QoS Differentiation Provisioning & Management System Exploiting Mobile Agent Technology

Angelos Michalas[1], Malamati Louta, *Member, IEEE*, Vassilis Loumos, *Member, IEEE*, Dimitrios Zisopoulos and Georgia Charitoudi

***Abstract*—The DiffServ architecture provides a scalable mechanism for QoS introduction in a TCP/IP network. DiffServ model is based on the aggregation of traffic flows at an ingress (or egress) point of a network and the IP packet marking for different priority flows, according to several classification criteria. Two approaches exist in the DiffServ architecture: the Absolute and the Relative. In Absolute DiffServ, an admission control scheme is used to provide QoS guarantees as absolute bounds of specific QoS parameters. The Relative DiffServ model provides QoS guarantees per service class expressed with reference to guarantees given to other classes defined. Our study presents a QoS Absolute and Relative Differentiation Provisioning & Management System aiming to provide QoS Differentiation (Absolute and Relative) in IP DiffServ based Networks. The proposed system has been applied and performed well on a real network testbed.**

***Index Terms*— Quality of Service, Absolute and Proportional Relative Differentiation, Mobile Agents.**

I. Introduction

The research community has concentrated on two different techniques to provide QoS differentiation to customers of packet switched networks. First, the Integrated Services (*IntServ*) [1] and, second, the Differentiated Services (*DiffServ*) [2] approach.

In the context of this paper, Absolute and Relative Diffserv Provisioning and Management are achieved through a distributed QoS System. This system is based on an extension of the network management architecture followed and implemented within the scope of the European IST (*Information Society Technology*) Project MANTRIP (***MAN**agement, **T**esting and **R**econfiguration of **IP** based networks using Mobile Software Agents*) [3]. MANTRIP network management system supports quality of service configuration and monitoring in IP networks. Our extension provides QoS Differentiation (Absolute and Relative) in IP DiffServ based Networks.

The implementation of the QoS Provisioning & Management system is based on Intelligent Mobile Agent Technology (*MAT*). *MAT* has been considered as a paradigm that can help service designers handle the potentially increased functional complexity involved in service creation and deployment [4].

The rest of the paper is organized as follows. In the next *Section* as a first step, the high level architectural description of the proposed QoS Provisioning and Management System is provided, and as a second step its operational procedures are described. Finally, concluding remarks are made and issues for future study are provided.

II. QoS Provisioning & Management System

Fig. 1 illustrates in a graphical manner the QoS Provisioning and Management System Architecture. The different software modules that constitute the overall system are organized in four different layers. The **Application Layer** comprises the logic for performing the QoS provisioning and management tasks. The **Service Layer** contains the services that support the execution of the application. The **Adaptation Layer** is responsible for hiding the protocol details from the Service Layer and includes the network adapters and wrappers. The **Network Layer** includes the network resources. All network nodes support IP DiffServ, which is implemented by a *Class Based Queue* (*CBQ*) scheduler [5] on each network node interface.

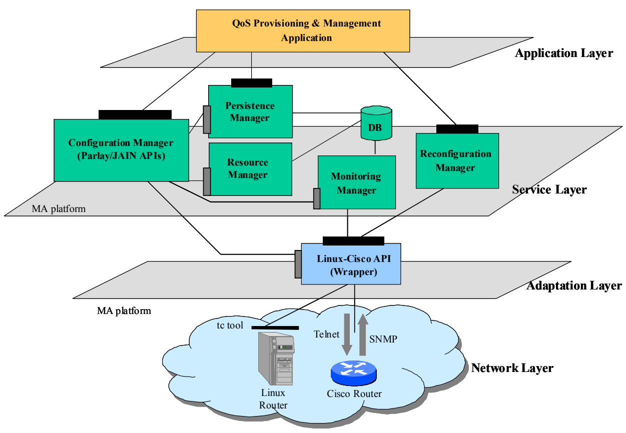

Fig. 1. QoS Provisioning and Management System Architecture

QoS Provisioning & Management System caters for the initial configuration of the network routers (i.e., definition of the QoS parameters of the DiffServ service classes on the basis of past experience/ historical data) by means of

[1] A. Michalas and V. Loumos are with the National Technical University of Athens, GREECE (telephone: +30 -210 7721447, e-mail: michalas@central.ntua.gr).

M. Louta, D. Zissopoulos, and G. Charitoudi are with the Technical Educational Institute of Western Macedonia, GREECE (e-mail: louta@kozani.teikoz.gr).

the *Configuration Agents* sent from the *(Re)Configuration Management subsystem* (implemented on the management station) as close as possible to the routers in order to perform their mission. In *Absolute DiffServ*, considering the case of higher service class overloading, worse packet forwarding may emerge with respect to the lower service classes. In such a case, service rate reconfiguration of routers output link is required in order to provide the best QoS possible per flow. Consequently, assuming that users and applications cannot get the requested absolute service level assurance, such as an end-to-end delay bound or throughput due to network resources insufficiency, a consistent service differentiation on output links of core routers should be provided, so that most of the QoS required levels are satisfied. Similarly, *Relative DiffServ* could be achieved by reconfiguring the service rate of each class according to its packet arrival rate and buffer occupancy. Authors' previous work on these issues include [6][7].

Considering a connection reservation request for Absolute QoS across two Service Access Points (*SAPs)* issued by the user, as a first step, the QoS Provisioning & Management System performs Call Admission Control (*CAC*). In case creation of the connection is authorized (that is, there are available network resources to serve the requested connection), the system proceeds with the establishment of the connection by configuring the routers associated with the specific path across the two *SAPs*.

In case the user requests Relative QoS (e.g., Proportional Delay Differentiation), the system does not perform admission control. Instead, *Reconfiguration Agents* are initiated by the administrator and sent on each router's outgoing network interface to estimate and allocate new bandwidth values (service rates) to service classes of the CBQ schedulers.

Reconfiguration may be applied either on a static or on a dynamic base. In the static case, the service rates are adjusted to the *CBQ* scheduler once, whereas in the dynamic case, the system achieves the required differentiation through the dynamic adaptation of the service rates per service class. In our system, the *Reconfiguration Management subsystem* is responsible for preserving dynamically the specified end-to-end *Absolute Delay Constraints* (*ADCs)* or/and *Relative Delay Constraints* (*RDCs*) for established connections. Specifically, a *Reconfiguration Agent* created by the *Reconfiguration Management subsystem* is sent to the *Adaptation Layer* of each core router of the Diffserv network. The *Reconfiguration Agent* retrieves regularly the number of packet arrivals $a_i(t)$, the number of packet departures $dp_i(t)$, and the number of packet drops $dr_i(t)$ per class of service. Thereafter, it finds the current router queue load: $q_i(t) = a_i(t) - dp_i(t) - dr_i(t)$ and estimates the current delay per class of service: $d_i(t) = \frac{q_i(t)}{r_i(t)}$, where $r_i(t)$ is the current service rate of class-*i*. The results are sent to the *Reconfiguration Manager*, which, in accordance to the $d_i(t)$ values, can predict if an absolute or relative delay constraint violation on a specific connection exists. In case of an *ADC* or *RDC* violation, it issues a reconfiguration request to the *Reconfiguration Agents* in order to dynamically reconfigure the service rates per class of service on each node involved in the connection.

For service rate computation in case of an *ADC* violation the following algorithm is applied. A portion of the service rates of the lower priority classes that meet their *ADCs* are exploited in order to increase accordingly the rate of the classes with an *ADC* related violation. In essence, the available resources of service classes are utilized in order to succeed in satisfying the *ADCs* of all service classes. The process is iterated until an *ADC* violation does not exist and all available resources have been redistributed. If after the completion of the reassignment process there are still classes that violate their *ADCs*, the strict *ADCs* of the lower priority service classes are relaxed in favour of the higher order classes. Thus, the service rates of the higher order classes may still be increased by reducing accordingly the rates of the lower priority classes, until a minimum predefined service rate has been reached. It should be noted that, in such a case, the *ADCs* of the lower service classes are violated. In case of an *RDC* violation, the service rates per class of service are re-estimated in accordance to the ratio of their corresponding Delay Differentiation Parameters [2].

III. Conclusions

In the context of this paper, Absolute and Relative Diffserv provisioning and management in packet switched networks are achieved through a distributed QoS System. The implementation of the proposed QoS provisioning & management system is based on Intelligent Mobile Agent Technology (*MAT*), which added flexibility, scalability, manageability to our system, while at the same time allowed for a relatively easy implementation supporting even various configurations without introducing major modifications to the main architectural design.

The system was applied on a real network testbed and it performed well succeeding in satisfying the *ADC* and/or *RDC* related constraints posed each time. Directions for future work include but are not limited to the realization of further wide scale trials so as to experiment with the applicability of the framework presented herewith.

References

[1] P.P White, "RSVP and Integrated Services in the Internet: A Tutorial," *IEEE Comm. Mag.*, pp. 100-106, May 1997.

[2] K. Nichols, S. Blake, F. Baker, and D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers," RFC 2474, Dec. 1998.

[3] MANTRIP Del. D2.1: System Requirements and High Level Architecture.

[4] M. Breugst and T. Magedanz, "Mobile Agents—Enabling Technology for Active Intelligent Network Implementation," *IEEE Network*, vol. 12, no. 3, Aug. 1998.

[5] S. Floyd and V. Jacobson, "Link-sharing and resource management models for packet networks," *IEEE/ACM Transactions on Networking*, vol. 3, no. 4, Aug. 1995.

[6] M. Louta and A. Michalas, "Quality of Service Management in IP networks through Dynamic Service Rate Reconfiguration", Journal of Internet Technology, vol 7, no. 1, 2006.

[7] A. Michalas, M. Louta, P. Fafali, G. Karetsos, V. Loumos, "Proportional Delay Differentiation Provision by Bandwidth Adaptation of Class Based Queue Scheduling", International Journal of Communication Systems, Wiley InterScience, vol. 17, no 7, 2004.