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WAVELENGTH ASSIGNMENT STRATEGIES IN WDM OPTICAL NETWORKS

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ABSTRACT

This paper reviews various kinds of wavelength assignment strategies used in WDM optical networks. In the present paper wavelength assignment strategies are classified on the basis of type of traffic considered.

KEYWORDS: Wavelength assignment strategy, Static wavelength assignment strategy, Dynamic wavelength assignment strategy.

INTRODUCTION

Wavelength Assignment in WDM optical networks refers to assigning network resources to traffic demand. It deals with resource allocation with the aim to either minimize the resource requirement or to reduce the blocking probability. Wavelength Assignment in WDM networks has been subjected to considerable interest for researchers and network operators. The interest concentrates on roughly two categories of settings: (i) The case of limited deployed fiber, where provisioning seeks to minimize the number of required wavelengths [1]. (ii) The case of limited number of wavelengths per fiber, where provisioning seeks to minimize the amount of required fiber[2] or to maximize accommodated traffic [3].

In WDM network there are three main constraints related with wavelength assignment: wavelength continuity constraint (WCC), distinct wavelength assignment constraint or wavelength clash constraint (DWAC) and non wavelength continuity constraint (NWCC). In WCC, a lightpath must be assigned same wavelength along the route. In DWAC two lightpaths cannot be assigned the same wavelength at a time on any fiber. In NWCC, since nodes are equipped with wavelength converters hence different wavelengths can be used on the links along the selected route [4].

CLASSIFICATION AND APPLICATION OF WAVELENGTH ASSIGNMENT STRATEGIES

Wavelength assignment problem can be categorized into two categories: static wavelength assignment problem and dynamic wavelength assignment problem. In static wavelength assignment problem the traffic considered is static in nature hence the aim is to minimize number of wavelengths used in network. For the dynamic wavelength assignment, instead of attempting to minimize the number of wavelengths here the aim is to minimize blocking probability with fixed number of available wavelengths. Random wavelength assignment, first-fit wavelength assignment, least-used wavelength assignment, most-used wavelength assignment etc. [5] is the example of dynamic or on line algorithms and can be combined with different routing schemes discussed earlier.

- Random wavelength assignment: In this strategy, a wavelength is selected randomly from the available wavelengths. The node maintains a list of free wavelengths at every instant. [6].
- First-fit wavelength assignment: This strategy is implemented by predefining an order on the wavelengths. The list of used and free wavelengths is maintained. The assignment scheme always chooses the lowest indexed wavelength from the list of free wavelengths and assigns it to the request [7].
- Most-used wavelength assignment: In this strategy, the free wavelength that is used on the greatest number of fiber links in the network is assigned to the request. If several available wavelengths share the same maximum usage, the wavelength with a specific index, for example the lowest index, is chosen.
- Least-used wavelength assignment: It is similar to the most-used wavelength strategy, but in this strategy the least used wavelength in the network is assigned. This technique is also called Spread scheme

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assignment [6]. The main purpose of this approach is to achieve a near-uniform distribution of the load over the wavelength set.

Of the above strategies, random and first-fit techniques are the most practical, as these are simple to implement. Unlike Most used and Least used they do not require global knowledge of the network. They simply depend on the state of the node at that instant and choose the wavelength from the set of free wavelengths at that output link. Most used and Least used algorithms require additional storage and are complex to implement [8].

Few heuristics viz. Min-Product, Least Loaded, MAX-SUM, Relative Capacity Loss have been proposed in the literature for multifiber networks. The goal of Min Product is to pack wavelengths into fibers, thus minimizing the number of fibers in the network. In a single-fiber network, Min-Product becomes First Fit [9]. The Least Loaded heuristic selects the wavelength that has the largest residual capacity on the most-loaded link along route. In [10], it is shown that Least Loaded outperforms Most Used and First Fit in terms of blocking probability in a multi-fiber network. MAX-SUM [11], [12] was proposed for multi-fiber networks but it can also be applied to the single-fiber case. MAX-SUM considers all possible paths (lightpaths with their pre-selected routes) in the network and attempts to maximize the remaining path capacities after lightpath establishment. It assumes that the traffic matrix (set of possible connection requests) is known in advance, and that the route for each connection is pre-selected. These requirements can be achieved since the traffic matrix is assumed to be stable for a period of time, and routes can then be computed for each potential path on the fly.

The wavelength-assignment schemes so far discussed attempt to minimize the blocking probability. However, considering that longer lightpaths have a higher probability of getting blocked than shorter paths, some schemes attempt to protect longer paths. These schemes are wavelength reservation and protecting threshold [13].

In [14] static wavelength assignment problem is solved as the Graph-coloring problem. In the graph coloring approach a Graph G = (V, E) is constructed, such that each lightpath in the system is represented by a node in graph G. There is an undirected edge between two nodes in graph G if the corresponding lightpaths pass through a common physical fiber link. Now color the nodes of the graph G such that no two adjacent nodes have the same color. This problem is NP-complete [15]. Also the minimum number of colors needed to color a graph G, (which is known as the chromatic number) is difficult to determine. If we are given a fixed number of colors then we do have efficient sequential graph-coloring algorithms, which are optimal for allocation of the given number of colors. In a sequential graph coloring approach, nodes are sequentially added to the portion of the graph already colored and new colorings are determined to include each newly adjoined vertex. At each step, the total number of colors necessary is kept to a minimum [14]. A novel approach for assigning wavelengths in multihop WDM optical networks is proposed in [16]. For a given network, they first construct its auxiliary graph and then formulate wavelength assignment as a graph coloring problem on the auxiliary graph.

In [17] authors proposed wavelength reassignment technique to improve blocking performance of the network caused by wavelength continuity constraint (WCC). In this technique, when the new call gets blocked due to wavelength continuity constraint, the already established calls or lightpaths are wavelength reassigned, so as to create a wavelength-continuous route in order to accommodate the new call. The author proposed two heuristic reassignment algorithms namely, MOLC (Minimum Overlap wavelength to Least Congested wavelength) and Random wavelength reassignment techniques. Simulation results show that proposed algorithms exhibit improved call blocking performance caused by WCC. In [18] the performance of first fit, random, most used, least used and proposed algorithm (best-fit sparse-wavelength conversion algorithm—BFSWC algorithm) is evaluated in terms of blocking probability and fairness. The result shows that the performance of first-fit algorithm is better than random algorithm whereas the proposed algorithm offers the least blocking. In the proposed algorithm sparse-wavelength conversion (wavelength converters used at a few strategic nodes) network is considered. In [19] the author proposed a path length based wavelength assignment strategies in which wavelength is assigned to the connection requests according to the path length of the connection request. One wavelength assignment technique to reduce usage of wavelengths for a bidirectional WDM ring network is proposed in [20]. The presented network model in this paper is an all-optical network. Wavelength assignment scheme with para-metric wavelength conversion is proposed in [21]. The proposed scheme minimizes the number of wavelength converters provided the number of wavelengths is given.

CONCLUSION

This paper gives detailed information about wavelength assignment strategies and their classification according to types of traffic considered in WDM optical networks.

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