A Shared Buffer-Constrained Topology Reconfiguration Scheme in Wavelength Routed Networks

Chan Hyun Youn, Hye-won Song, and Ji-Eun Keum

The reconfiguration management scheme changes a logical topology in response to changing traffic patterns in the higher layer of a network or the congestion level on the logical topology. In this paper, we formulate a reconfiguration scheme with a shared buffer-constrained cost model based on required quality-of-service (QoS) constraints, reconfiguration penalty cost, and buffer gain cost through traffic aggregation. The proposed scheme maximizes the derived expected reward-cost function as well as guarantees the required flow's QoS. Simulation results show that our reconfiguration scheme significantly outperforms the conventional one, while the required physical resources are limited.

Keywords: Virtual topology reconfiguration scheme, DEB cost model, shared buffer.

I. Introduction

A logical topology reconfiguration problem starts from an optimal design problem. Reconfiguration is more complex because it must consider packet loss during processing. Therefore, the design problem is accessed by optimization using a linear formulation, but the reconfiguration problem is usually accessed using a heuristic scheme [1]-[6]. Two representative objective functions for logical topology design and a reconfiguration problem are a throughput optimization through minimizing the congestion of the network and a delay optimization through minimizing the average number of hops. These objective functions can be used together or separately in the formulation, subject to many constraints such as degree, traffic, wavelength, and delay constraints.

During the reconfiguration phase, while the network makes a transition from one wavelength assignment to another, some cost is incurred in terms of packet delay, packet loss, packet de-sequencing, and the control resources involved in receiver retuning [6], [7]. Clearly, since unnecessary retuning affects the performance encountered by users, this kind of retuning should not be very frequent. Hence, it is desirable to minimize the frequency of network reconfigurations. However, postponing a necessary reconfiguration also has adverse effects on overall performance. Since the network does not operate at an optimal point in terms of load balancing, it takes longer to clear a given set of traffic demands, causing longer delays and/or buffer overflows, as well as a decrease of the network capacity in carrying the traffic. Similarly, if return decisions are made merely by considering the degree of load balancing, even tiny changes in traffic demands can lead to constant reconfiguration, thereby significantly affecting network performance. Consequently, it is important to have a performance criterion

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Chan Hyun Youn (phone: +82 42 866 6126, email: chyoun@icu.ac.kr) and Hye-won Song (email: hwsong@icu.ac.kr) are with the Department of Engineering, Information and Communications University, Daejeon, Korea.

Ji-Eun Keum (email: je.keum@samsung.com) is with the Department of Telecommunication & Networks, Samsung Electronics, Suwon, Korea.

that can capture the above tradeoffs in an appropriate manner, which is called a reconfiguration policy.

Reconfiguration is correlated to connection disruption due to lightpath deletion. Intuitively, it can be seen that if paths were established between node pairs with high traffic between them, then routed traffic reduces, and hence the average weighted hop count would also reduce. Also, we must consider the cost occurred by retuning the transceivers to turn to the better logical topology. The effective bandwidth is a scalar one that summarizes the amount of resources required by a connection in order to preserve its own quality-of-service (QoS) requirements. Hence an important first step to develop a reconfiguration policy is to find a workable and accurate way for quantifying resource usage for QoS constraint applications.

In this paper, we propose a more practical reconfiguration scheme regarding when the reconfiguration process should be triggered and how the reconfiguration should be performed. Toward these objectives, we developed an adaptive scheme for triggering reconfiguration, which considers the required QoS constraints, reconfiguration penalty cost, and the shared buffer gain cost through traffic aggregation. The proposed scheme maximizes the expected reward-cost function for reconfiguration as well as guarantees QoS requirements.

II. QoS Constraint Reconfiguration Based on Deterministic Effective Bandwidth Cost Model

We consider wavelength-routed networks with N nodes, and assume that the traffic matrix representing the traffic between each pair of nodes is given according to the specified leaky bucket parameters. Here, we define the parameters used in the problem formulation:

- s and d used as a subscript or superscript denote the source and destination of a packet, respectively.
- i and j denote the originating and terminating nodes, respectively, in a lightpath.
- The number of wavelengths per fiber is W.
- $e_d(\alpha)$ represents the deterministic effective bandwidth associated to given source α and delay requirement D.
- C_{DEB} represents the cost factor per unit of deterministic effective bandwidth.
- D'_{sd} indicates the actually served delay to traffic flow that required a delay constraint.
- $\delta_{D_{sd}}$ denotes the sensitivity according to the delay variation.
- $C_{CD}(\alpha(t))$ represents the discount tariff cost based on the deterministic effective bandwidth of traffic source $\alpha(t)$.
- $BG(t)$ denotes buffer gain at time t.
- $C_{BG}^{ij}(t)$ represents the gain cost through sharing a buffer over a virtual link between node i and j.
- $C_{RPC}(t)$ represents the reconfiguration penalty cost.
- $\alpha_{ij}^{sd}(t)$ denotes the traffic flow's arrival curve that traverses from source s to destination d passing through the virtual link i,j at time t.
- $T(t)$ is a traffic matrix, in which $T_{sd}(t)$ denotes the traffic flow from node s to node d at time t.
- $R(t)$ is a virtual topology, in which $R_{sd}(t)$ describes the lightpath that exists from node s to node d in the virtual topology at time t.
- $C(t_{disrupt})$ represents the proportional cost to the ranges of disruption time $t_{disrupt}$.
- $S_{ij}(t)$ is defined as the service-specific factor on the lightpaths between nodes i and j.

1. Formulation for QoS Guarantee and Shared Buffer

When congestion occurs on the virtual link, call requests passed through the overloaded virtual links suffer a lack of necessary resources, which leads to QoS degradation. In order to compensate for the damaged call requests, the network provider needs to discount the call requests' charges. Since the amount of the discount charge is originated from the lack of resource usage, we consider a usage-sensitive pricing scheme [8]. This charging mechanism is based on the assessment of the deterministic effective bandwidth (DEB) [9], [10].

In this paper, we consider sources that are leaky bucket constrained with an additional constraint on their peak rate. A traffic descriptor for a given source S comprises three parameters (p, R, M), which are respectively the peak rate, the mean rate, and the maximum burst size of the source. Such a source is able to pass through the leaky bucket controller that has a token rate R, a token bucket depth M, and a peak rate p. The size of the token bucket is $M' = M \times (p-R)/p$ since the peak rate of the source is finite. Our traffic management scheme is based on deterministic QoS guarantees. A given source S has thus one QoS constraint, which is its maximum end-to-end delay requirement.

$$\alpha(\tau) = \min(p\tau, R\tau + M\frac{p-R}{p}),\ \tau \geq 0 \tag{1}$$

A source is modeled through an arrival curve that represents an upper bound on the volume of traffic it can send during any time interval τ with a maximal end-to-end delay requirement. The deterministic effective bandwidth $e_D(\alpha)$ associated with a given source S and a delay requirement D, is defined as the minimum service rate that ensures to this source a delay smaller than D.

In general, usage-based charging depends on both static contracted information such as a customer's expectation regarding a service delay and the measured resource usage. The parameter C_{DEB} in (2) represents the cost factor per unit of deterministic effective bandwidth, which is determined by the network provider using a billing. Curve $\alpha_{sd}(t)$ represents the arrival curve of traffic flows at time t from source s to destination d. Delay $D_{sd}^{'}$ indicates the actually served delay to traffic flow that required delay constraint D_{sd}. Sensitivity $\delta_{D_{sd}}$ denotes the sensitivity according to the delay variation, $\delta_{D_{sd}} = \partial e_{D_{sd}}(\alpha_{sd}(t)) / \partial D_{sd}$. When the account contract is established between the network provider and user, the required QoS constraint is expected to be guaranteed, namely $D' = D$. Therefore, the account is only based on the a priori d and contracted traffic description parameters that result in $e_D(\alpha)$. However, the actually served delay D' may be different from the anticipated value D owing to the network situation such as congestion. When this QoS violation happens, the users' should not be charged as normal. The according discount should consider the difference between the experienced delay D' and the estimated delay D, and the sensitivity according to the delay variation $\delta_{D_{sd}}$. Therefore, the discount charging function per unit time based on the DEB for service i can be represented as follows.

$$C_{CD}(\alpha_{sd}(t)) = C_{DEB}\delta_{D_\alpha}(D_{sd}^{'} - D_{sd}) \tag{2}$$

When multi-traffics go out on the same wavelength at each node, we can utilize a buffer gain by sharing a buffer that is located in the optical switch. For every link we can consider the gains, which are represented as the difference of deterministic effective bandwidth, by aggregating flows into one wavelength as follows. When identical traffic sources come into a network, the buffer gain $BG(t)$ at time t can be formulated mathematically as follows.

Definition 1. When identical traffic sources come into a network, the buffer gain $BG(t)$ at time t can be defined as

$$BG(t) = \sum_{i,j} e_D(\alpha_{sd}^{i,j}(t)) - e_D \sum_{i,j}\sum_{k=0}^{W} \{\alpha_{sd,k}^{i,j}(t)\}, \tag{3}$$

where $\alpha_{sd}^{i,j}(t)$ denotes the traffic flow's arrival curve that traverses from source s to destination d passing through the virtual link i, j at time t. When multi-traffic flows get aggregated into one flow, the delay constraint of an aggregated flow should be the minimum value among all delay constraints. The first term represents the deterministic effective bandwidth before aggregation, and the second term means the deterministic effective bandwidth after aggregation.

Lemma 1. Cost gain, $C^{i,j}\left(BG(t)\right)$, through sharing a buffer over a virtual link between node i and j, can be represented as

$$\begin{aligned}C^{i,j}((BG(t)) = C_{DEB}\Bigg\{ &\sum_{s,d} e_{D_{sd}}(\alpha_{sd}^{i,j}(t)) - e_D \sum_{s,d}\sum_{k=0}^{W}(\alpha_{sd,k}^{i,j}(t)) \\ &- \frac{\partial e_D\left[\sum_{s,d}\sum_{k=0}^{W}(\alpha_{sd,k}^{i,j}(t))\right]}{\partial D}(D'-D) \\ &+ \sum_{s,d}\frac{\partial e_{D\,sd}(\alpha_{sd}^{i,j}(t))}{\partial D_{sd}}(D_{sd}^{'} - D_{sd})\Bigg\}.\end{aligned} \tag{4}$$

Proof. Buffer gain is originated from the traffic aggregation into one transmitter buffer. Therefore, we try to get the difference between the costs in the case of pre-aggregation and after-aggregation. Before the traffic flows get aggregated into one wavelength, the summation of each flow's cost is calculated as follows.

$$\begin{aligned}&\sum_{s,d} C_{sd}(\alpha_{sd}^{i,j}(t)) \\ &= C_{DEB}\left\{\sum_{s,d} e_{D_{sd}}(\alpha_{sd}^{i,j}(t)) + \sum_{s,d}\frac{\partial e_{D_{sd}}(\alpha_{sd}^{i,j}(t))}{\partial D_{sd}}(D_{sd}^{'} - D_{sd})\right\}.\end{aligned} \tag{5}$$

After the traffic flows get aggregated into one wavelength, the cost for the aggregated flows is as

$$\begin{aligned}C\left(\sum_{s,d}\alpha_{sd}^{i,j}(t)\right) = C_{DEB}\Bigg\{ &e_{D_{\min}}\sum_{s,d}\sum_{k=0}^{W}(\alpha_{sd,k}^{i,j}(t)) \\ &+ \sum_{s,d}\frac{\partial e_{D_{\min}}\left(\sum_{s,d}\sum_{k=0}^{W}(\alpha_{sd,k}^{i,j}(t))\right)}{\partial D_{\min}}(D_{\min}^{'} - D_{\min})\Bigg\}.\end{aligned} \tag{6}$$

In (6), $D_{\min}$ and $D_{\min}^{'}$ represent the actually served minimum delay and the required minimum delay constraint among multi-traffic flows, respectively.

Then, the cost gain $C^{i,j}(BG(t))$ that we can get by sharing a buffer is the difference between (5) and (6).

□

From lemma 1, we define gain function as

$$g(\cdot) = C^{i,j}(BG(t)) = C(\alpha_{sd}^{ij}(t)),$$

and it is maximized when $C^{i,j}(BG)(t))$ is the maximum value and $C\left(\alpha_{sd}^{ij}(t)\right)$ is the minimum value. The gain function is a transmission gain of a specific traffic over a logical topology. It covers two parts. One is the multiplexing buffer gain expressed as $C^{i,j}(BG)(t))$, which means the network provider does not need to use as much bandwidth as the users asked because of statistical multiplexing, so it is a reward. In the second part, $C\left(\alpha_{sd}^{ij}(t)\right)$ is the tariff charge; it is a cost, which means the network provider has to refund the users because of the violation of the QoS contracts, since the experienced delay by the user is over the contracted delay (the case when the experienced delay is less than the contracted delay will not improve the reward of the network provider).

2. Reconfiguration Scheme with a Shared Buffer Constrained Model

When link congestion occurs unexpectedly owing to the traffic rate fluctuation, we need to add a new lightpath between node *s* and node *d* to release the congestion. Here, the required lightpaths are established depending on the availability of wavelengths and transceivers. Available resources (transmitter at source node and receiver at destination node) or wavelengths to establish a new lightpath may not exist. Then, the deletion or disruption of existing lightpaths is necessary, which leads to packet loss and service outage [6], [7]. Since the traffic on the lightpaths is of the order of gigabits per second, the disruption in traffic needs to be minimized. Moreover, traffic has a different impact factor on the disruption service. Let's consider a reconfiguration problem. When a new traffic comes, of course, the current logical topology is not the optimized one. Therefore, we can calculate under current logical topology the maximized gain in (2) and (3), that is, the gain of the network provider if no reconfiguration happens, that is, $\max(g(R(t), T'(t))$ under current *R*(*t*) and new traffic $T'(t)$. Namely, it is the difference of gain before and after reconfiguration (with new topology $R'(t)$),

$$\Delta G = \max\big(g(R'(t), T'(t)) - g(R(t), T'(t))\big). \tag{7}$$

To prevent the deterioration of service quality due to the deletion of the lightpath during reconfiguration, we consider the reconfiguration penalty cost (RPC), C_{RPC}. This RPC is an inevitable damage for existing services to release network congestion by adjusting the logical topology according to the change in the traffic pattern. The impact of lightpath disruptions also varies because the carried service types are different. However, since the contracted charges and cost gain through a sharing buffer are determined statistically at the admission process, it is not easy to estimate a discount tariff cost. Our objective through reconfiguration is to minimize the RPC. We specify C_{RPC} during Δ*t*, which is similar to that defined in [7],

$$C_{RPC}(t+\Delta t) = C(t_{disrupt})\sum_{i,j} S_{ij} U(R(t) - R'(t)), \tag{8}$$

where $U(R(t) - R'(t))$ represents the number of lightpath disruptions between the nodes *i* and *j*, and *U*(*x*) is defined as *U*(*x*) = *x* (in case of *x* > 0) or 0 (*x* ≤ 0). Cost $C(t_{disrupt})$ denotes the proportional cost to the ranges of disruption time $t_{disrupt}$ [7]. The impact of lightpath disruptions also varies because the carried service types are different. The service-specific factor on the lightpath, $S_{ij}(t)$, depends on the QoS requirements in each application service. In general, the value of $C(t_{disrupt})$ depends on the lightpath disruption time that is almost fixed while the same optical equipments are used at the each node. It is difficult to manage the number of deleted lightpaths when the logical link has congestion. Therefore the main factor that can be dealt by the network manager is the service-specific cost factor on the lightpaths between the nodes *i* and *j*. Since the whole reward-cost function is more gain from the reconfiguration minus C_{RPC}, the final objective function is to maximize the following F(·).

$$F(\cdot) = \max\left[\Delta G - C(t_{disrupt})\sum_{i,j} S_{ij}(R(t), R'(t))\right]. \tag{9}$$

That means, to minimize the service damage owing to lightpath deletion, the reconfiguration process should be performed to maximize the total expected reward. To decide on a triggering instant for reconfiguration, we show the inequality from the formulation for QoS guarantee and shared buffer.

Theorem. If the cost gain of the shared buffer given in lemma 1 satisfies (9), a triggering instant for reconfiguration is given by the following inequality,

$$C(t_{disrupt})\sum_{i,j} S_{ij} U(R(t) - R'(t)) \geq \sum_{s,d}\sum_{i,j} g(\cdot). \tag{10}$$

Proof. The optimal policy for the QoS constraint network reconfiguration is to maximize the expected reward-cost function F(•) given in (9). This means that all DEB costs in a given topology should be kept for guaranteeing the QoS. Therefore, the necessary condition satisfying the requirements, from definition 1 and lemma 1, is presented as

$$\begin{aligned}
&\sum_{i,j} C_{DEB}\left\{\sum_{s,d} e_{D_{sd}}(\alpha_{sd}^{ij}(t)) - e_{D_{min}}\sum_{s,d}(\alpha_{sd}^{i,j}(t))\right\} \\
&\quad + \sum_{is,d} C_{DEB}\left\{\delta_{D_{sd}}(D'_{sd}(t) - D_{sd}(t))\right\} \\
&\quad - C(t_{disrupt})\sum_{i,j} S_{ij} U(R(t) - R'(t)) \geq 0.
\end{aligned} \tag{11}$$

From inequality (11), the reconfiguration penalty cost should be less than the summation of cost gain through sharing the buffer and the discount tariff cost owing to the unexpected lack of QoS. In other words, the summation of cost gain through sharing the buffer and the discount tariff cost is the upper bound of the reconfiguration penalty cost. Hence, the virtual topology reconfiguration should be performed so that the reconfiguration penalty cost should not exceed this upper bound. As a consequence, a network will be reconfigured when the impact of deleted lightpath,

$$C(t_{disrupt})\sum_{i,j} S_{ij}U(R(t))-R'(t)),$$

is estimated to be less than or equal to the threshold,

$$\sum_{i,j} C_{DEB}\left\{\sum_{s,d} e_{D_{sd}}(\alpha_{sd}^{ij}(t))-e_{D_{min}}\sum_{s,d}(\alpha_{sd}^{i,j}(t))\right\}$$
$$+\sum_{s,d} C_{DEB}\left\{\delta_{D_{sd}}(D_{sd}^{'}(t))-D_{sd}(t))\right\}.$$

Otherwise, no reconfiguration takes place. □

The reconfiguration scheme based on this theorem is a good policy for determining when to trigger the reconfiguration process. In section III we discuss the performance according to the proposed scheme.

III. Performance Evaluation and Discussion

To evaluate the reconfiguration scheme with a shared buffer constrained cost model, we consider a traffic source that is leaky bucket constrained with an additional constraint in its peak rate. The traffic descriptor of $T_{s,d}$ flow from s to d is (p_{sd}, R_{sd}, M_{sd}). The traffic model is randomly generated, such that a certain fraction F_r of the traffic parameters using a uniform law,

$$p_{sd}\in\left[\frac{0.9C}{\alpha},\frac{C}{\alpha}\right],\ R_{sd}\in\left[\frac{0.4C}{\alpha},\frac{0.5C}{\alpha}\right],M_{sd}\in\left[\frac{0.4C}{\alpha},\frac{0.5C}{\alpha}\right],$$

and the remaining traffic parameters are distributed over the following ranges:

$$p_{sd}\in\left[\frac{0.9C}{\alpha}\times\gamma,\frac{C}{\alpha}\times\gamma\right],\ R_{sd}\in\left[\frac{0.4C}{\alpha}\times\gamma,\frac{0.5C}{\alpha}\times\gamma\right],$$
$$M_{sd}\in\left[\frac{0.4C}{\alpha}\times\gamma,\frac{0.5C}{\alpha}\times\gamma\right],$$

based on the model used in [5], where C is the lightpath channel capacity, α is an arbitrary integer which may be 1 or greater, and γ denotes the average ratio of traffic intensities between node pairs with high traffic values and node-pairs with low traffic values. Also, let e_{sd} be the deterministic effective bandwidth of T_{sd}. We divide the traffic flows into three classes according to application service requirements. Application services such as normal WWW and file transfers have delay requirements of 200 to 300 ms, and interaction services like video or audio conferencing services need less than 100 ms. As for mission-critical services, we set the delay constraints to 50 ms. For those mission-critical services, even a short period of disruption cannot be tolerated. However, there are also many IP-based services allowing a relatively longer outage. According to [11], over 95% of services can survive a 200 ms outage. As mentioned previously, we consider the wavelength-routed networks as a network model, and we assume each lightpath is a unidirectional channel. The physical topology model for the simulation is 14-node NSFNET that has five transceivers and does not support wavelength continuity. We set the parameter values as follows: C = 1260, α = 20, γ = 10, F_r = 0.7. Since it is possible to reduce the virtual topology reconfiguration disruption time in the data plane to an order of magnitude of tens of milliseconds, as shown in those protection and restoration studies [4], the disruptive time is set to 100 ms and the lightpath disruption cost during the variation of Δt is set to 0.01 according to multiplexing gain.

We consider 50 different traffic scenarios generated from the given conditions. We assume the interval time among incoming traffic scenarios is 1 ms evenly for simplicity. Namely, the network traffic manager monitors periodically with intervals of 1 ms. For each scenario, we compare the total expected reward-cost function values of the following cases: a static network and the load threshold policy of a virtual link. The results are shown in Fig. 1.

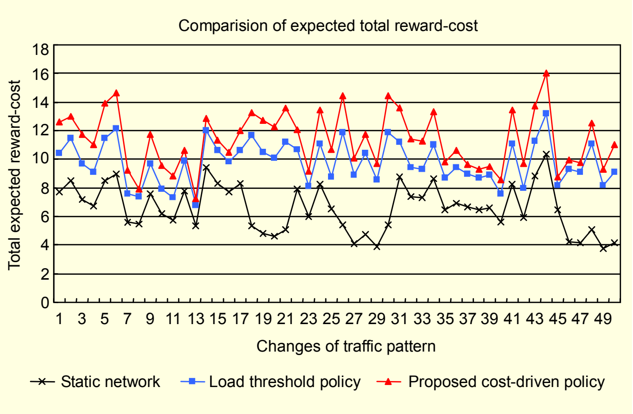

Fig. 1. Comparison of the expected reward-cost in reconfiguration policy.

To compare the policy, we limit the number of deleted lightpaths that determines the lower and higher threshold of load on the virtual link to 10 [2]. The static network means that the virtual topology reconfiguration is impossible, so that the inadequate virtual topology to a changing traffic pattern leads the discount tariff cost. When no reconfiguration is allowed, 85% of the required service flow suffers a lack of QoS constraints. For the load threshold policy using the heuristic adaptation algorithm suggested in [2], the objective is balancing a load in no relation with service requests. Our proposed scheme reconfigures the topology to guarantee the

QoS constraints in case of insufficient resources. Another reason for the existing difference of expected reward-cost is originated from the reconfiguration method.

To identify the performance comparison, we consider the deleted traffic flow's delay sensitivity to minimize the reconfiguration penalty cost. For each scenario, we compare the reconfiguration penalty cost C_{RPC} obtained by neglecting the deleted traffic flow's delay sensitivity, that is, considering only the amount of load on the lightpath. In Fig. 2, the results show that the reconfiguration penalty cost of our proposed scheme is about 18.09% lower than the conventional reconfiguration scheme on average. Thus we can recognize that our proposed policy minimizes the reconfiguration penalty cost.

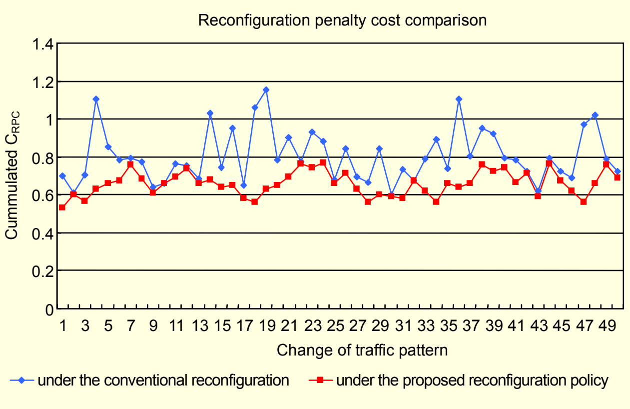

Fig. 2. Reconfiguration policy to minimize the RPC.

We obtain the results of the reconfiguration instance decision policy using buffer gain cost sensitivity. Previously, we assumed the traffic monitoring is performed every 1 ms, hence the amount of discounted tariff cost can be obtained by multiplexing with a duration time of 1 ms [8]. We compare the total expenses that a network provider should pay. As the traffic pattern has changed, the reconfiguration or tariff discount is required almost at a similar time because the congestion in the virtual link is the cause of both reconfiguration and tariff discount. The discount tariff depends on the amount of DEB shortage, that is, the overloaded degree of a lightpath, while mainly the number of overloaded virtual links affects the reconfiguration penalty cost. Therefore, if many traffic flows are close to the peak k rate (even the peakness is relatively smaller), the reconfiguration penalty cost is large. Otherwise, the discount tariff cost is larger than the reconfiguration penalty cost. This depends on the traffic characteristics. In our proposed reconfiguration mechanism, we can select the adequate policy from the reconfiguration or discount through comparing the costs to each action. Therefore, the total cumulated network expenses become much smaller. Figure 3 compares the cost performance for the optimal decision in each reconfiguration instance. As shown in this figure, the total expected cost of our proposed scheme is decreased about 10% when compared with no reconfiguration.

Additionally, we evaluate the impact of the disruption time. The results show that the expected reward-cost function values decrease, which is proportional to the increase of disruption

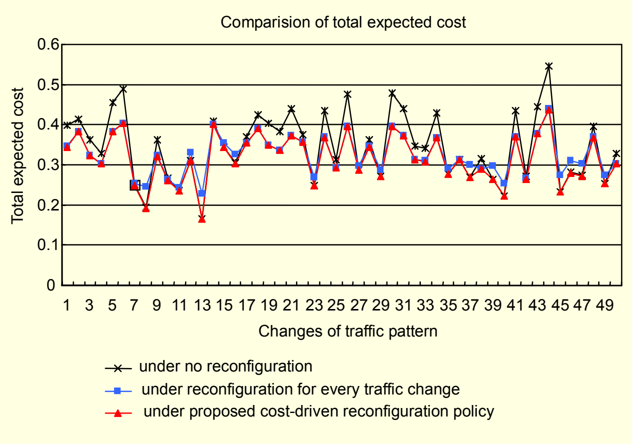

Fig. 3. Comparison of cost optimization in configuration mechanisms.

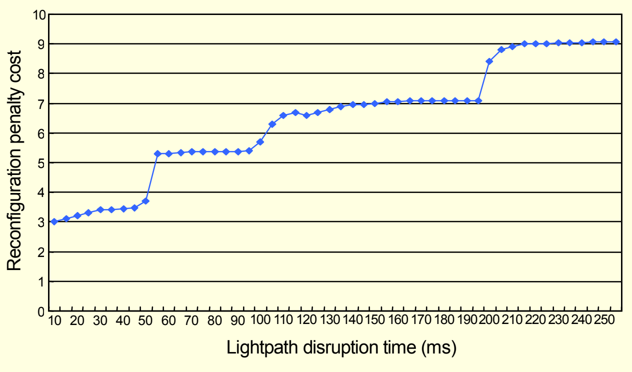

Fig. 4. RPC according to the variation of lightpath disruption time.

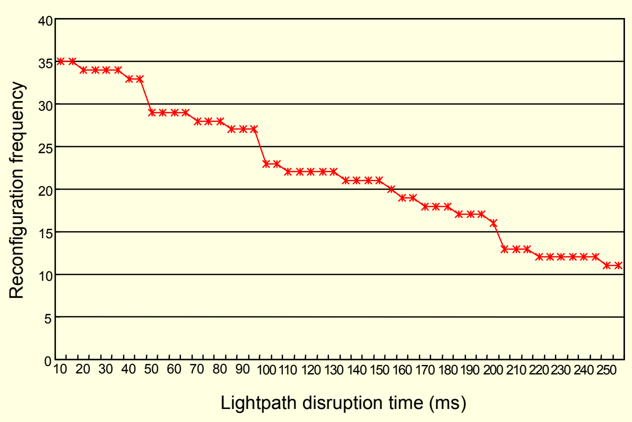

Fig. 5. Reconfiguration frequency according to the variation of lightpath disruption time.

time as depicted in Figs. 4 and 5. We get three points that show granular changes of penalty cost around 50, 100, and 200. This result gives us the relation between disruption time and delay constraints in service traffic flow. For simulation, we set the delay constraint for traffic requests as three kinds of values, such as D1 as 200 ms for WWW and normal file transfers over the Internet, D2 as 100 ms for video or audio conferencing, and D3 as 50 ms for mission critical services.

IV. Conclusion

Reconfigurability is one of the principal advantages in WDM networks. The optimality of logical topology in WDM networks is quite affected by traffic changes. We discussed the reconfiguration problem and reconfiguration policies to manage the logical topology efficiently in wavelength-routed optical networks. The objective of the reconfiguration that is carried out in response to changing traffic patterns is to improve network performance in terms of maximum throughput. However, it is not the best way for maintaining or improving the network performance to reconfigure the logical topology whenever the traffic pattern changes. Therefore, the policies regarding reconfiguration instants and reconfiguration methods are becoming important for a traffic adaptive optical network.

As a result, we propose a more practical reconfiguration scheme, regarding when the reconfiguration process should be triggered and how the reconfiguration should be performed. As an objective, we developed the expected reward-cost function with consideration of the required QoS constraints, reconfiguration penalty cost, and buffer gain cost through traffic aggregation. The proposed reconfiguration scheme with the shared buffer cost model is to maximize the derived expected reward-cost function as well as guarantee the required flow's QoS through triggering the threshold dynamically. Simulation results show that the reconfiguration with our proposed scheme outperforms the conventional ones when the traffic patterns change. Moreover, this is adaptive to the network scalability because of the computational simplicity compared with previous works.

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Chan Hyun Youn received the BS and MS degrees in electronics engineering from Kyungpook National University, Daegu, Korea, in 1981 and 1985, respectively. He also received a PhD in electrical and communications engineering from Tohoku University, Japan, in 1994. He served in the Korean Army as a Communications Officer, First Lieutenant, from 1981 to 1983. Before joining the University, from 1986 to 1997, he was a Leader of High-Speed Networking Team at Korea Telecom (KT) Telecommunications Network Research Laboratories where he had been involved in the research and development of a centralized switching maintenance system, MOVE, and HAN/B-ISDN network testbed. Especially, he was a Principal Investigator of high-speed networking projects including an ATM technical trial between KT and KDD, Japan, Asia—Pacific Information and Communications University, Daejeon, Korea. He also was a Visiting Scholar at MIT, Cambridge, USA in 2004. He is a Vice President of Grid Forum Korea. Currently, he is interested in the Grid middleware, high performance routing, multicasting, optical Internet, and network performance measurement. He was a recipient of IEICE PAACS Friendship Prize, Japan, in 1994. He is a Member of IEEE, IEICE, KICS and KISS.

Hye-won Song received the BS degree in electronic engineering from Kyungpook National University, Daegu, Korea, in 2002. She also received the MS degree in communications and networks engineering from Information and Communications University (ICU), Daejeon, in Feb. 2005. Currently, she is a PhD student in communications and networks engineering from ICU. She is interested in policy based network management, optical burst switching and network management based on autonomic computing.

Ji-Eun Keum received the BS degree in electronic engineering from Kyungpook National University, Daegu, Korea, in Feb. 2001. She also received the MS degree in communications and networks engineering from Information and Communications University (ICU), Daejeon, in Feb. 2003. Since Mar. 2003 she has been working in the Telecommunication R&D Center at Samsung Electronics Co., Ltd., Suwon, Korea in the field of 802.16e system development (2004-current) and home network standardization (2003). She is interested in 4G network communication, Wibro, and policy based network management.