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Guest-editorial

Quality of Service Routing and Signaling

For a long time the proponents of the 'best-effort' Internet argued that the appropriate response to increased demand for bandwidth and resulting congestion is added capacity. Things have changed! In the last few years we have witnessed the demand for bandwidth to increase at a rate much faster than ISPs can handle. We have also observed a shift in application requirements for networkservices. For many applications the best-effort service offered by today's Internet is no longer adequate. Most people now seem to believe that the Internet requires more than just 'speeds and feeds'. The network administrators do not want to be passive observers at times of congestion – they like to have and exert some control over their networks. QoS gives them the power to predict and control network behavior by prioritizing applications, subnets and end-stations, and guaranteeing users specific levels of service. While a fast network can reduce the negative effects of over-subscription, QoS can deliver end-to-end control over traffic flows based on policies rather than congestion. The focus of this special issue are the protocols that constitute the control plane of a QoS enabled Internet, specifically QoS signaling and routing.

An important component in a QoS enabled network architecture is the ability to associate a QoS to a traffic flow. There are two primary approaches to doing this. One uses a directory-based approach, while the other uses signaling. In the directory-based approach, QoS profiles associated with traffic flows in the network are stored in one or more directories. This is typically done manually by the network administrators. From the directories these profiles are down-loaded to the routers and the switches where they are used to discharge service to traffic flows in accordance with their respective QoS profiles. The directory-based approach works well in small networks, but is difficult to extend beyond a single administrative domain.

Using signaling, such as the resource reservation protocol (RSVP), pairs of RSVP-enabled end-stations can communicate the QoS requirements and reserve network resources for an application session. QoS signaling allows applications and end-hosts mechanisms to exert fine grain control over resource reservation and service levels over a wide range of time scales. This flexibility and control however, comes at a cost. QoS signaling can be complex and heavy weight. RSVP embodies both the flexibility and the complexity of QoS signaling. It is a functionally rich and relatively complete signaling protocol. It is also quite complex and suffers from known scalability problems. Consequently, the deployment of RSVP has met with limited success. Designing a light weight QoS signaling protocol for the Internet is still an open problem.

Once a QoS profile of a flow has been identified, it is the job of the network to find a path that satisfies the QoS requirements of the flow. QoS routing is control plane component designed perform this task. In an well architected network, QoS signaling and routing should work hand in hand to find the best path for a flow.

QoS routing is not a new problem. It has been investigated in the context of circuit-switched networks, most notably ATM networks. However, despite all the attention given to QoS enablement of the Internet, QoS routing in the Internet is largely an unsolved problem. Current Internet routing protocols, e.g., OSPF, RIP, use shortest path routings optimized for a single metric, typically hop count. The IETF is investigating various approaches to enhancing the current routing infrastructure so that it can handle additional routing metrics, e.g., delay, and available bandwidth and can compute routes that satisfy various QoS constraints of the data flows. Many technical problems remain unresolved. Backward compatibility and incremental deployment are some of the important issues that are being debated. Also on the table are overhead of QoS routing and its impact on the aging routers, inter-domain QoS routing, and QoS routing for point-to-multipoint flows.

To address some of the unanswered questions in QoS signaling and routing we have put together a special issue of the *Journal of High Speed Networks* on 'Quality of Service Routing and Signaling'. For this issue, we received over twenty papers, of which five were selected for publication. They address issues ranging from how to reduce the overheads of QoS routing to routing for multicast communications.

The paper by Apostolopoulos, Guérin, Kamat and Tripathi addresses the issue of overhead associated with QoS routing. Using extensive simulation experiments, the authors quantify the processing complexity of on-line computation of QoS route. They also propose and evaluate alternatives to on-line route computation. The paper by Pornavalai, Chakraborty and Shiratori shows that for networks that employ weighted fair queueing scheduling discipline, the problem of finding multiple QoS constrained routes can be reduced to that of shortest path routing. The paper by Rajagopalan and Nair deals with QoS routing for multicast flows. The authors identify the key issues in multicast routing with resource reservation and propose heuristic solutions to address these problems. Segall, Bhagwat and Krishna propose a route computation scheme that avoids hot spots in the network in an effort to improve call blocking performance. The paper by White and Crowcroft focuses on resource reservation protocol. They examine the strength and weaknesses of RSVP and other alternatives. In light of their observations, they propose a new sender based dynamic reservation protocol that combines the virtues of RSVP with that of reservation protocols designed for ATM networks.

As you will see, the papers selected for this issue address some of the technical obstacles facing the QoS enablement of the Internet. Many problems still remain. We believe that the five papers in this issue will take us a step forward towards our ultimate goal.

Enjoy!

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