Master Thesis
A Study on Routing for Resource Reservation Network

Yasutaka Miwa
Graduate School of Computer Science, Keio University
miwa@mt.cs.keio.ac.jp

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1 Introduction

The Internet is the connectionless packet network with IP (Internet Protocol), and the packets transferred on IP share the resources of routers or links. So, there should be two reasons why the service on the Internet is called the best-effort service. One is that the packets are equivalently delayed or lost when some congestion occurs, and the other is that most of all the services on the Internet are composed of the connectionless data links.

In recent years, however, such connection oriented data links as ATM (Asynchronous Transfer Mode) have come into wide use because they are able to support QoS (Quality of Service) to each connection. Besides that, continuous media (ex. real-time audio and video) and large bulk data (ex. super high definition image) transfer are also in great demand. Then, the **Guaranteed Service**[1] on the Internet comes to be essential.

That requires another kind of modern architecture which consists of various schemes. They are, for example, the resource reservation, the rouitng, the policy control, the admission control, or the packet scheduling. The resource reservation and the routing are two of the most important schemes of all.

While RSVP[2, 7] was proposed as one of the effective resource reservation schemes as early as in 1993 and was accepted as the standard for the Internet in 1997, the routing scheme still remains under discussion[3] by QoS Routing Working Group in IETF and is being developed now.

2 Goal

Our goal is to make the suitable routing scheme for the guaranteed service.

The former routing scheme is basically designed for the best-effort service by IP. A routing protocol is able to gather the information of reachability for the networks and for the nodes, select the best routes to the destination, and set up a routing table. But that's not sufficient enough.

The Guaranteed Service provides QoS to each flow, and every flow requires a variety of QoS parameters. That means, some need a minimized delay, others need a maximized bandwidth. Consequently, the routing protocol need to deal with the QoS parameter or the available network resources, and the routing table should manage the entries per flow. Plus, when in lack of the resources in the route provided first, the alternative must be selected immediately and effectively.

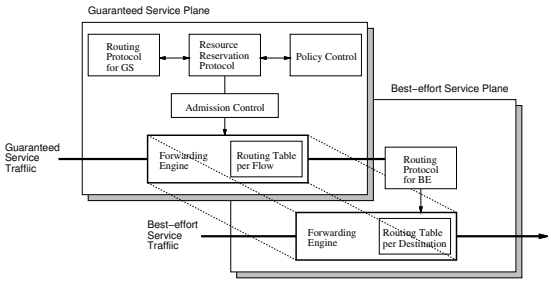

Figure 1: The Resource Reservation Network Architecture

We call the network for the guaranteed service the **Resource Reservation Network**. We discuss the routing scheme for that next section.

3 Architecture

Fig.1 shows the architecture for Resource Reservation Network. It has two planes. One is the Best-effort Service (BE), and the other is the Guaranteed Service (GS). The both routing schemes are separated from each other. Here I explain the routing protocols and the routing table in the GS plane.

3.1 Routing Protocol

The routing protocol in the GS plane doesn't set up the routing information on the routing table directly, but provides it to the resource reservation protocol. Then, the resource reservation protocol decides whether it is able to reserve it for the route or not. If it is, it sets up the information on the routing table. That, however, can't always reserve the resource for the route the routing protocol provides, because these proceedings are closely related with the policy control and the admission control.

3.2 Routing Table

As for the former routing scheme in the BE plane, the routing table keeps the route information about each destination. Compared to that, the one in the GS plane keeps it to each flow.

We focus especially on the routing protocol in the GS

plane. The functions it needs, the problems it has, and the policy it should adopt for the design and setting up of such protocol are shown next section.

4 Issues

4.1 Requirements

The functions the routing protocol for GS should possess are:

- managing the routes per flow.
- selecting the route that meets the demands of flows
- using the resource information of the network in order to select the best route.
- providing the alternative route.

4.2 Problems

- scalability

  The routing protocol for GS has less scalability than the former one in the network or in the traffic, because it needs much more information about the resource reservation or about the network resources in order to calculate various routes for every flow.

- stability

  The routing protocol for GS is fine-grained and state dependent. The information about the resource reservation is updated as soon as a flow is set up or deleted. The frequent updating of the routing information has bad influence on the stability of the routes[4].

- efficiency

  The route optimization is quite complicated and hard because one flow requires a variety of QoS parameters[5].

4.3 Design

In this study, the routing protocol is designed to cope with those problems, according to three policies below:

- cooperation with the resource reservation scheme or the routing scheme for BE

  The resource reservation protocol keeps the information about the reservation, while the routing protocol keeps that of the network topology. Consequently, the new routing protocol avoids increasing the cost because it can utilize the information from them.

- route calculation on the source node

  The increase of the quantity of calculation will be avoided by adopting the source routing scheme, because it calculates the routes only on the source node.

- decision to gather the information about the network

  The relation between gathering the precise information about the network resources and the cost for exchanging them is that of trade-off. I had many simulations with some algorithms as for getting the information about the network resources. Here are the results:

  - It is more scalable to notify the information of the resources to the particular node than to all nodes in the routing area.
  - It is more efficient to update the information in response to the change of the available resources than to do that periodically.

  Owing to these consequences, the network resource information should be updated only on the occasion that the reservation is failed by lack of resources, and it should be notified to only the node which calculates the route for it.

5 RRR

5.1 Overview

The overview of **RRR (Routing for Resource Reservation** is as follows:

- It provides the per-flow-routes to the resource reservation scheme.

  The resource reservation scheme asks RRR about the route for the flow, and RRR answers it.

- It uses the link-state routing information so as to calculate the route by TOS (Type Of Service) metric.

  RRR gets the information about the network topology or about the metric of the links from OSPF, and forms a SPF Tree by Dijkstra's algorithm with the TOS metric the flow requires.

- It calculates the route on the source node and sends the route information to the down stream nodes along the paths.

  Even though RRR calculates the route only on the source node, it can make use of the function of the route distribution, and can provide the route information at every node on the routes.

- It provides the alternative routes.

  It provides the alternative routes in case the first route is blocked for lack of the resources.

- It exchanges the available information of the network resources in order to select the best route.

  RRR exchanges the information named "alert", which indicates the state having no resource to reserve on the links. Notifying the state of alert from the resource reservation scheme, it reports the information to the source node of the flow. Accepting the alert information on the source node, it calculates another route to avoid the link.

- It supports the route for IP multicast.

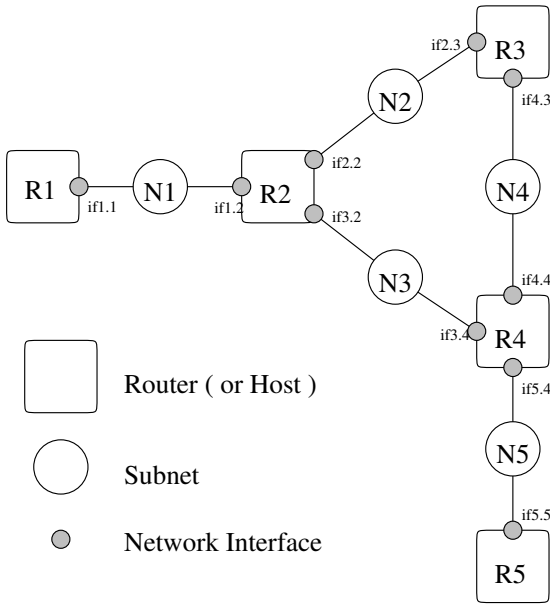

Figure 2: Sample network

5.2 Interface to the resource reservation scheme

RRR uses the extended RSRR[6] as the interface to the resource reservation scheme. The messages exchanged between RRR and the scheme are:

- from the resource reservation scheme to RRR

  Route_Query_Flow
  → To ask a route of the flow

  Route_Flush
  → To delete a route

  Route_Alert
  → To notify the alert information and request the alternative route.

- from RRR to the resource reservation scheme

  Route_Reply_Flow
  → To answer Route_Query_Flow

5.3 Providing a route

The process for providing the routes is indicated with the sample network on fig.2. Here We consider the case when the resource reservation scheme queries RRR on R5 about the route from R1 to R5. (fig.3)

1. The resource reservation scheme asks about the routes.

   The resource reservation scheme on R5 sends RRR the Route_Request_Flow message about the flow from R1 to R5 via RSRR interface.

2. Request the route for the source node.

   RRR on R5 sends a message to request the route to the source node of the flow, R1.

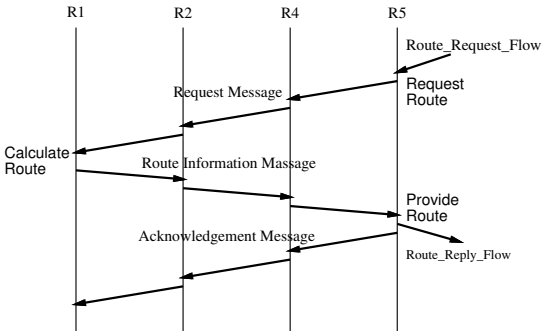

Figure 3: Providing a route

3. Calculate the SPF tree and selecting the route on the source node.

   RRR on R1 calculates the route of the flow after getting the message.

4. Send the route information to the down stream node and make an entry on the RRR route table.

   RRR sends the route information (R1 - R2 - R4 - R5) to R5. Then, each RRR on the route makes a new entry for the RRR route table to store the information.

5. Acknowkledges, and provides the route for the resource reservation scheme.

   The route information message arriving at R5, RRR sends the resource reservation scheme the Route_Reply_Flow message via RSRR interface, and the acknowledgement message to R1.

5.4 Providing an alternative route

Secondly, We show the process of providing the alternative routes. Here is the case when the state of alert occurs between the links from R2 to R4 in making a reservation for the flow from R1 to R5 (the route is R1 - R2 - R4 - R5). (fig.4)

1. Notify the state of alert from the resource reservation scheme.

   The resource reservation scheme on R2 sends RRR the Route_Alert message that indicates the state of alert in the flow from R1 to R5.

2. Report on the alert information and request for the alternative route.

   RRR on R2 sends the alert information to the source node, R1 with the request for the alternative routes.

3. Recalculate the route on the source node.

   Accepting the alert information message, RRR on R1 records that the link between R2 and R4 is on alert, and begins to calculate another route for the alternative.

4. Delete the former route information.

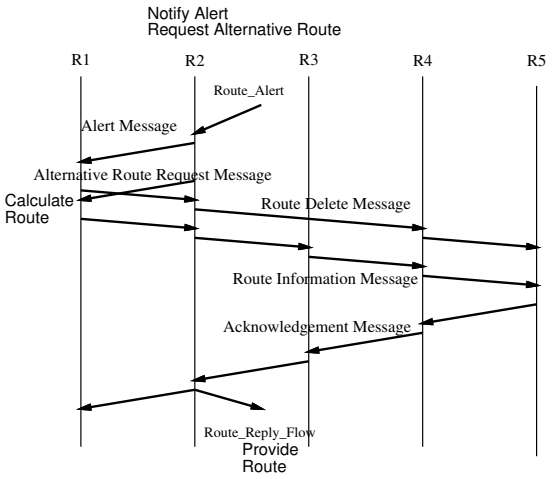

Figure 4: Providing an alternative route

RRR on R1 uses the route delete message to delete the former route information on which the alert status occurred. Accepting the message, RRRs on the routes delete the former entries about the flows from the route table.

5. Distribute the new route information and make the entry to the RRR route table again.

   RRR on R1 sends the new route information message (R1 - R2 - R3 - R4 -R5) to R5. RRR which accept it makes the new entry to the route table and stores it.

6. Provides the alternative route to the resource reservation scheme.

   Accepting the acknowledgement message, RRR on R2 sends the Route_Reply_Flow message to the resource reservation scheme via RSRR interface as the alternative route.

6 Implementation

6.1 Method

RRR here is implemented as the routing protocol daemon, **RRRD (Routing for resource reservation)**. This is the user process run on FreeBSD 2.2.1-Release based on 4.4BSD Lite. Fig.5 shows the overview of this implementation. GateD, originally done by Merit GateDaemon Project in the University of Michigan, is changed in some code in order to utilize the OSPF link-state database here. I referred to rsvpd Release 4.2a1 implemented by the Information Science Institute in the University of South California so as to make the RSRR interface of RRRD. For the management of the IP multicast groups, IGMP version 2 is supported.

6.2 Limitation

- The scale of the routing area of RRRD

  Using the link-state database of OSPF, RRR can provide the routes only within a single area. That means RRR can't provide the routes between the areas.

- The kinds of TOS metrics

  RRRD cannot support kinds of TOS metric any more than GateD can. It deals with either bandwidth or delay.

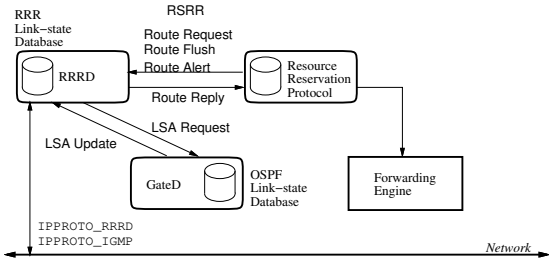

Figure 5: Implementation overview

7 Closing

In this study, the architecture of the Resource Reservation Network is defined and the new routing protocol is proposed for GS.

RRR doesn't create the route information directly on the routing table, but provides it for the resource reservation protocol. And the resource reservation protocol manages the routing table. RRR is separated from the routing table, so that it is able to select the routes quite flexibly, and the resource reservation protocol is able to fix the routes of the flows on which it reserves the resources.

Though RRR doesn't always provide the best route, it is sure to include all of the functions that the routing scheme should have for GS. That's why it is considered as to be able to do much for the realization of the resource reservation network. I'm going to evaluate it in detail on the actual network and improve it more.

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