Resource Management in QoS enabled IP networks with the AQUILA RCL

Abstract

Voice, video, online games, and other future Internet applications require IP networks which provide enhanced transport services in terms of bandwidth, delay, jitter, and packet loss in addition to today's standard best effort data delivery. AQUILA, a joint European research project funded by the European Union for three years, defines and implements a new scalable and efficient *Resource Control Layer* (RCL). It complements IP networks, that use the differentiated service code points (DSCP) in IP headers to sort IP packets into a small number of distinguished QoS classes. The RCL comprises *Admission Control* (AC) and *Resource Management* (RM) as well as an inter-domain QoS approach. Scalability is reached through independently operating local admission control (AC) functions at the network border. AC control the traffic that enters or exits the network per edge device. Efficiency is based on adaptive resource provisioning based on continuous demand measurements. Bandwidth requirements are estimated and network resources allocations are adapted. Performance studies showed that our RCL works well and illustrate the trade-off between adaptation frequency and resource utilisation. Here, we give an overview about our resource management functions and present performance results.

Extended Abstract

Voice, video, online games, and other future Internet applications require IP networks which provide enhanced transport services in terms of available bandwidth, delay, jitter, and packet loss in addition to today's standard best effort data delivery.

Differentiated Services (DiffServ) allows to classify IP packets into a small number of service classes through setting the DSCP bits in the IP header at the network border when a packet enters a network. With DiffServ no state information has to be kept at core routers and no QoS signalling messages have to be processed there like with IntServ. All core routers have to do is to sort incoming IP packets into the right queue according to their DSCP values in the IP header and to service a predefined small number of queues with a predefined policy (scheduler). There is no dynamic queue set up like in IntServ. All burdensome processing (classification, marking, policing) is shifted to edge routers at the network border.

DiffServ can be used to divide network traffic into service classes (DSCP) and to designate a certain share of the available network resources to each service class (queuing and scheduling). In order to reach a given level of QoS, the traffic that enters a DiffServ service class has to be controlled. This is the task of an additional *Resource Control Layer* (RCL). AQUILA defines and implements such a RCL together with user and application interfaces to enhanced IP services and a measurement infrastructure for testing and QoS evaluation (see www.ist-aquila.org). AQUILA is a joint European research project funded by the European Union for three years.

First, the AQUILA RCL is an intra-domain control layer that controls a single administrative domain. It comprises resource management, AC and traffic policing functions. Resource management provisions bandwidth to AC functions that reside at the network edge. AC functions control the traffic that enters and leaves enhanced service classes at the network border. There is an independent AC function for each edge router. If AC accepts a new flow, a traffic policer is configured to open a gate for this traffic and to enforce that the stream of passed IP packets stays within the negotiated traffic specification.

Moreover, AQUILA defines an inter-domain resource management. The AQUILA inter-domain resource management approach does not require the AQUILA RCL in all domains. AQUILA refines and implements BGRP which has been proposed by Ping P. Pan, Ellen L. Hahne, and Henning G. Schulzrinne. Currently, there is an Internet draft available that describes our BGRP Plus architecture. It comprises a signalling protocol and resource management functions that damp inter-domain signalling effort.

The most simple AC can be realised with a pre-configured mesh of point-to-point pipes between all ingress and egress points. Then, ingress AC functions simply have to control access to bandwidth limited pipes. This scales perfectly, measured in number of signalling messages that have to be send and processed. But this has a detrimental effect on the required network resources. In particular, this approach does not work end-to-end, i. e. inter-domain across the Internet. On the other hand, per flow hop-by-hop inter-domain AC, i. e. to send AC requests from domain to domain all the way down from a source to a destination in order to request resources for individual flows, does not scale. Our approach uses the simple AC model introduced above, but adds egress AC and dynamic resource provisioning based on online demand measurements. Thus, we combine both AC models. Hop-by-hop AC is applied on seldom used paths. Dynamic configured pipes across domains are used to connect source domains with destination domains across frequently used paths. Feedback from traffic measurements is used to dynamically adapt these inter-domain reservations. A key component is a demand estimator that updates demand estimates as infrequently as possible, is a tight upper bound, and follows substantial demand shifts fast. Demand estimation should be updated as infrequently as possible, because each change results in signalling and processing power consuming actions. The estimate should be tight and follow substantial changes fast, because a loose upper bound results in low resource utilisation and may bind resources unnecessarily that are needed anywhere else. A simulation model has been used to evaluate the performance of our approach. In addition, AQUILA also implements and tests its RCL using real network equipment. A first trial that concentrated on intra-domain resource management showed that our concepts work in real network in spring 2001. A refined RCL and inter-domain scenarios will be tested in the second half of 2002.

The reminder of the paper will be organised as follows. Fist the architecture of our RCL as well as the different resource management functions will be presented. We will illustrate how they co-operate to allocate network resources dynamically. A simulation model has been used for performance analysis using voice over IP scenarios. Some evaluation results will be present. Finally, we will conclude.