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"AN EFFICIENT MATHEMATICAL MODELING FOR THE COMPREHENSIVE DESIGN OF AON INCLUDING WAVELENGTH ASSIGNMENT SCHEME"

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ABSTRACT

This paper recommends a systematic wavelength assignment scheme which deliberately enhance the quality of service by minimizing the average dispersion in optical network. In this approach assignment of the wavelength recommended that allocates the wavelength as per mathematical model based on the path length request. Results validate that path length-based scheme improves the system performance in comparison with the commonly used existing assignment technique which works on the principle of first fit wavelength assignment(FFWA) and former assignment methodology should be ideal choice when the number of connection requests extremely high.

KEYWORDS

Dispersion, RWA, WCC, lightpath.

1. INTRODUCTION

In all optical network, dispersion greatly depends upon the assigned wavelength and if the assignment of the wavelength is not appropriate it reduces the system performance to a large extent. By using several compensating techniques such as phase conjugation, dispersion compensating fiber, we generally reduce the effect of dispersion but they are costly methods. In brief dispersion means broadening or scattering of the light pulse which results the distorted signal during transmission and the effect of dispersion largely depends on the fiber length as fiber length goes on increasing, level of dispersion also enlarged. Thus the aim is to reduce the system dispersion considering expense of designed network in mind. The choice of systematic WA approach plays a comprehensive role as it directly impact the network performance. Various assignment schemes suggested but in this scenario we consider only those techniques which not requires any conversion of the wavelength approach. Many existing wavelength assignment schemes mostly used are first fit (FF) wavelength, random WA, most used as well as least used assignment schemes. The existing conclusion obtains that FFWA scheme is superior on many aspects as compare to other above-mentioned schemes. Now a days to meet the ever-increasing demand of traffic we make our network efficient enough to handle the traffic in any conditions. But with the evolution of the Internet traffic, requirement for better services have been rapidly increased. Many difficult tasks came on to the picture in order to provide services like video-conferencing,internet telephony which requires a higher bandwidth than other applications. Various queuing techniques suggested to perform quality of services and all the existing schemes utilizing buffers at intermediate nodes with stipulated buffer limit.

For any communication networks, the measure problem relates while assigning resources as buffers and providing bandwidth to various links. The restricted resources assigned depending upon type of traffic flows in order to enhance the system performance. The operation of routers can be controlled in accordance with different queuing schemes such as WFQ, FQ, Frame-based FQ and all these existing schemes comprises buffers at intermediate nodes with stipulated buffer limit. Now a days to meet the ever-increasing demand of traffic we make our network efficient enough to handle the traffic in any conditions. But with the evolution of the Internet traffic, requirement for better services have been rapidly increased. Many difficult tasks came on to the picture in order to provide services like video-conferencing, internet telephony which requires a higher bandwidth than other applications. The result obtains by using simulation tool OPNET Modeler (version 14.5) [14]. The Opnet stands for Optimum Network performance. It is a network simulation tool which consists Opnet products palette along with some additional modules such as 3D network visualize, Application Characterization Environment (ACE) and system in the loop modules which enables advanced simulations for both wired and wireless networks.

In this paper new approach based on path length has been recommended that allocate the wavelength to the requested links in accordance with the length a light travel. The outcome of suggested scheme is distinguished with the existing FFWA terminology with respect to overall dispersion. The rest paper is structured in different sections, section 2 emphasize on simulation model along with mathematical formulations, section 3 reveals the outcomes of the recommended approach and lastly section 4 gives conclusion supporting the current work describes.

2. SIMULATION MODEL ALONG WITH MATHEMATICAL FORMULATIONS

The former first fit wavelength assignment scheme works on the approach of Greedy algorithm which hungrily finds the connection keeping in mind getting the least delay from an initial topology designed. In this scheme numbering of wavelengths should be accomplish by allocating smaller number or subscript to higher priority for assigning the wavelength as per user requests. In FF, the wavelength having lowest character is allocated first to the connection requests in order to initiate the path. In any case, if the smallest symbol wavelength is not available, then network link makes an attempt to check the availability of second lowest subscript wavelength and so on. This approach does not assign the wavelength according to the path length, here assignment of wavelength should be done in accordance with highest priority given to lowest subscript as per the availability of free wavelengths.

The brief algorithm approach as below:

a. For each request generated distinguish it by source-destination (s–d pair).
b. Find out the path to route the information using the look-up table.
c. Search a free wavelength availability and assign some specific holding time to the free wavelength in order to establish the path request.
d. In case of unavailability of free wavelength during requested time, the said call request is blocked.

Secondly the proposed scheme works on another emerging algorithm known as an Evolutionary algorithm whose primary responsibility is to make the best use of network resources in such a way so that it minimises the average delay of an optical network. In order to fulfil that it uses both hybrid routing as well as WA strategy to simulate the initial topology and works on the said approach to design the final topology. Here the allocation of wavelength should be performed according to path length rather than to assign on the basis of first free wavelength available. In the path length based approach, allocation of wavelengths as per accordance with the wavelengths having higher dispersion are designated to the shortest path link requests and vice-versa. This proposal elevates network performance like reducing the overall dispersion. So here describing one simple approach by defining two sets of wavelengths:

In first set, there is an availability of all the available wavelengths and in second set, only few higher subscript wavelengths are available. Let's assume that there is an availability of 6 wavelengths in WDM network then

set 1= (λj), where value of j= 1 : 6
set 2= (λk), where value of k= 5 : 6

The second set wavelengths generally used when the path requests having longer distance will come, all the shortest distance requests will be served by set one. Now the challenge is to categorized the requests, whether it’s come for shortest lightpath distance or for longest lightpath distance. So we opted one threshold path length based on some mathematical analytics and all the request with distance ≤ to Z (where Z is threshold distance) acted as shortest distance requests and the path requests with path length > Z acted as longest distance requests. For extracting the value of Z, specific mathematical computation performed for all possible s-d pairs including their path length.

The brief algorithm approach as below:

a. For every request established distinct it by source destination pair.
b. Search out the exact path distance for the given request for different pair.
c. If the requested distance is ≤ to Z, then allocation of wavelength should be done based on FFW approach from set 1 wavelengths.

(i) Then search a free wavelength availability from set 1 and assign some specific holding time to the free wavelength in order to establish the path request.

(ii) In case of unavailability of any free wavelength during requested time, the said call request is blocked.

d. If path length is greater than Z

(i) Then again search a free wavelength availability from set 2 and assign some specific holding time to the free wavelength in order to establish the path request.

(ii) In case of unavailability of any free wavelength during requested time, the said call request is blocked.

The proposed path length structured WA scheme *deliberately enhances the quality of service by minimizing the average dispersion in all optical network.* To accomplish our aim, the link requests allocate the wavelength in accordance with such that longer distance are allocated those wavelengths which contains lesser dispersion and those containing higher dispersion are allocated with shorter path distance but the conventional WA approach not works on the same principle as mentioned above due to which the average dispersion may increase which lowers the quality of given signal. So, if the wavelengths are allocated as per above path length-based WA strategy, the overall total dispersion can be improved to higher extent which leads to provide improved quality of service in accordance with average signal quality keeping in mind not to increase the network setup expense. The brief explanation of how to assign the wavelength is understand via the below algorithm, where K represent alternate paths and the below table defines the notations and flags which we are going to use in this paper.

Table 1 Used notations.

Notation	Meaning
N, E	Total number of nodes and total number of links or edges in the network respectively
W, L	Total number of wavelengths per fiber link and total number of links between a s–d pair
$C(s, d, t_H)$	Connection request from source s to destination d within holding time t_H
λ, Y	Wavelength and total number of wavelengths per fiber link respectively
Z	Total number of connection requests in the network
K	Total number of paths (including primary path) for a connection request $C(s, d, t_H)$
D, N_D and P_L	Dispersion in [ps/(nm km)] of an optical fiber, the total dispersion in [ps/nm] of the network and the total propagation loss in [dB] of the network respectively

TO ANALYSIZE THE COMPLEXITY OF ABOVE ALGORITHM WITH RESPECT OF TIME

To understand its complexity, flags and notations defined as above.

• The time to organize all the wavelengths as per ascending arrangement based on its dispersion is O(WlogW.E).

• Computing K number of paths, arrange them according to their foremost path distance in the descending order is O(((E+NlogN+K))·Z)+ZlogZ).

• The timeline for carry out allocated wavelength for Z connection request is O(L·W·K·Z).
Consequently average timeline needs is O(WlogW·E) + O(((E+NlogN+K))·Z)+ZlogZ) + O(L·W·K·Z).

Algorithm 1. QWA

Input: Network configuration and set of connection requests.
Output: Wavelengths assignment and total dispersion of the network.
Assumption:
(a) Connection requests $C(s, d, t_H)$ arrive to the system based on Poisson process.
(b) Each fiber link carries equal number of wavelengths and the network is without wavelength conversion capabilities.

Step 1: Arrange the wavelengths of each fiber link in the increasing order of their dispersion, estimated using Eqs. (1)–(8).
$W_1 = \left\{\lambda_1, \lambda_2, \cdots, \lambda_Y\right\} | D(\lambda_1) \leq D(\lambda_2) \leq \cdots \leq D(\lambda_Y)$
where W_1 is the ordered set of wavelengths and $D(\lambda_i)$ indicates the dispersion of the wavelength λ_i.

Step 2: Compute K number of shortest paths (including primary path) for each of the connection request using Dijkstra's algorithm and sort them in descending order of their primary path lengths.
$R = \{r_1, r_2, \cdots, r_Z\} | dis(r_1) \geq dis(r_2) \geq \cdots \geq dis(r_Z)$
where R represents the ordered set of connection requests and $dis(r_i)$ indicates the length of the shortest lightpath of connection request r_i.

Step 3: For each of the connection request in R, perform the following in the given sequence:
(a) First, try to assign a wavelength with less dispersion to the primary path.
(b) If no wavelength assignment is possible in Step 3(a), consider the alternate paths in the ascending order of their lightpath distance for assigning a wavelength (with similar constraint on dispersion like in Step 3(a)) till one alternate path is assigned a wavelength.
(c) If no wavelength assignment is possible either in Step 3(a) or Step 3(b) within t_H, the connection request is treated as blocked one. Otherwise, compute the dispersion (with the assigned wavelength) for the connection request and add this dispersion to the total dispersion of the network.
(d) Drop the connection request from the network.

3. OUTCOMES OF THE PROPOSED SCHEME

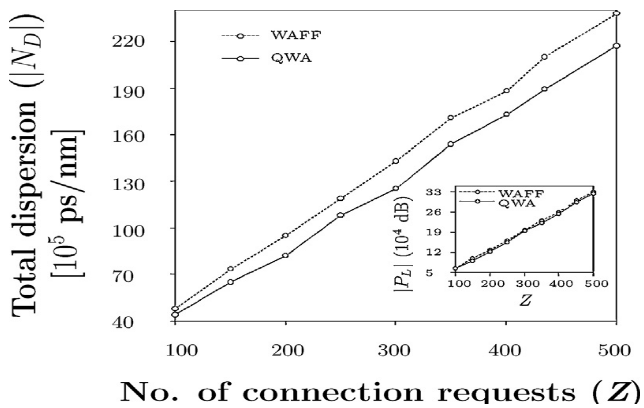
The below figure 1 shows the graph between the overall dispersion and number of link requests for the path length-based wavelength and mostly used first fit WA schemes considering the link requests in WDM network are set-up productively. This graph shows the two types of lines, the solid line pointing to overall dispersion for path length-based wavelength

assignment scheme (QWA) and the dotted line represent the total dispersion for first fit wavelength assignment scheme (WAFF) respectively. Simulation result obtains that overall dispersion increases when no. of link requests increases either in case for QWA or for WAFF schemes but the overall growth of total dispersion in case of QWA is less than that of WAFF.

Figure 1. Overall dispersion and number of link requests (small plot inside shows the behavior between propagation losses and no. of link requests).

where **WAFF**: represents the approach where wavelength assigns based on FF scheme
QWA: represents the approach where the wavelength assigns according to the path length

This is due to the fact that in case of path length-based assignment, link request consists larger distance allocate those wavelengths which contains fewer dispersion and vice-versa. The small plot inside the figure shows the behavior between the propagation loss and no. of link requests for both the approaches. It is concluded to the above plot that propagation loss for both the approach is nearly similar and it increases by increasing the link requests.



4. CONCLUSION

The consequence of the discussed scheme is analyzed through the above simulation and it's concluded that by using path length-based WA scheme, the overall dispersion of optical network reduces remarkably in comparison with most commonly used conventional first fit wavelength assignment scheme which in result enhance the service quality keeping in mind not to increase the network expense. Hence, proposed scheme is an efficient and profitable approach in most of the practical networks and the above discussed scheme would be best choice especially whenever the requests goes high.

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