

# Adaptive Resource Reservation Protocol for High-speed Resource Information Advertisement

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**Abstract**—This paper proposes an adaptive resource reservation protocol for high-speed resource information advertisement. The adaptive resource reservation protocol (ARRP) is a protocol that adaptively decides whether to use a 1-way reservation scheme or 2-way reservation scheme on the basis of resource information in the route calculation. Examples of the resource information are unreserved bandwidth and unreserved wavelength. The 1-way reservation is used when all links along the calculated route has enough resources. Otherwise, the 2-way reservation is used.

In GMPLS (Generalized Multi-Protocol Label Switching) network, the source router decides a label switched path (LSP) route using collected resource information from the network. The resource information is advertised by an OSPF-TE (Open Shortest Path First-Traffic Engineering) protocol.

If the unreserved resource information of calculated LSP route is too old and inconsistent with the current information, the resources on the LSP route cannot be reserved and thus data loss will be occurred. In order to support real-time unreserved information update, quite a lot of update packet transmissions are needed. It causes increasing of the processing load of all routers. Therefore OSPF-TE cannot advertise real-time unreserved resource information.

In the proposed method, when a LSP route is established or released by ARRP, only one packet informs update information of each links along LSP route to all edge routers. The proposed method can support more frequent updates by decreasing the amount of the update packets and can advertise the real-time resource information. By use of the real-time resource information, the proposed method certainly guarantees the reservation of resources on LSP route in spite of the 1-way reservation.

By the computation simulation, it is indicated that the number of the control packets in proposed method is one digit less than that in the conventional OSPF-TE. Compared to the OSPF-TE, the proposed method keeps low blocking probability even when traffic occurs more frequently. Thus, it is shown that the proposed method effectively use network resources.

## I. INTRODUCTION

The broadband communication services are increased rapidly. Traffic Engineering (TE) has been researched, because the more traffic increases and the more congestion of the network happen. The aim of TE is optimization of both utilization efficiency of network resources and traffic performance.

Multi-Protocol Label Switching (MPLS) is different from the IP routing. In the IP routing, a routing table is used for packet routing. On the other hand, in the MPLS, packets are forwarded by referring a label [1]. The label is an identifier with a short fixed length. A label switched path (LSP) is set between end-to-end routers. Generalized Multi-protocol Label Switching (GMPLS)

enhances MPLS architecture by the complete separation of the control and data planes of various networking layers. GMPLS enables a seamless interconnection and convergence of new and legacy networks by allowing end-to-end provisioning, control and traffic engineering. A router that exists in a boundary of the GMPLS domain and other domains is called an edge router.

The process established the LSP route is explained here after. In the source edge router, OSPF-TE (Open Shortest Path First-Traffic Engineering) calculates the LSP route to the destination edge router by using the cost and resource information on each link. Next, RSVP-TE (Resource reSerVation Protocol-Traffic Engineering) reserves the resource on the LSP route and distributes labels. The LSP is established by RSVP-TE [2].

When the routing protocol such as RIP (Routing Information Protocol) and OSPF (Open Shortest Path First) is used, the shortest path is selected by the routing protocol in a source edge router. If many routes pass specific links, utilization efficiency of the resource will be decreased. As a result, the congestion of the network may happen. To solve this problem, the TE is needed. In the TE of GMPLS (MPLS), the source edge router controls the network traffic by calculating the route using the collected network resource information (i.e. unreserved bandwidth or wavelengths) by OSPF-TE.

The network resource information e.g. the maximum resource and a link cost is necessary for the LSP route computation. The unreserved resource information is one of the network information. In case of the WDM optical network, the number of unreserved wavelengths of each link is the unreserved resource information. The unreserved resource information is frequently changed by connection requests. The other network resource information is not frequently changed. To execute precise TE, when unreserved resource information is changed, the real-time advertisement of the resource information from routers is necessary.

The unreserved resource information is advertised to all routers by information flooding of the OSPF-TE mechanism. In the flooding of OSPF-TE, the frequent update cases a problem that the amount of the update packets increases. Longer update interval can decrease the amount of the update packets. However, the real-time resource information advertisement is impossible.

If the unreserved resource information of calculated LSP route is too old and inconsistent with the current information, the resources on the LSP route cannot be reserved and data loss is occurred. Therefore, each router

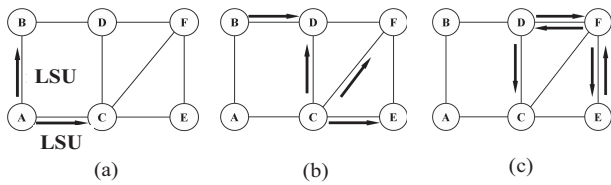


Fig. 1. Spread of LSU packets in OSPF when the LS is changed

should have the real-time unreserved resource information of all links on the network, and advertisement method of the unreserved resource information is very important for routing protocol to decided more suitable route. In order to support real-time unreserved resource information update, quite a lot of update packet transmissions are needed. It causes increasing of the processing load of all routers.

In this paper, we propose an adaptive resource reservation protocol (ARRP) for high-speed resource information advertisement. The ARRP is a protocol that adaptively decides whether to uses a 1-way reservation scheme or 2-way reservation scheme on the basis of resource information in the route calculation. The 1-way reservation is used when all links along the calculated route has enough resources. Otherwise, the 2-way reservation is used. When a LSP route is established or released by ARRP, only one packet informs update information of each links along LSP route to all edge routers. The proposed method can support more frequent updates by decreasing the amount of the update packets and can advertise the real-time unreserved resource information. By use of the real-time resource information, the proposed method certainly guarantees the reservation of resources on LSP route in spite of the 1-way reservation.

By the computation simulation, the number of the control packets in proposed method is one digit less than that in the conventional method. Compared to the conventional method, the proposed method keeps low blocking probability even when traffic occurs more frequently. Thus, the effectiveness of the proposal method is shown.

## II. OSPF-TE

OSPF-TE is extend OSPF for TE, and can advertise unreserved resource information on each link [4]. All routers maintain synchronizing network information. Each edge router can calculate the shortest path to all routers based on the maintained network information. The route is decided by using the calculated shortest path table when requesting path setup between routers. To advertise changed information to other routers when the link state (LS) of each link is changed, the router executes the link stare update (LSU). LSU transmits the update packets that advertise updated information to other routers when LS is changed. LSU synchronizes the network information in each router. The method of advertising the LSU packet and the transmitted interval are explained as follows.

### A. Advertisement Method of LSU Packet

An advertisement method of the LSU packet in OSPF-TE is explained. Each router has the link-state advertisement (LSA) database that shows state information at each link. When the router has two or more simultaneous change links, it stores their LSAs in a LSU packet and transmits the LSU packet to other routers by flooding.

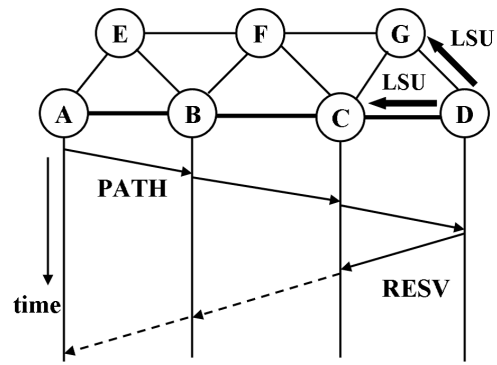


Fig. 2. Transmition of LSU packets when the RSVP-TE reserves the resource in Router D

As shown in Fig.1 (a), a case that the LS of Router A is changes is explained. Router A stores the LSAs in the LSU packet, and it transmits to B and C that is the neighboring router by flooding. The router that receives the LSU packet judges whether to reflect it in own LSA database or not. The LSU packet is discarded when the received LSU packet contains old information or has been already received. As shown in Fig.1 (b), Router C and D make new LSU packets when the LSU packet is reflected in the LSA data base, and transmit them. In Fig.1 (c), Router C and F discarded LSU packets because they had received same data before. Thus, the LSU packets spread into the whole network. When LSU packets arrive at all routers in the network, it can be said that the all routers are synchronized.

### B. Interval of LSU

The interval and timing of LSU influence the control overhead and the LSP setup blocking probability. There are the following three major methods as the LSU method [5].

#### 1) Periodic Update

Periodic update is a method to transmit the LSU packet at regular intervals (e.g. 30 seconds) [6], [8]. This method has an advantage of suppressing the amount of update packets to transmit the LSU packets, and decreasing the control overhead. However, it cannot realize real-time information update.

#### 2) Immediate Update

Immediate update is a method to transmit LSU packet whenever resource information changes [7], [8]. It can realize real-time information update. However, frequent LSU packets transmission causes the enormous control overhead increasing. It is not a realistic method under the dynamic LSP setup and teardown environment.

#### 3) Hold-down timer

Hold-down timer is a method to install the limitation at update intervals in Immediate update [7], [8]. After transmitting a LSU packet at the end, it doesn't transmit next LSU packet in a certain time. Compared with immediate update, it can reduce the number of update packets and the control overhead.

In order to reduce the control overhead, OSPF-TE uses Hold-down timer [9], [10].

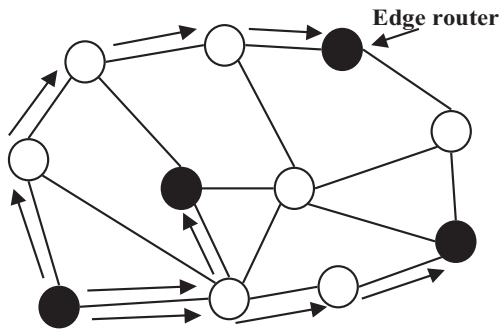


Fig. 3. Spread of AP in the proposed method

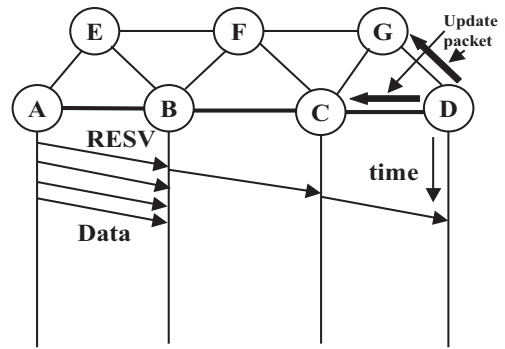


Fig. 5. transmission of AP in the 1-way reservation

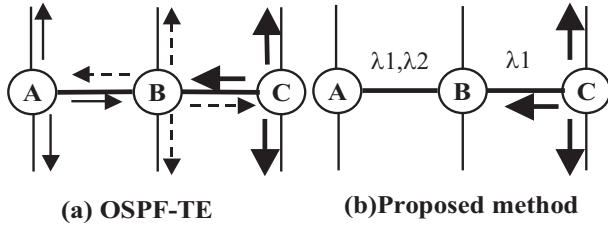


Fig. 4. Packets generated when the route is established in the proposed method

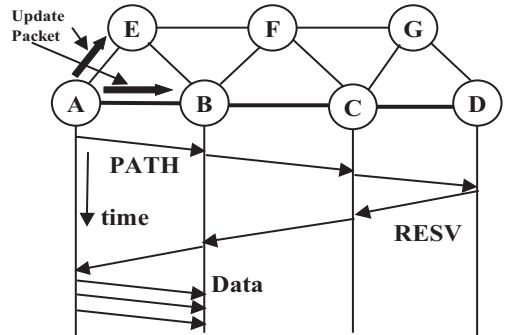


Fig. 6. transmission of AP in the 2-way reservation

C. Relation between the Resource Reservation and the Control Packet

The generations flow of the LSU packet when the resource is reserved by RSVP-TE is explained as follows. As shown in Fig.2, RSVP-TE belongs to the 2-way reservation scheme. When the resource is reserved, all routers on the LSP route transmit LSU packets. When the network scale grows and the resource is reserved frequently, a huge amount of control packets are generated.

Let's assume that on a present network, the arrival interval of request is shortened and the LS is frequently changed. In OSPF-TE, to prevent enormous generation of the LSU packets, hold-down timer is used. Therefore, the limitation of the update packets in the OSPF-TE disturbs the advertisement packets of the real-time information update. The resource information that all edge routers maintain becomes inaccurate and not synchronized. And therefore, the blocking probability of the LSP setup is increased. It is necessary to achieve the immediate update that the number of the control packet can be decreased.

III. PROPOSED METHOD

In this section, we propose an adaptive resource reservation protocol (ARRP) for high-speed resource information advertisement. When the resource is reserved or is released, the proposed method consolidates LSAs on all links in the LSP route into one packet. This packet is called Advertisement Packet (AP). The amount of the control packets can be reduced by transmitting the AP only to edge routers. Therefore, the immediate update is possible. The AP is used with the ARRP.

A. Advertisement Packet (AP) of Unreserved Resource Information

When the unreserved resource information on the router is changed, the router performs the proposed method without transmitting the LSU packet. In the proposed method,

changed information on all links in the LSP route, which is determined by the routing process, is accommodated into the AP. The source or the destination edge router transmits APs to other edge routers. It is possible to reduce the amount of the update packets and the control overhead in a frequent update case. As shown in Fig.4 (a), in a conventional method, the LSU packet was transmitted from all routers on the LSP route.

On the other hand, as shown in Fig.4 (b), in the proposed method, the information that corresponded to all LSA in the LSP route is consolidated into the AP. Fig.?? shows a packet format of the AP as used in Fig.4 (b). The AP contains the routers information and reserved resources information along the LSP route. Moreover, as shown in Fig.3, the AP is not advertised to all routers by the flooding but is advertised only to edge routers that need unreserved resource information update. The proposed method can advertise the real-time unreserved resource information to all edge routers.

B. Adaptive Resource Reservation Protocol(ARRP)

ARRP is a protocol which adaptively uses the 1-way reservation scheme and the 2-way reservation scheme based on the resource information on the LSP route. The 1-way reservation is used when there are enough link resources on the LSP route. Otherwise, the 2-way reservation is used. The 1-way reservation and 2-way reservation are described as follows.

1) 1-way reservation scheme

Fig.5 shows a mechanism of the 1-way reservation. The source edge router transmits a RESV signaling packet to the destination edge router and reserves the resource. After transmitting the RESV signaling packet, the source edge router begins transferring the

data. When the RESV packet arrives to the destination edge router, the router transmits APs to other edge routers. After generating the request, the 1-way reservation can reduce the delay to the data transmission beginning. Therefore, the resource reserving time can be minimized, and the utilization efficiency of the resource has been improved. Because the data transmission is begun before the confirmation of the reservation, it is not guaranteed that the transmission data correctly reaches the destination router.

2) 2-way reservation scheme

Fig.6 shows a mechanism of the 2-way reservation. The source edge router transmits a PATH signaling packet. When the PATH signaling packet arrives at the destination edge router, the destination edge router send back a RESV signaling packet to the source router. Each router along with the LSP route reserves the resource by RESV packet. When the RESV packet arrives to the source edge router, the router transmits APs to other edge routers. It is guaranteed that the transmission data correctly reaches the destination edge router to begin the data transmission after the RESV packet is received.

The ARRP is a method combined with the 1-way reservation and the 2-way reservation method by considering the number of wavelengths in the route that can be reserved the unreserved link resource information. The probability that can be reserved with the 1-way reservation is high when there are number of wavelengths that can be reserved enough. It is possible to shorten the delay to the data transmission if blocking is not occurred. However, the blocking probability rises if the number of wavelengths that can be reserved is few. If the number of wavelengths that can be reserved is few, the data transmission should be guaranteed by the 2-way method.

The amount of the resource used by the link is  $w_{used}$ , the amount of the maximum resource is  $w_{max}$ . The threshold is  $th$  when the router decide the 1-way or 2-way reservation.  $K$  is a constant that shows amount of the maximum guaranteed resource.

$$th = \frac{Kw_{used}}{w_{max}} \tag{1}$$

$$\begin{cases} \text{1-way reservation} & (th \geq w_{max} - w_{used}) \\ \text{2-way reservation} & (th < w_{max} - w_{used}) \end{cases} \tag{2}$$

At the source edge router all  $w_{max} - w_{used}$  along with the LSP route are calculated. When the 1-way is selected with all links in the route, the 1-way is used. Otherwise, the 2-way is used.

IV. PERFORMANCE EVALUATION

A. Simulation Model

In this section, the simulation model used by the computation simulation is explained. The network topology is a random mesh topology. The link degree of the node is 5. The number of edge nodes is 40% of the number of all nodes. The link delay of the control packet is  $5\mu\text{sec}/\text{km}$ . The LSP setup request is generated only at the edge routers.  $K$  is set to 3.

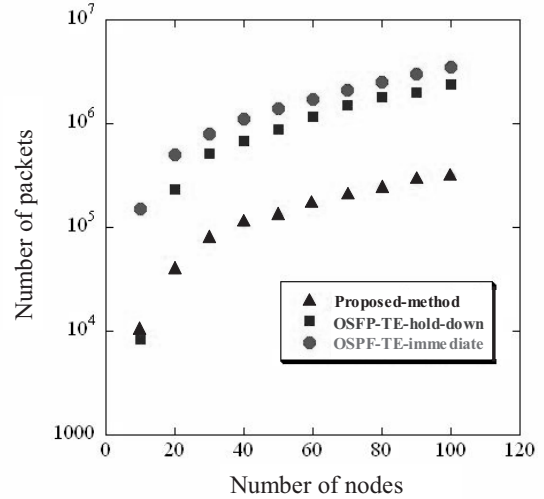


Fig. 7. Relation between number of packets and number of nodes

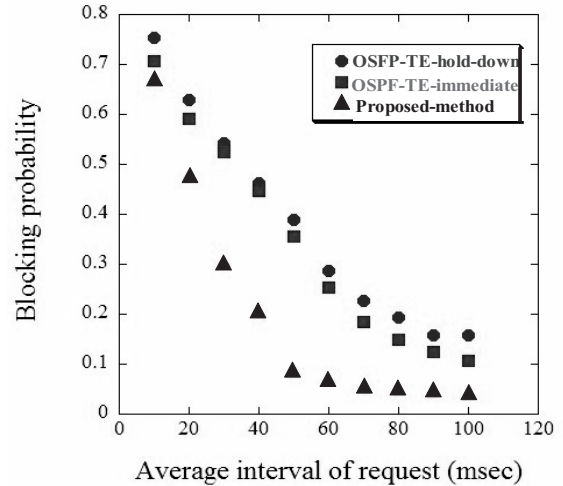


Fig. 8. Blocking probability when average interval of request changes

B. Number of Packets Generated When Resource Information Changes

The amount of the update packets according to an increase in the number of nodes of networks is shown in Fig.7. When the number of nodes increases, as for conventional OSPF-TE flooding methods, the number of hops of routes increases. Therefore, the amount of the control packet increases. Moreover, the number of unnecessary packets increases because the LSU packets spread into all routers by the flooding. On the other hand, in proposed method the number of the control packets is one digit less than that in the conventional methods so far because the packet spreads only to the edge routers, and only one packet (AP) is made.

C. Blocking Probability

The call blocking characteristics when the average arrival interval of the request is changed is shown in Fig.8. The number of nodes is set to be 30. When the average arrival interval of the request is 50 msec, conventional methods exceed the blocking probability 0.3. However, the proposed method indicates 0.1 or less. This is because

using the 1-way reservation improves the utilization efficiency of the network resource.

## V. CONCLUSION

This paper proposed an adaptive resource reservation protocol (ARRP) for high-speed resource information advertisement. The ARRP adaptively selects the reservation scheme on the basis of the resource information on the route. The proposed method is reduced an unnecessary packets by consolidating the update packet into the AP. Therefore, the proposed method can reduce the amount of the update packet generated when information is changed. Moreover, the proposed method improves the utilization efficiency of the network resource and reduces the call blocking probability by using the 1-way reservation method. By the computation simulations, the number of the control packets in proposed method is one digit less than that in the conventional OSPF-TE. Compared to the OSPF-TE, the proposed method keeps low blocking probability even when traffic occurs more frequently. Thus, the effectiveness of the proposed method is shown.

## ACKNOWLEDGMENT

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