be implemented in the network even different network technologies.

Since EuQoS deals with multi-domain and heterogeneous network environment, it is obvious for us that the problem of defining appropriate set of NSs requires a comprehensive approach taking into account both the current QoS capabilities of all investigated network techniques as well as the

[1] AQUILA – Adaptive Resource Control for QoS using an IP-based Layered Architecture, IST-1999-10077

inter-domain aspects. Again let us recall, that the intention of EuQoS is to provide end-to-end QoS, where a connection can be established via different access networks like xDSL, UMTS, WLAN, LAN/Ethernet and IP core. So, we should carefully examine each of the above network technologies from the QoS capabilities viewpoint. In addition, our focus will be paid on the type of tested by EuQoS applications that are VoIP, VoD, VTC, medical application, distributed class room and tele-engineering. As a consequence, to take into account all these "pieces together" we should have clear and comprehensive approach for providing QoS.

After definition of NSs, the further step is to specify associated QoS mechanism that will allow us for the successful implementation. The NSs should meet our expectations, it means that the packet streams submitted to a given NS should experience the required QoS with respect to such characteristics as packet transfer delay, packet losses etc. The QoS mechanisms, we mentioned above are of different type but mainly through the mechanisms governing the packet handling in the routers (like classifiers, schedulers, policers, droppers etc.), packet handling in wireless networks (the mechanisms of MAC – Medium Access Control) etc. Generally, we will focus on mechanisms available in the network devices that can help us with the controlling packet transfer.

Another point we will discuss is the dimensioning/provisioning for the NSs. Roughly speaking, for each NS we need an allocation of network resources, means link capacity and buffer size in the places where we plan perform admission control.

The organization of this paper is as follows. We start with recalling EuQoS scenario. Next we present the concept of the network services and our point on types of network services in EuQoS. Finally, we summarize the paper.

2. EuQoS scenario

The scheme for EuQoS scenario at the network layer is depicted on Figure 1. For now, we assume that accepting the flows (traffic streams – the stream of packets with the same both source and destination IP addresses, port numbers, etc.) is based on per flow operations (on-line submission). So, the QoS request is generated by a source (end user side) to the network by using the signalling system, named EQ-SSN (*EuQoS Signalling System in the Network*). This QoS request is transmitted along the path established by the EQ-BGP protocol (*EuQoS – Border Gateway Protocol*). The QoS request crosses the consecutive domains and the system makes the necessary resource reservations for the call. Furthermore, we assume that when the QoS request is submitted we have fixed the route by the network and it is done by the EQ-BGP supported by the rules from TERO (*Traffic Engineering Route Optimisation*) module, as assumed for EuQoS.

When QoS request is submitted to the network, the path from source to destination in known "*a priori*". The path is established by EQ-BGP and TERO function.

The QoS request crossing by the consecutive domains and inter-domains links is addressed to particular NSs that are available in these parts of network. Assuming that the NSs are well defined and implemented, we can expect that by admitting the QoS request we expect that the quality of the packet transfer will follow our expectations. Decision about admission/rejection of new flow to a given network service is based on applied admission control principles and, of course, depends on the current load in the network, amount of network resources assigned to this NS and information about new call.

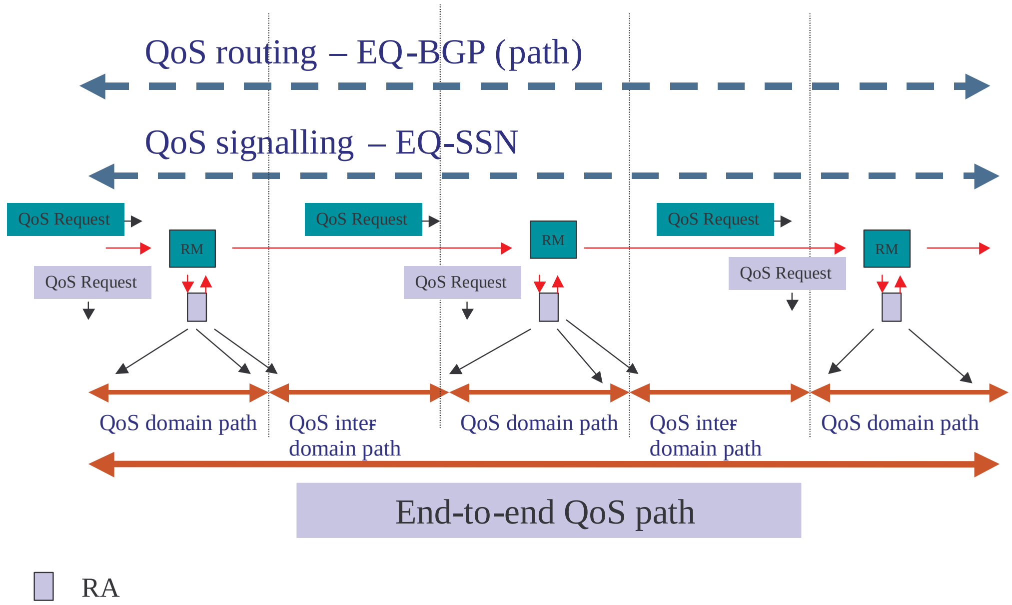

Figure 1. EuQoS scenario from the point of view of the network layer, RM – Resource Manager, RA – Resource Allocator.

3. Network service

The notion of network service is not new, and as it was mentioned above it was successfully used in ATM and some prototypes of IP-based network, like AQUILA, GEANT. Briefly speaking, the network service is a service the network offers to the traffic streams. By using this service we can expect that a packet traffic submitted to this service will be transferred according to the guarantees specified for this service. For instance, when we consider *best effort* service one can expect that the packets submitted to this service may affect unpredictable transfer delay and even may be lost. Therefore, in the case of the EuQoS we will speak about, so called, QoS network services, the services that will guarantee for the packets streams specific quality expressed in the form of packet delay characteristics, packet loss characteristics etc.

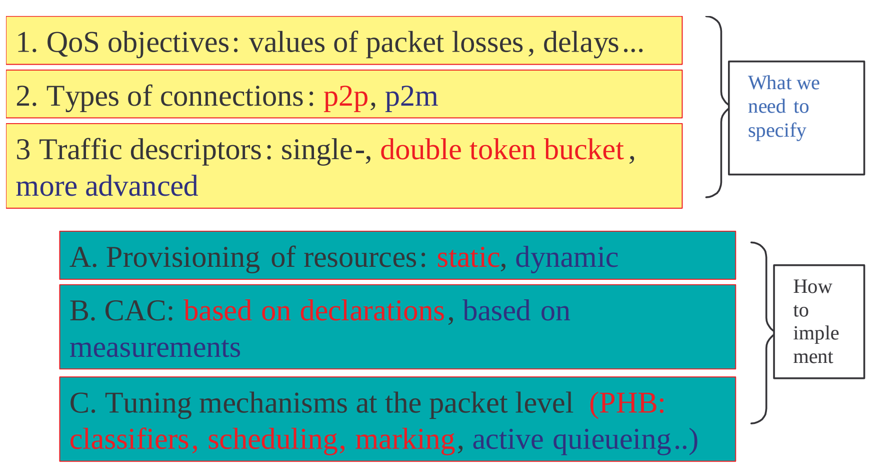

Figure 2. The element of the network service specification.

Figure 2 depicts the main elements of network service definition. For specifying a NS we need to define:

1. QoS objectives that a NS should meet. The QoS objectives are specified in terms of the parameters we want to guarantee. For these parameters we should set concrete values. The parameters of interest are:
    - Maximum possible packet transfer delay, e.g. not greater that 150 msec.
    - Maximum packet delay variation, e.g. not greater than 20 msec.
    - Maximum possible packet loss ratio, e.g. not greater that 10^{-4}
    - Maximum value of capacity, e.g. 100 kbps
    - and so on
2. Types of connections supported by the NS. The connection can be point-to-point (p2p) or more advanced, like point-to-multipoint (p2m) or even point-to-anywhere (p2e). The definition of type of connection is important from the point of view of volume of network resources we need to allocate to this NS.
3. Traffic description of the connections handled by the NS. The traffic description is usually expressed in the form of, so called, the traffic descriptors. The traffic descriptors are:
    - Single token parameters, for declaration of constant bit rate traffic that is characterized by the peak bit rate – PBR, and peak bit rate tolerance - PBRT
    - Double token parameters, for declaration of variable bit rate traffic that is characterized by two token buckets, one corresponding to the PBR, PBRT and one corresponding to the, so called, sustainable bit rate – SBR jointly with maximum packet burst – MBS.
    - More sophisticated parameters.

Assuming that we have specified the above three points, the next step is to implement the NS. For this task we assumes 3 points that are:

- Dimensioning of network services. For NS we should allocate the network resources. More specifically speaking, we should allocate the volume of allocated capacity jointly with allocated buffer size.
- Algorithm for performing admission control. Such algorithm is possibly different for each of network services, since different traffic types are served by each NS as well as different QoS objectives are fixed. In particular we will perform different algorithm when constant bit rate traffic is submitted and different algorithm when variable bit rate traffic is submitted.
- Tuning parameters of the QoS mechanisms operating at the packet level. By applying these mechanisms, we mean droppers, classifiers, schedulers etc., we can provide different handling of packets in the network elements like routers.

Example of NS: NS dedicated for handling VoIP traffic, that is regarded as constant bit rate. Specification:

1. QoS objectives: most acceptable for voice codecs, packet losses < 10-4, packet delay < 150msec., jitter < 20msec
2. Types of connections: p2p
3. Traffic descriptors: single token bucket
    - G,711: PBR= 64kbps then MOS=4.43 (*MOS – Mean Opinion Score*)

- G.729: PBR = 8 kbps then MOS=4.18
- G.723.1: PBR=6.3 then MOS=4.0 or PBR=5.3 then MOS=3.83

How to implement this service in IP-based network:

A. Provisioning of resources:
   Made in a static way: C_1 capacity, that is a part of the C link capacity ($C_1<C$), is dedicated for VoIP NS, the buffer for this C_1 should be also fixed, e.g. for 10 packets
B. CAC function can be based on declarations submitted by the QoS request and we assume, so called, peak rate allocation scheme. Flows are characterized by: Single Token Bucket (peak bit rate (PBR) and peak bit rate tolerance (PBRT).
   New flow is admitted if:

$$PBR_{new} + \sum_{i=1}^{N1} PBR_i \leq \rho C_1$$

   where N1 denotes the number of connections in progress and parameter ρ ($\rho<1$) specifies the admissible load of capacity allocated to the VoIP class. The value of ρ can be calculated from the analysis of M/D/1/B system taking into account the target packet loss ratio and the buffer size [1].
C. Tuning mechanisms at the packet level – e.g. in border routers (Per Hop Behaviour - PHB: classifiers, policing, marking, dropping, queuing, scheduling [7]), as it is shown on Figure 3. In this figure, Traffic class #1 may correspond to the VoIP NS, while the rest traffic classes correspond to other NSs.

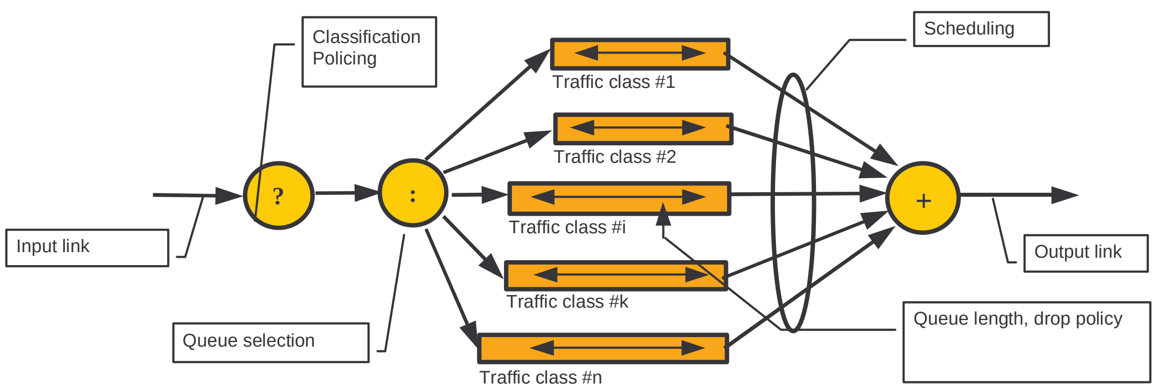

Figure 3. Example showing in which way we may do setting PHB in the routers.

4. Network services for the EuQoS system

Since we plan to deploy the EuQoS system over multiple domain networks and over different network technologies, the issue of fixing the network services is most critical. We should focus on network services that should be visible by the user side. The first step is to have a look on the applications we plan to use and test in EuQoS, more specifically on their requirements corresponding to the QoS. On the Figure 4 we present the first QoS assessment as required from the applications.

Application		Throughput	Delay	Jitter	Packet loss
VoIP		Medium	High	High	High
Videoconference		High	High	High	Medium
Video Streaming		High	High	High	Medium
Tele-Engineering (PLATINE)					
	Chat	Low	Low	Low	Medium
	Presence	Low	Low	Low	Medium
	Videoconferencing	High	High	High	Low
	Audio conferencing	Low	High	High	Medium
	White board	Medium	Low	Low	Medium
	Application sharing	Medium	Medium	High	Medium
Medical Applications (MEDIGRAF)					
	Videoconferencing	High	High	High	Medium
	Data Transfer	High	Low	Low	High
	Collaboration	Medium	Low	Low	Medium
	Chat	Low	Low	Low	Medium
Distributed Classroom (FORMARE)					
	Audio (unidirectional)	High	Medium	High	High
	Video(unidirectional)	High	Medium	High	Medium
	Slideshow	Medium	Medium	Low	Medium
	Whiteboard	Medium	Low	Low	Medium
	Chat	Low	Low	Low	Low

Figure 4. The QoS requirements coming from the applications.

As one can observe, the requirements coming from the pointed out applications are different with respect to such parameters as throughput, delay, losses and jitter. So, we expect that in EuQoS we will need to specify a number of NSs. In addition, we can expect that mapping between applications and NSs will not be “1 to 1” in the case of applications like tele-engineering or medical application.

Now we concentrate our focus on the network services for the EuQoS. The general view is depicted on Figure 5.

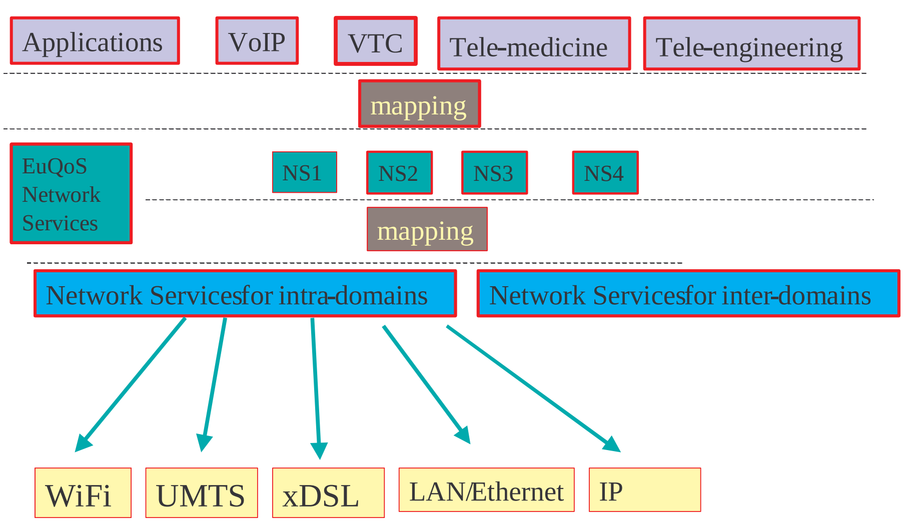

Figure 5. General view of the NSs in EuQoS.

We state that we need to specify the end-to-end NSs, namely EuQoS Network Services. The EuQoS NSs will be visible by the applications (end users). A mapping between applications and EuQoS NSs should be defined. We assume that we will need a few EuQoS NSs, say max. 4. The EuQoS Network Services will constitute key point in QoS Framework. The packet traffic from the application will be submitted to one of these NSs and the experienced QoS at the packet level will in straightforward way depend on the effectiveness and reliability of this service.

After defining the QoS objectives for each of the EuQoS NSs, the next step is to solve in which way we can use the NSs currently available by different network technologies and which NSs we need to establish for inter-domains parts of the network. We expect that currently available NSs in particular types of access networks, as in WiFi, are not so adequate for the EuQoS, like we expect for VoIP. So, in this area we will focus on original EuQoS proposals. This can be a challenging task.

Anyway, as the starting point we plan to focus on the set of network services discussed as the network services visible on the inter-provider gate. This set jointly with expected QoS is presented on Figure 6 and Figure 7 [4]. We assume that on the inter-domains links we will have only 4 types of network services that are:

- Ctrl – for transferring system information;
- Real-time (RT) – for transferring the packet streams sensitive on delay and losses characteristics and corresponding to, so called, streaming traffic. This type of service is named as EF (Expedited Forwarding);
- None Real Time (NRT) - for transferring the packet streams not sensitive on delay and losses characteristics but requiring a guaranteed transmission rate. This type of service is named as AF (Assuring Forwarding);
- and, Best Effort.

Inter-Provider Service Class	Tolerance To			PHB	End-To-End Service Class	DSCP Name	DSCP Value
	Loss	Delay	Jitter				
Ctrl	Low	Low	Yes	CS	Network Control	CS7	111000
Real Time	VLow	VLow	VLow	EF	Telephony	EF	101110
					Signalling	CS5	101000
					MM Conferencing	AF4x	100xx0*
					RT Interactive	CS4	100000
					Broadcast Video	CS3	011000
None Real Time	Low	LIM	Yes	AF	MM Streaming	AF3x	011xx0*
					Low Latency Data	AF2x	010xx0*
					OAM	CS2	010000
					High ThruPut Data	AF1x	001xx0*
Best Effort	NS	NS	NS	DF	Standard	DF	000000

* xx = 01, 10 or 11

Figure 6. The types of network services.

Aggregate	Tolerance To			End-To-End Service Class	Tolerance To		
	Loss	Delay	Jitter		Loss	Delay	Jitter
Ctrl	Low	Low	Yes	Network Control	Low	Low	Yes
Real Time	VLow	VLow	VLow	Telephony	VLow	VLow	VLow
				Signalling	Low	Low	Yes
				MM Conferencing	L-M	VLow	Low
				RT Interactive	Low	VLow	Low
				Broadcast Video	VLow	Med	Low
None Real Time	Low	LIM	Yes	MM Streaming	L-M	Med	Yes
				Low Latency Data	Low	L-M	Yes
				OAM	Low	Med	Yes
				High ThruPut Data	Low	M-H	Yes
Best Effort	NS	NS	NS	Standard	NS	NS	NS

Figure 7. QoS requirements for NSs.

In the access network we assume that the set of network services will be more enhanced than this supported on the inter-domain links. On inter-domain links we will keep only 4 NSs, as above mentioned, among them two NSs - RT and NRT - will be of our main interest. On the contrary, in the access domains the intention is to keep more network services, strictly corresponding to the types of applications. For instance, the telephony and video services will be accessible on the access network and they will be aggregated to one, in this case RT, service. Such aggregation is presented on Figure 8. Similarly, for aggregate service NRT, we plan to keep MM streaming and High Data Throughput in the access (see Figure 8).

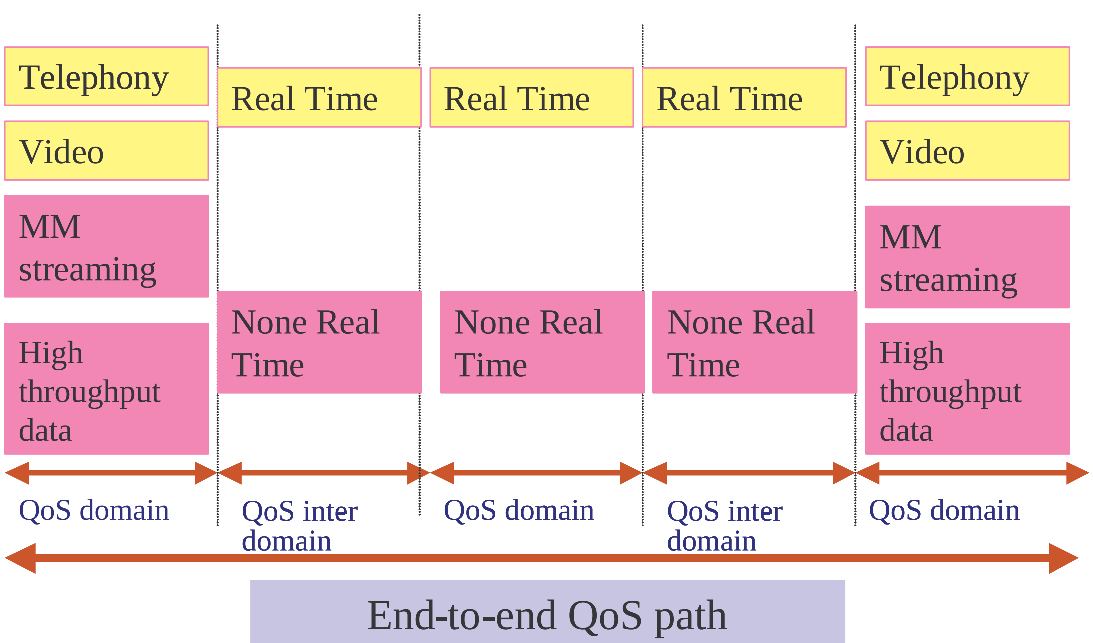

Figure 8. Example how we plan to deploy network services in EuQoS.

5. Summary

In this paper we presented our approach for providing end-to-end QoS in EuQoS. The key element of this approach is to define and implement effective QoS network services, accessible by the user/applications. However, in order to do it we should solve the following points:

1. understanding of the QoS required by the applications;
2. specifying the QoS objectives, types of connections and traffic profiles for the network services in the access networks;
3. specifying the QoS objectives for the inter-domain (inter-provider) area;
4. specifying the QoS mechanisms and QoS algorithms (CAC) for the fixed network services for each type of access networks and for the inter-domains;
5. defining rules for dimensioning of particular network services.

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