S-38.3180 QoS in the Internet / Exercise 2: RSVP/Integrated Services

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Abstract

You will familiarize yourselves (in pairs) with the service levels received by VoIP-clients and other network nodes in different network conditions. You will write a report maximum of 10 pages (including figures) and submit it before the deadline.

Instructions

The exercise lectures are held on November 18th, in Maarintalo (Maari-C) starting at 9am / 2pm depending on to which exercise group you have registered.

- The report of this exercise is due December 9th, at 4pm. Return is via web or or email to lynx@netlab.hut.fi . Note: If you wish you can use ITGuru's web reporting to aid in doing your report. Please note, that the results produced by the ITGuru web reporting may not be enough to complete the exercise. Should you choose to use the web reporting you have to return a working URL to lynx@netlab.hut.fi by the deadline. If returned in electronic format, PDF-documents are appreciated. Postscript is acceptable, other formats are not accepted.

1 IntServ exercise with Opnet/ITguru

The program contains good tutorials (Help-¿Tutorials) and you are highly recommended (but not, of course, required) to go through the first three tutorials (Introduction, Small Internetworks, ja LAN Modeling) before the actual exercise. You should be able to finish the tutorials in about 2 hours.

The support for IntServ in ITGuru is somewhat limited. The RSVP functionality is fully implemented, however, only the controlled load -traffic class exists. This exercise will concentrate on observing the packet behavior of VoIP-clients as the packets they send are treated in different ways in the network.

The exercise scenarios are as follows:

1. First, construct a network that looks like the one shown in Figure 1. This scenario will give you the baseline to which you can compare the results.

2. Second, duplicate the first scenario and replace the link between the routers with a link of higher capacity.

1.1 Exercise setting

You will build two different network scenarios. The scenarios are similar except the bottleneck link capacity in conncecting the two routers. The network is shown in Figure 1.

The traffic parameters are given in Table 1 below. The same settings are also used in the demonstration given in the exercise lecture.

The general procedure for creating a simulation scenario is roughly as follows:

1. After initializing the project, place the network elements and Application Config, Profile Config and QoS attribute Config -nodes into the network setting.

    - In this exercise you will use ethernet_wkstn, ethernet_server and ethernet4_slip8_gtwy and their _adv -versions. The routers are conncected to each other either with PPP_DS1 -link (first scenario) or PPP_DS3 -link (second scenario). The workstations are connected to the routers with 10Base_T -links. The ethernet workstations and the routers should be the adv-type when using RSVP.

2. Configure the QoS-settings (define RSVP flows and profiles etc.)

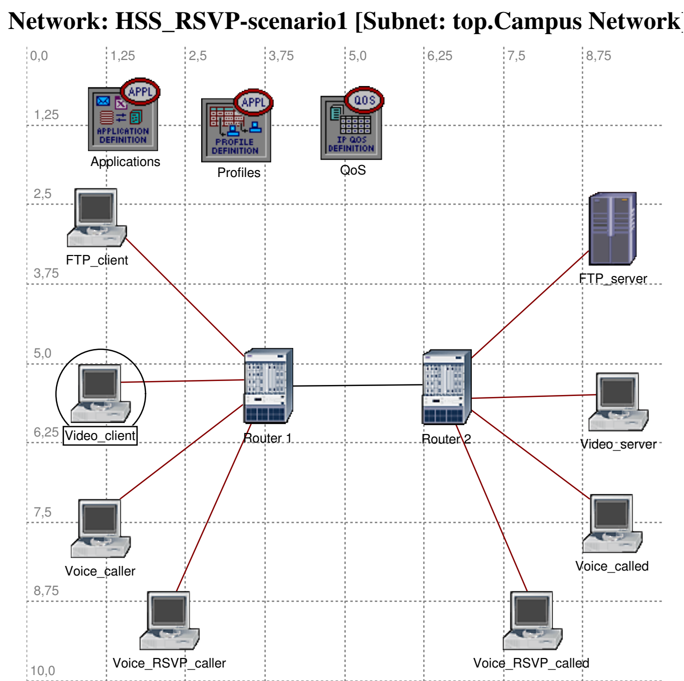

Figure 1: Topology used in IntServ -exercise

Table 1: Miscellaneous settings

General settings

Parameter	All apps/General	FTP	Video	Voice	Voice with RSVP
Inter request time	-	10	-	-	-
File size	-	1000000	-	-	-
ToS-value	-	0	4	6	6
Video type	-	-	Low resolution	-	-
Speech quality	-	-	-	PCM quality speech	PCM quality speech
Start time	100	-	-	-	-
Duration	End of Profile	-	-	-	-
Repeatability	Once at start time	-	-	-	-
Start time offset	-	5	5	5	4
Operation mode	Simultaneous	-	-	-	-
RSVP flow spec / bandwidth	50000	-	-	-	-
RSVP flow spec / buffer size	10000	-	-	-	-
Max. reservable BW	75%	-	-	-	-
Max. reservable BW/flow	75%	-	-	-	-
Simulation time (sec)	150	-	-	-	-

3. Configure the applications.

4. Configure the profiles.

5. Configure the workstations and servers and interfaces.

   - Apply the appropriate profiles and services (Application: Supported profiles or Supported services)

6. Configure the routers (and the intermediate link) to be used with WFQ as QoS-scheme and ToS-based QoS- profile. Remember to also enable

the RSVP on the links where you need it.

7. Finally choose the appropriate statistics and configure and run the simulation. Observe the results.

1.2 Exercise questions

Your primary task in this exercise is to observe the delay behavior of the different network services.

Write a report with maximum of 10 pages including figures, that has the following contents:

- Present *a comparison on the delay behavior of a VoIP–clients*. Analyze and compare the delay behavior of VoIP–clients that either use or do not use RSVP to reserve resources. The following results are required per scenario although you may present more if you think it will clarify your point of view:
  1. Graphic presentation (cumulative distribution function) of the *delay distributions* in the different scenarios for both types of VoIP-clients and for the video client.
  2. A short discussion on the results.
- Observe some overall network statistics:
  1. What are the total overall packet drop rates in different scenarios?
  2. Where (in the topology) do the packet drops, if any, occur?
  3. A short discussion on the results.
- Present a brief and concise analysis on your results. Do not write fairytales, just tell what you learned and what still remains a puzzle.

1.3 How to get started?

Instructions on how to get started with the ITGuru are available at
http://www.netlab.hut.fi/opetus/s383180/2005/harj/H2/

2 Introduction to IntServ

In the current Internet, there are no guarantees for either relative or absolute QoS and it is debatable if we can ever expect the Internet to provide absolute end-to-end QoS [1, 2, 3, 4]. The contemporary Internet is characterized by the diversity of its networking technologies. In the core of the network ATM, which is able to offer QoS [5], is slowly pushing FDDI–solutions to the background. This trend would implicate that the core Internet could be able to offer some kind of service levels if the penetration of QoS capable technologies reaches an adequate level. However, in the edges of the network the multitude of network solutions is overwhelming. All the different LAN technologies, some capable to offer QoS and some not, create a substantial obstacle to an absolute end–to–end Quality of Service in the Internet. Furthermore, the ever growing diversity in access technologies, such as the introduction of xDSL techniques and the strong foundation of traditional PSTN–modem solutions suggests that offering a possibility of consistent QoS in the Internet would introduce a number of problems regarding, for instance, the definition of QoS parameters.

Quality, in the Internet frame of reference, could be understood as the combination of exactly defined measures such as data loss, delay, jitter and use of network resources associated with the feeling or notion of Quality that the user of the network experiences. Major difficulty lies in defining the Quality as a function of both the measures **and** the human factor.

In this light, the *Quality of Service* in general terms and when speaking of networking, means that the user of some service receives a predefined, but not necessarily a constant amount of resources from the network guaranteeing that the user's packets are delivered to their destination within the set parameters and performance bounds.

On a related issue, *Class of Service* (CoS) is a closely related concept to QoS. Using CoS instead of QoS means that the traffic of one user is treated better than the traffic of another. No absolute guarantees are given, only promise to differentiate traffic. The Class of Service solution will most probably be the concept first deployed in the Internet before the actual end-to-end absolute Quality of Service.

3 Integrated Services

The recent developments of software and the emerging new services with increasing commercial efforts suggest that QoS, or at least different levels of service, Class of Service (CoS), should be introduced to the Internet. The emergence of various bandwidth hungry and delay sensitive applications, such as Voice over IP and video conferencing, require, or at least benefit from QoS or some other form of network performance guarantees. Similarly, the probable growth of new QoS sensitive applications [6] using the Internet protocol might expect some sort of QoS guarantees from the network. Several IETF[1] workgroups, such as IntServ[2] and DiffServ[3], have participated in the discussion and definition of Internet service architectures, but their work has not yet reached to any conclusive solutions. Various architectural and technological solutions have emerged and the heated debates for and against these solutions have dominated the discussion on the future Internet.

3.1 Integrated Services -architecture

The Integrated Services -architecture[4] proposal starts from the assumption that some traffic flows in the network need end-to-end Quality of Service guarantees [7] and that a relatively small number of flows ask for these guarantees (rate controlled applications) while the rest are satisfied with the normal best effort type of service (adaptive applications) [8]. To this end, the IntServ proposal uses the resource ReSerVation Protocol (RSVP). The IntServ has suggestions for several service classes but only two have been defined, in addition to the traditional best effort -'service':

1. Guaranteed service[5] that provides an assured level of bandwidth, a firm end-to-end delay bound and no queuing loss for the conforming packets of the traffic flow.

2. Controlled-load service[6] that provides no firm quantitative guarantees and tries to offer the flow a service level equivalent to lightly loaded best-effort network.

The concept of Integrated Services is essentially of the per-flow type. It is intended that all of the network elements that take part in the packet forwarding have knowledge of the flow, or connection, that the packet belongs to. This knowledge consists of information that is needed to produce deterministic network characteristics in terms of available bandwidth, delay, jitter and packet loss to the flow. In essence, the Integrated Services aims to provide Quality of Service to the selected flows. The implementation and realization of the Integrated Services in an IP router is open for vendors but a committed effort has been seen in realizing the RSVP -protocol.

[1] http://www.ietf.org/

[2] http://www.ietf.org/html.charters/intserv-charter.html

[3] http://www.ietf.org/html.charters/diffserv-charter.html

[4] RFCs 2205-2216 and RFC 1633

[5] RFC 2212

[6] RFC 2211

3.2 RSVP - Resource reSerVation Protocol

The RSVP was designed to enable the senders, receivers, and routers of communication sessions to communicate with each other in order to set up the necessary router state to support the IntServ service classes. RSVP accommodates all kinds of connection types, including multicast, it uses soft state, and it is designed to be relatively easy to implement in the Internet routers [7, 9]. RSVP identifies a communication session by the combination of destination address, transport-layer protocol type and destination port number. The primary messages used by the RSVP are the *PATH* and the *RESV* message:

- The *PATH* message originates from the traffic sender. The primary roles of the *PATH* message are to install reverse route state in the routers along the path and to provide receivers knowledge about the sender traffic.

- The *RESV* message originates from the traffic receiver. The primary role of the *RESV* message is to carry resource reservation requests to the routers between the receiver and sender.

The RSVP supports three types of reservations [10]:

1. The Wildcard Filter reservation is aimed particularly for multicast connections and is shared with all senders and extended automatically to new senders as they join the path.

2. The Fixed Filter reservation of resources is distinct and the sender is specified explicitly.

3. The Shared Explicit reservation is particularly suitable for multicast connections and the reservation is shared by selected senders.

The work in the Integrated Services -architecture has been mostly done based on the assumption that it is the user who initiates the resource allocation process. The role of the network is then to calculate if the requested resources are available and either accept or reject the request. This calls for an admission control unit in all of the routers in the packet path.

It is quite evident that charging schemes are needed to protect an IntServ network from arbitrary resource reservations and to create a funding mechanism to extend network capacity at the most desired locations at the expense of those users that actually use these resources [11].

3.3 Discussion on Integrated Services

As the goals of the Integrated Services -approach are rather ambitious, it has also met a lot of criticism. The main issues of controversy and debate have been identified as:

1. **Bringing state into the Internet.** The traditional paradigm of Internet has been stateless and the discussion circulates mainly around whether to bring state to the Internet or not. In the traditional Internet, routers do not keep connection state information. This is to improve the robustness of the communication system and routers are designed to be stateless, forwarding each IP packet independently of other packets. Consequently, redundant paths can be exploited to provide robust service in spite of failures of intervening routers and networks. All state information required for end-to-end flow control and reliability is implemented in the hosts, in the transport layer or in application programs. All connection control information is thus co-located with the end points of the communication, so it will be lost only if an end point fails. With the introduction of the IntServ -scheme, the need to know of the state of the traffic flows is unavoidable. To guarantee deterministic performance on a flow, all the intermediate parties need to be aware of the requirements to provide such service.

2. **Complexity.** One of the main problems with any resource reservation technology is the burden of implementing complex systems needed for setting up and maintaining state information. Since the processors and other physical building blocks are becoming ever so fast, it has been argued that this aspect of complexity should not be considered as the key obstacle.

3. **Scalability.** The essential issue with the IntServ -scheme is the per-flow state scalability. While the number of simultaneous connections (and state table requirements) may be reasonable at the edges of the network the size of the state tables increases easily to intolerable levels in the core of the network. This effect is further enhanced with the recent trend in traffic patterns where 80% of the traffic is forwarded outside of the LANs.

4. "Flag day requirement". To work in a consistent manner the IntServ -functionality should be implemented throughout the packet path. This requires, in the case of IntServ, that the RSVP and related functionality should exist as well in the hosts at the edges as in the core routers.

Essentially this means updating the whole of Internet to support RSVP functionality and this is not seen as a trivial task.

3.4 Summary

The current functionality in the Internet is capable of offering a fair sharing of resources using basically only the FIFO-method of queuing in the routers and advanced flow control in the TCP-protocol. It seems likely that the dominant position of the router will continue and it will be providing mechanisms for realizing Quality of Service also in the future Internet, although, bringing service differentiation or QoS to the Internet requires several changes in the router architectures and especially requires broadening the ways we think an Internet router should function.

Integrated Services -approach aims to provide end-to-end deterministic Quality of Service to the few selected users. While doing this, it requires per-flow knowledge throughout the network, which in turn introduces problems in the traditional Internet paradigm, issues in the complexity of the implementation and doubts in the capability to scale.

Acknowledgements

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References

[1] M. Borden, E. Crawley, B. Davie, and S. Batsell. *Integration of Real-Time Services in an IP-ATM Network Architecture.* August 1995.

[2] S. Shenker, C. Partridge, and Guerin R. *Specification of Guaranteed Quality of Service.* February 1997.

[3] Eric Crawley, Raj Nair, Bala Rajagopalan, and Hal Sandick. *A Framework for QoS-based Routing in the Internet.* March 1996.

[4] Bala Rajagopalan and Raj Nair. *Quality of Service (QoS) -based Routing in the Internet - Some Issues.* October 1996.

[5] *Traffic Management Specification Version 4.0.* ATM FORUM, April 1996.

[6] Eugenio Guarene, Paolo Fasano, and Vinicio Vercellone. IP and ATM integration perspectives. *IEEE Communications Magazine*, January 1998.

[7] Paul P. White and Jon Crowcroft. The integrated services in the internet: State of the art. Technical report, University College London, 1996.

[8] Alistair Croll and Eric Packman. *Managing Bandwidth - Deploying QoS in Enterprise Networks*. Internet Infrastructure Series. Prentice-Hall, 2000.

[9] Paul P. White. RSVP and integrated services in the internet: A tutorial. *IEEE Communications Magazine*, 35(5):100–106, May 1997.

[10] Paul Ferguson and Geoff Huston. *Quality of Service: Delivering QoS on the Internet and in Corporate Networks*. John Wiley and Sons, 1998.

[11] Martin Karsten, Jens Schmitt, Lars Wolf, and Ralf Steinmetz. Cost and price calculation for internet integrated services. 1998.