A New Dynamic Multicast Traffic Grooming Algorithm in Optical Networks

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ABSTRACT

With the growing popularity of multicast applications and the gaining recognition of traffic grooming, the optimizing design with multicast traffic grooming in WDM networks becomes more and more important. Different grooming strategies require different resources, such as grooming ports, optical transceivers. In order to use the least of the current resources in the network for a multicast, a new dynamic multicast traffic grooming algorithm (DP_GA) is proposed. Firstly, a new traffic grooming discriminant is designed in DP_GA algorithm, which judged whether it is suitable for traffic grooming according to the network resource status in real time. Secondly, a formula named total routing cost is designed to select one grooming strategy from multi-hop, hybrid and extended optical tree. Compared with ADMGA algorithm, DP_GA algorithm can fully use of limited network resources and reduce request blocking rate.

INTRODUCTION

The emergence of automatic switching optical network, making optical transmission field have been rapid development. In recent years, the data traffic in optical network is increasing [1], such as network videos conferencing, tele-education, stock quotes, virtual reality games and other emerging user requirements are widely appearing, making the proportion of multicast data business gradually increased [2]. With number of optical multicast business consumed lots of network bandwidth resources, making the performance of optical networks reduced, and the congestion of business occurred. Traffic grooming is an effective way to reduce the blocking rate of business requests and improve the utilization rate of single-
wavelength bandwidth in optical network [3]. At present, existing algorithms mostly lack the study of self-adaptability, and choose the best strategy to establish the route according to the situation of current network resource [4]. More importantly reducing the blocking rate, and improving the bandwidth utilization rate will bring a lot of positive effects to improve the network economic efficiency.

**DP_GA ALGORITHM**

**Traffic Grooming Discriminant**

Whether the grooming technique is implemented determined by the discriminant, which is designed according to the remaining resources in the network, such as grooming ports, optical receivers, and optical transmitters at the nodes that the multicast request contains. A multicast request contains a source node and multiple destination nodes. The number of destination nodes in the multicast request occupies a large proportion, and it can’t be neglected. Therefore, it is meaningful to make judgment of resource status at each destination node in real time. The design of the traffic grooming discriminant is given by Eq. 1.

\[
\rho = \frac{1}{n} \left( g_s^i \frac{t_a^i}{r_a^j} + \sum_{j} g_a^j \right), \quad (i = s, j \in D) \tag{1}
\]

\(n\) is the total number of multicast request nodes. \(g_a^i\) and \(g_s^i\) is the remaining number of grooming ports at the source node and the destination nodes. \(t_a^i\) and \(r_a^j\) is the remaining number of optical transmitters and receivers at the source node and destination nodes.

The setting of grooming port threshold \(TH\) in the traffic grooming discriminant according to the method in the paper [5]. If \(\rho < TH\), indicates the number of grooming ports is too few for the multicast request at present. Traffic grooming is unsuitable to carry out, and considers to create a new optical tree to implement the multicast request. Otherwise, it means the grooming ports are adequate, so it is suitable to groom the multicast requests in the current network resource environment.

**Total Routing Cost Formula**

The total routing cost formula consists of two parts, one is the optical transceiver cost and the other one is the grooming port cost. The weight of the two can be modified in real time according to the result of the discriminant. Three kinds of grooming strategies are used to establish the multicast request. Calculate the total routing cost for each strategy, and select the strategy with least cost to achieve the multicast request.
(1) grooming port cost $g_i$ for node $i$:

$$g_i = 1 + \frac{g_i^i - g_{\text{a}}^i}{g_i^i}, \left(0 \leq g_{\text{a}}^i \leq g_i^i\right)$$  \hspace{1cm} (2)

$g_i^i$ is the total number of grooming ports for node $i$. $g_{\text{a}}^i$ is the remaining number of grooming ports for $i$.

(2) cost of optical transceiver for node $i$:

optical transmitter cost:

$$t_i = 1 + \frac{t_i^i - t_{\text{a}}^i}{t_i^i}, \left(0 \leq t_{\text{a}}^i \leq t_i^i\right)$$  \hspace{1cm} (3)

optical receiver cost:

$$r_i = 1 + \frac{r_i^i - r_{\text{a}}^i}{r_i^i}, \left(0 \leq r_{\text{a}}^i \leq r_i^i\right)$$  \hspace{1cm} (4)

$t_i^i$ is the total number of optical transmitters for node $i$, and $t_{\text{a}}^i$ is the number of available optical transmitters for node $i$. $r_i^i$ is the total number of optical receivers for node $i$, and $r_{\text{a}}^i$ is the available number of optical receivers available for node $i$.

(3) total routing cost:

$$\text{cost} = \omega_g \sum g + \omega \left(t + \sum r\right), \left(\omega + \omega_g = 1\right)$$  \hspace{1cm} (5)

$\omega_g$ is the weight of current grooming port cost, $\omega$ is the weight of current optical transceiver cost. They can be adjusted according to network resource status. Because of the different principles of different grooming strategies, different routes are established. So the total routing cost is calculated according to the actual situation.

SIMULATION

In order to compare the performance between DP_GA algorithm and ADMGA algorithm, the simulation is carried out. In the simulation, the paper uses the NSF network topology which composed of 14 nodes and 21 links. The NSF network topology is shown in Figure 1. The nodes are connected with bidirectional links, with one fiber in each direction. There is the same number of wavelengths in each fiber, and the capacity of each wavelength is same.
Figure 1. NSF network topology.

The selection of threshold has great influence on algorithm performance. Figure 2 shows that the request blocking rate of different thresholds in different load intensity. If TH is too large, the value of discriminant $\rho$ would be always smaller than TH, many new light trees would be created when new requests arrived. Otherwise, $\rho$ would be often bigger than TH, and the ports used for traffic grooming would be a scarce resource. And when TH is $1/3$, the blocking rate is lowest at the same load intensity.

![Blocking rate graph](image)

Figure 2. Blocking rate in different threshold $TH$.

It can be seen in Figure 3: Firstly, the blocking rate increases as the network load increases. Secondly, DP_GA algorithm is always less than ADMGA algorithm in the blocking rate, under a certain network load condition. It is because the required bandwidth of most multicast requests in the network is less than a whole wavelength bandwidth. When the DP_GA algorithm is adopted, the remaining bandwidth of the existing optical tree, optical path can be better used, and the blocking rate can be reduced.
Figure 3. Blocking rate indifferent load intensity.

Figure 4 compared the average request processing time in different load intensity. It shows that the average request processing time of ADMGA algorithm is less than DP_GA algorithm. That is due to establishing a multicast request, DP_GA algorithm increases the computational process, and more time is needed.

SUMMARY

In the paper, the DP_GA algorithm firstly designs a traffic grooming discriminant to determine whether the current network is suitable for the traffic grooming or creating a new light tree. The discriminant considers the use of the grooming ports and optical transceivers at the source and destination nodes. Then, the total routing cost formula is added in the selection of the grooming strategy, which makes the selection of strategy more credible. Simulation results show: compared with ADMGA algorithm, DP_GA algorithm can according to the remaining resources of the existing situation to establish business requests to adapt the change in network resources, and can effectively reduce the request blocking rate.
REFERENCES


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