

# ROUTING AND WAVELENGTH ASSIGNMENT FOR CONSTRAINT BASED OPTICAL NETWORKS USING MODIFIED DWP ALGORITHM

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## **ABSTRACT:**

*A new approach to constraint-based path selection for dynamic routing and wavelength allocation in optical networks based on Wavelength Division Multiplexing (WDM) has been proposed. The Distributed discovery wavelength path selection algorithm (DWP) proposed in the previous work takes a longer time for path selection even though it could solve some conflicting constraints imposed by electronic regenerators. The proposed work DWP algorithm has been refined and Enhanced (Modified) DWP. The proposed algorithm takes a lesser amount of time to select a path and also preserves the advantage of overcoming the conflicting constraints imposed by electronic regenerators. The effectiveness of the proposed approach has been verified through analytical and simulated results for a well known 21 node ARPANET and the approach is shown to effectively accommodate multiple constraints. Both the algorithms are compared in terms of blocking probability, convergence time and computational complexity. Results reveal that MDWP algorithm converges quickly compared to the DWP algorithm and also provide lesser blocking probability.*

**KEY WORDS :** DWP, WDM, Enhanced (Modified) DWP, Rerouting and MTV\_WR.

## **1. Introduction**

WDM optical networks have gained prime importance due to the rapid growth of internet and the ever increasing demand for voice and video transmission Harsha V Madhyastha et al (2003). Allowing several channels to be routed on the same fiber on different wavelengths, the capacity of each link is increased tremendously. Efficient planning and provisioning of light paths needs to be done to accommodate this also calls for more efficient planning before provisioning light paths. The recent advent of high bit rate IP network applications is creating the need for on demand provisioning of wavelength routed channels with service differentiated offerings within the transport layer. To fulfill these requirements different optical transport network architectures have been proposed driven by fundamental advances in WDM technologies. The availability of ultra long reach transport and all optical switching has enabled the deployment of all optical networks.

While being attractive for their transparent and cost effective operation all optical networks require accurate engineering of WDM spans to meet the requirements of dynamic wavelength routing. The additive nature of signal degradations, limited cascade ability of optical components and traffic dependent signal quality (e.g., by increasing the number of channels the physical constraints increase as well) are some of the reasons that make the provisioning of on demand wavelength channels a challenging task. To overcome the problems of analog WDM design, electronic

regeneration is deployed at optical switching nodes in the so called opaque optical networks. However electronic regeneration can also impose limitations on the wavelength routing, such as delay accumulation, connection and (network) reliability reduction and increase in the operational cost. The cost could be reduced in translucent networks where regeneration functionality is only employed in some nodes instead of at all nodes. The goal of reduction of OEO conversion and electronic switches leads to the concept of the all Optical transparent networks A.A.M.Saleh,(2000). These issues become particularly critical if service requirements force multidimensional optimization such as maximum reliability and minimum transmission degradation A. Jukan et al (2004). The question for constraint-based routing is how to account for these conflicting effects and whether the usage of electronic regeneration can be efficiently controlled. In this paper a new approach to constraint-based path selection for dynamic routing and wavelength allocation has been proposed which allows controlled usage of network elements, in particular of the electronic regenerators. We particularly focus on the impact of electronic regeneration, which is a good example to study for two fundamental reasons. First electronic regeneration is currently being widely considered as the building block for state-of-the-art optical switching nodes and will continue to be deployed in the near future. More importantly, however, they represent a class of network elements that can impose

conflicting constraints on end-to-end service guarantees. Our approach is shown to efficiently accommodate multiple conflicting routing metrics related to different services and network architectures.

The proposed method is service-centered and fully decentralized, as it uses local network state information. The rest of the paper is organized as follows, in section II we present the DWP algorithm and analyze the various advantages and disadvantages of it. In section III we have modified the DWP algorithm and propose MDWP algorithm. In section IV we analyze the blocking probability and convergence time by simulation and justify the same using analysis. In section V we finally summarize our work focusing on the need for MDWP algorithm in constraint based WDM Optical Networks.

## 2. DWP ALGORITHM

The DWP method proposed in. A. Jukan et al (2004) is capable of

1. Handling Multiple constraints without usage of weights
2. Enabling services differentiated routing and wavelength reallocation
3. Finding of multiple candidate paths among which the best one can be chosen based on routing objectives.
4. Usage of decentralized instead on centralized global network state update

The DWP Algorithm is explained using a specific architecture shown in Fig .1 and the working of the DWP Algorithm can be explained in the following 4 steps

### Advantages and Disadvantages of DWP

The DWP algorithm seen above has numerous advantages it solves the problem of

- a) Electronic Regenerators
- b) Weighted Networks
- c) Centralized Networks
- d) Demerits of Shortest Path Algorithm

Despite the above advantages it does have the following

### Disadvantages

- a) Long Time to select a Path
- b) Limited Scalability

This work on MDWP involves in reducing the time to select a path which also preserves the advantage of overcoming the conflicting constraints imposed by electronic regenerators.

## 3 ENHANCED DWP ALGORITHM

The MDWP Algorithm overcomes the disadvantages of DWP algorithm by implementing the following concepts

Predefined Routes & Dynamic wavelength

Creating Check Points at Each Node

Buffering for Future use

### Predefined Routes and Dynamic Wavelength:

The Route between the source and the destination is going to be specified in that particular source node itself but the wavelength is going to be selected dynamically. So by using this method the number of packets that reach the destination can be much reduced and thus the complexity can also be reduced. By doing so we are able to reduce the time required for the convergence of a path.

### Creating Check Points at Each Node:

Here we are going to create check points at each node, so that the packets that do not satisfy the constraints are going to be blocked from reaching the destination. This concept also reduces the time required for convergence of a path.

### Buffering for future Use:

Here if our network state is going to vary after x time units and a service between source a and destination b has taken only y time units, where  $x \gg y$ . Then immediately a service request for the same source and destination arrives it will be time consuming to select a path once again. Since the network state has not changed it is better to allocate the same path that has been used earlier

### Concept of Wavelength Rerouting:

In a wavelength routed WDM network, a light path needs to be wavelength continuous this constraint results in inefficient utilization of wavelength channels (G.Mohan et al 1996).improving channel utilization is an important problem in this type of network. Wavelength rerouting is one possible solution to this problem. .wavelength rerouting accommodates a new connection request by migrating a few existing light paths to new wavelengths while maintaining their path. In addition to this we are also going to consider only the constraints required for that particular service i.e. if a particular service have only a constraint for delay then only the delay parameter is going to be updated at each node so that the computational complexity at each node is considerably reduced.

### Wavelength rerouting

Some basic operations that can be used for migrating a light path have been presented in. K.C.Lee et al (1996).Move to vacant wavelength retuning (MTV-WR) moves a light path to a vacant wavelength on the same path. It can greatly reduce the disruption period. MTV-WR operation has advantages of both MTV and WR operations while overcoming their drawbacks. Now, we briefly explain the implementation of this operation. A central controller is used for sending control messages to set up, migrate, and release light paths. The following steps are used for light path migration C.Siva Ram Murthy et al (2002).

- 1.The controller sends control messages to the intermediate switches(routing nodes) on the path of

the rerouted light path. These messages are used to set the state of a switch such that the new wavelength is switched from an inbound link to an appropriate outbound link. Then, the source node prepares to switch data transmission from the old wavelength to the new wavelength.

2. The source node appends an end-of-transmission (EOT) control packet after the last packet on the old wavelength and holds the first packet on the new wavelength for a guard time. The EOT packet is used to inform the destination node that the data transmission via the old wavelength has ended and data will soon arrive via the new wavelength. The guard time prevents data from being lost during the transient period of light path migration.

3. The source node tunes its transmitter to the new wavelength and, after the end of the guard time, starts transmission via the new wavelength. Upon detecting the EOT packet, the destination node tunes its receiver to the new wavelength and becomes ready for receiving data via the new wavelength.

Rerouting and minimization of incurred disruption due to rerouting in a wide area all optical wavelength division multiplexed (WDM) network with random circuit arrivals and departures. One limitation of such a network is the wavelength constraint imposed by the all-optical cross-connect switches which do not allow a circuit to be placed on a no wavelength-continuous route. Wavelength rerouting is proposed to rearrange certain existing circuits to create a wavelength-continuous route in order to accommodate a new circuit. To reduce the disruption period, move-to-vacant wavelength rerouting (MTV\_WR) is used as the basic operation of circuit migration. (Siva Ram Murthy et al (2002)), and K.C.Lee et al (1996) in which a circuit is moved to a vacant wavelength on the same path, and parallel MTV\_WR rerouting is used to reroute multiple circuits.

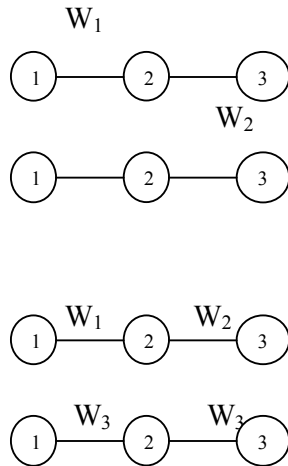


Figure 1 An Example Showing the Benefit of Wavelength Rerouting

Scheme used is MTV\_WR

- Guard time depends on three factors
- The switching time of optical Tx and Rx
- The processing time of detecting the End-of-transmission at destination

The differential propagation delay of two wavelength  $W_2$  and  $W_3$ .

#### 4 BLOCKING PROBABILITY ANALYSIS

There are few assumptions considered we have considered while analyzing the blocking probability Milan Kovacevič et al (1996)

1. Each circuit connection uses entire wavelength channel.
2. Each link has same number of wavelength.
3. Each node has one transmitter and one receiver per wavelength.
4. Connection arrivals have Poisson distribution.
5. The average duration of the holding time is exponentially distributed.

6. Wavelength continuity constraint is considered in a light path. This means that requests may be rejected even because of the non availability of the same wavelength at all fiber links leading to higher blocking probabilities

In this model  $P_k(i)$  denotes the blocking probability that  $K$  wavelengths are used on the  $i^{\text{th}}$  link of the path [.

$$P_k^{(i)} = \frac{L_i^k / k!}{\sum_{l=0}^{W-1} L_i^l / l!}$$

Let  $q_k(n)$  denote probability that there are  $k$  busy wavelengths over the first  $n$  links of the path then we know that  $q_k(1) = P_k(1)$

Let  $n_a, n_b$  denote the number of free wavelength in link  $a$  and  $b$  the probability that  $k$  wavelengths are available for the connection is equal to the probability that  $k$  wavelengths are free on both the links.  $R(k / n_a, n_b)$  denotes the conditional probability that  $k$  wavelengths are available for the connection. Now  $k$  can take only the values between  $n_a + n_b - w \leq k \leq \min(n_a, n_b)$ .

$$q_k(2) = \sum_{i=0}^w \sum_{j=0}^w R(w-k-w-i, w-j) q_i(n-1) p_j(n)$$

$$p(n) = Q_w(n)$$

for the case of rerouting.

$$p(n) = 1 - \prod_{i=1}^n (1 - p_w(i))$$

## V. SIMULATION AND RESULTS

### TIME ANALYSIS OF DWP

$$\left[ \sum_{k=1}^{n1} \sum_{j=1}^{no.of\_hops} \sum_{i=1}^{no.of\_W} Pdi \right] + tr * n1 * W + pb + ps$$

- pd -> propagation delay
- tr -> processing time at the receiver
- pb -> time for back messaging
- Ps -> processing time at the source

### Time analysis of MDWP

If miss occurs in buffer

$$\left[ \sum_{k=1}^{n2} \sum_{j=1}^{no.of\_hops} \sum_{i=1}^{no.of\_W} Pdi \right] + tr * n2 * W + pb + ps + bs$$

If hit occurs in buffer:

$$Time = bs(ave) + pw + pb + ps$$

bs -> time required for search in buffer

### Convergence Time analysis

First let us consider the best case situation, here the first physical path itself is going to be the suitable path for the requested service so the number of messages that reach the destination will be  $1 * W * h$  because here we are going to use only one physical path. Similarly the number of message update is going to be  $1 * W * h$ . For the worst case the number of packets that reach the destination is going to be  $n1 * W$  because the  $n1^{th}$  path is going to be the best path. The number of message updates is going to be  $n1 * W * h$ . Finally for the average case we have the number of packets that reach the destination is  $n2 * W$  and the number of message updates is  $n2 * W * h$ . where  $n2 = (n1 + 1) / 2$  considering each path has equal probability. Thus by considering the average case we can prove that the MDWP method converges quickly compared to the DWP method is as shown Table 1.

Table 1(for Time Convergence)

No of nodes	DWP(ms)	MDWP(ms)
8	34.9	15.2
10	44.8	19.9
21	87.6	37.8

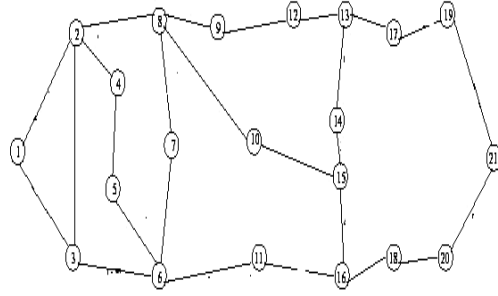


Figure 2 Analyzed Network 21 node Arpanet

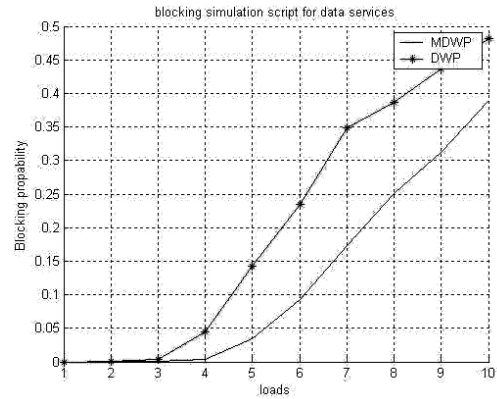


Figure 3 Simulated Result for Blocking Probability (Data services 21 node ARPANET)

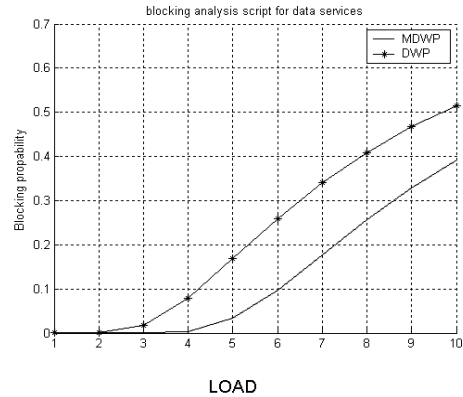


Figure 4 Analyzed Result for Blocking Probability (Data Services 21-node ARPANET)

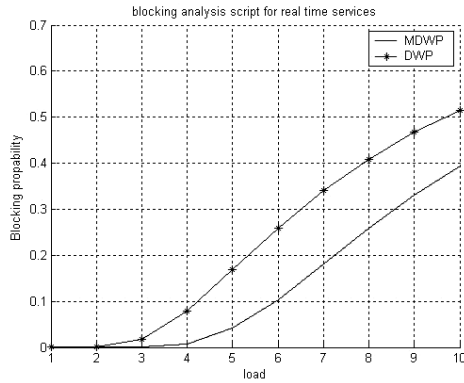


Figure 5 Analyzed result for Blocking Probability (Real time services 21 node ARPANET)

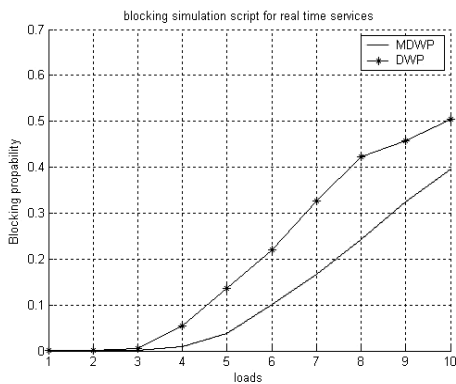


Figure 6 Simulated result for Blocking Probability (Real time services 21 node ARPANET)

### Performance Study

The simulation results show the connection request arrives according to Poisson process with call holding time being exponentially distributed. One request at a time is generated and propagated by flooding i.e. no queuing and prioritizing of the path information message. The simulated and analyzed results for the well known 21 node ARPANET have been presented in Figure 2. The service differentiated requirements imposing routing constraints are as follows:

#### Data service:

Signal degradation must be less than 90db delay must be less than 50 time units and the reliability must be greater than 60%. Harsha V Madhyastha et al (2003).

#### Real Time service

Signal degradation must be less than 60db. delay must be less than 20 time units and the reliability must be greater than 90%. Figure shows the analytical results of blocking probability for data service of 21 node ARPANET here the curve for MDWP is below the DWP as expected i.e. MDWP shows a decrease in blocking probability when compared to DWP. This reduction is mainly due to the rerouting of light paths. But some amount of reduction in blocking probability is obtained due to the first fit scheme which will be used in the MDWP

compared to the best fit used in the DWP. Figure 3 reveals the simulation results of blocking probability for the data service of 21 node ARPANET. In simulation results also it is proved that MDWP exhibits less blocking probability compared DWP and also the absolute values are close to the analyzed results which prove that our simulated results are valid. Figure 5 shows the analytical results of blocking probability for real time service of 21 node ARPANET here also we get the curve for MDWP below DWP as expected i.e. MDWP shows a decrease in blocking probability when compared to DWP. This reduction is mainly due to the rerouting of light paths. But we also get some amount in reduction blocking probability due to the first fit scheme which will be used in the MDWP compared to the best fit used in the DWP. We have done for two different service requirement to prove that our algorithm works effectively for both the scenarios. Figure 8 reveals the simulation results of blocking probability for the Real time services of 21 node ARPANET. In simulation results also it is proved that MDWP exhibits less blocking probability compared DWP and also the absolute values are close to the analyzed results which prove that our simulated results are valid. Table 1 gives the simulated results of convergence time for both the algorithm. MDWP algorithm converges much faster than DWP algorithm this is because we are going to store the different paths in memory and try to select a light path one by one and not all at once. This method reduces the time on an average. Also we get time reduction because of buffering the light path for future use and also because considering only the parameters required for the service. These concepts makes MDWP algorithm more efficient compared to DWP.

### 5 CONCLUSION AND FUTURE WORK

In this paper, we proposed a new approach to constraint based path selection for dynamic routing and wavelength allocation in optical networks based on WDM. Our approach considers service specific path quality attributes such as delay, signal degradation and reliability and uses flooding based transfer of path information messages from source to destination to find the feasible path. It is fully decentralized, as it uses local network information. We have presented the analyzed and simulated results for 21 node ARPANET for which our approach is proved to be better compared to the DWP algorithm. We have obtain the results for two different services viz data service and real time service to prove that this approach works better for different kinds of services also.

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