RSVP-TE Signaling for Photonic Networks

Nobuaki Matsuura1, Masaru Katayama1, Eiji Oki1, Kohei Shiomoto1 and Naoaki Yamanaka2
1NTT Network Service Systems Laboratories, 2NTT Network Innovation Laboratories, NTT Corporation
3-9-1 Midori-cho, Musashino-shi, Tokyo, 180-8585 Japan
E-mail: matsuura.nobuaki@lab.ntt.co.jp, Tel: +81-422-59-3758, Fax: +81-422-59-4549

Abstract
RSVP-TE is used as a signaling protocol to manage the hierarchical label-switched paths (LSPs) in generalized multi-protocol label-switching (GMPLS). This paper describes the functions of and considerations in connection with the use of extended RSVP-TE in GMPLS signaling. We propose extensions to RSVP-TE that make it suitable for use with photonic networks.

1. Introduction
The application of photonic cross-connect (PXC) to the Internet has become recently a real possibility. In order to deal with nodes that have various switching capabilities, such as PXC and packet-switching routers, within a unified framework, a common control plane for generalized multi-protocol label switching (GMPLS) has been standardized and RSVP-TE [1] has been adopted as the signaling protocol. The functions of RSVP-TE in GMPLS signaling and related considerations are discussed in this paper, along with extensions to make RSVP-TE suitable for use with photonic networks.

2. An overview of RSVP-TE
RSVP (the resource reservation protocol) was originally designed as a protocol for resource reservation in IP networks. RSVP is based on a soft state model and the states along a route are maintained by the periodical sending of messages between the sender and receiver. RSVP messages contain a common RSVP header and a number of objects which carry information in relation to RSVP sessions. The sender is the originator of an RSVP session and the receiver corresponds to the destination endpoint of the data flow that is associated with the RSVP session. The two basic types of RSVP message are the Path and Resv messages (Figure 1). Path messages are sent downstream from a sender to a receiver to mark the nodes of the route for use by the data flow. Resv messages are sent upstream from a receiver to a sender along the reverse path and carry resource-reservation requests.

RSVP has been extended to obtain RSVP-TE, which covers traffic engineering and the signaling of label-switched paths (LSPs) in MPLS networks. Several new objects are defined in RSVP-TE; they include the Label, Explicit_Route, and Record_Route. Label objects are carried in Resv messages and contain the labels selected by downstream nodes. Explicit_route objects are carried in Path messages and specify routes which the sender wishes to have included in the sequence of "abstract nodes" that makes up the LSP. Record_route objects, which are carried in Path and Resv messages, record those hops which the messages actually make and the labels allocated to each of the hops; they are used for loop detection, etc.

In GMPLS, RSVP-TE is further extended to support various features that come with the generalized concept, such as hierarchical, bundled, and unnumbered LSPs, and more specifically to support optical networks. Labels are generalized to include wavelengths and individual fibers as labels. A new type of label which represents a set of contiguous wavelengths, the waveband, is introduced as a special case of wavelength switching. Means for transferring labels from upstream nodes to reduce the setup latency for optical LSPs, the explicit sending of control label from a sender, the establishment of a bi-directional LSP in a single session, and other features, are also introduced [2]. Various mechanisms for notification, state deletion, and restart from failures, etc., are also provided.

3. Issues for RSVP-TE in GMPLS
The conventional RSVP is designed on the assumption of in-band signaling, i.e., control messages are transmitted through the same channel as the data flow. With GMPLS, however, such a condition no longer applies. GMPLS control channels might not physically correspond to data channels; in fact, they may be in a completely different medium. Consequently, the connectivity of a control channel is not necessarily correlated with that of the data channel. This separations of control channels from data channels raises the following issues.

Figure 1 The basic sequence of RSVP
RSVP downstream messages such as Path, PathTear and ResvConf messages are sent to receivers by means of IP routing, i.e., the destination addresses in their IP headers are set as the destination addresses for the corresponding RSVP sessions. However, the control channel might provide a more direct way to send these messages to the receiver when this control channel is configured independently of the corresponding data channel (Figure 2). To cope with this problem, Internet drafts[3] say that Path and PathTear messages should be addressed directly to adjacent nodes along the data channel. However, in this method, nodes must completely recognize the control plane’s adjacency, which is subject to change.

To avoid this complication of routing, logically or physically configuring the control channels in a one-to-one correspondence with the data channels is considered to be an adequate approach. Furthermore, it is convenient to have some RSVP messages sent through the data channels to verify the data channel’s connectivity (Figure 3).

4. RSVP-TE extensions for photonic networks

One challenge for signaling in photonic networks is the efficient use of resources like wavelengths and wavelength conversion. To control the use of such resources in a distributed manner, it is useful to have some of the selection of routes, including the selection of particular wavelengths and wavelength conversion points, handled by signaling instead of entirely having this handled by routing.

We can take advantage of the RSVP scheme by having information related to resources collected by Path messages as they pass along the route; this information can then be used in wavelength selection by the receiver node.

Since wavelengths are finite and discrete, the bit-map provides an efficient form for their expression. We suggest two alternatives for the implementation of the bit maps; an AND scheme and an ALL scheme (Figure 4). In the AND scheme, each node obtains the intersection between the bits of the received bit-map and its own available wavelengths and transmits the result in the downstream direction. This scheme is suitable for establishment of an LSP which uses a
single wavelength along its entire path. On the other hand, in the ALL scheme, each node might add its own bit-map to the received message. The receiver node is then able to determine all available wavelengths and select one or more wavelengths for the LSP to minimize the number of wavelength conversions at transit nodes.

Conclusions
We describe the issues for RSVP-TE signaling in GMPLS networks and suggest solutions along with extensions to make RSVP-TE suitable for use with photonic networks.

References