IP/WDM Optical Network Testbed: Design and Implementation

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Introduction

This work presents the design and implementation of an optical transparent IP/WDM network *testbed*. The implemented software allows the characterization of the transport, control and management planes of the network. The centralized vision of the control and management planes has the purpose economy of resource and time performance.

Furthermore was developed a user network interface (UNI) for the management of an optical IP/WDM network. The interface was developed in a Web-based environment. User and command audit have being implemented for maximum control of user and security in the network. A proposal of a hybrid mechanism heuristic/evolutionary to the optimization of Routing and wavelength Assignment (RWA) static oriented survivability, based in path protection shared is too showed.

Main Stuff

The development scenery of our proposal is LabCom testbed (Laboratory of Communications - University of Brasilia -UnB) [i]. The LabCom testbed had as base the OMEGA's network - CPqD (Center of Research and Development in Telecommunications – Campinas-Brazil) [ii] with control plane distributed. The optimization of the testbed, introducing management, brought us to migrate to a centralized control plane. In this plane a hybrid mechanism heuristic/evolutionary to the optimization of RWA static oriented survivability is development. For a best interaction with the client networks was implemented a user interface (UNI) Web based [iii]. The transport plane of this testbed is simulated by software.

Transport plane: For the simulation of the physical layer three programs had been implemented to represent respectively the Transponder, Amplifier and OXC. These programs implement the connection with the system and management control through the use of socket and make use of the TCP/IP protocol.

Control plane: The centralized control plane of network was developed. In synthesis, for this case a manageable switch is used so that each three ports form a VLAN. Thus, five 100Mbps VLANs are made available by use of fifteen NICs. After this adaptation, a given switch port will concentrate the output of five VLANS for the 10Mbps control system (equal to the addition of 5 ports with 2Mbps each) in way to reproduce a network rate of 2 Mbps for each link.

For overlay model a UNI interface is defined. The routes are provisioned and protected in equal way that in the OMEGA network. The interaction between the transport and control plane follows the client/server model, through sockets TCP. This plane must provide rerouting of failed connections in the event of data plane failures [iv].

Management plane: The manage layer has a functional structure based on fail management, on the network configuration program, on performance monitoring, on log of changes and on the access security system. Two instances of the System Management

Application Entity (SMAE) exist, implemented by different process (application layer), situated at the management unit and at the agent unit [v]. Thus, we have a centralized vision of the manage process. The manage objects (OXCs. Amplifiers and Transponders) will have persisted parameters in their own information management base, that will be distributed among the manage entity and the agent in each optical element. Figure 1 presents the layout of the implemented network.

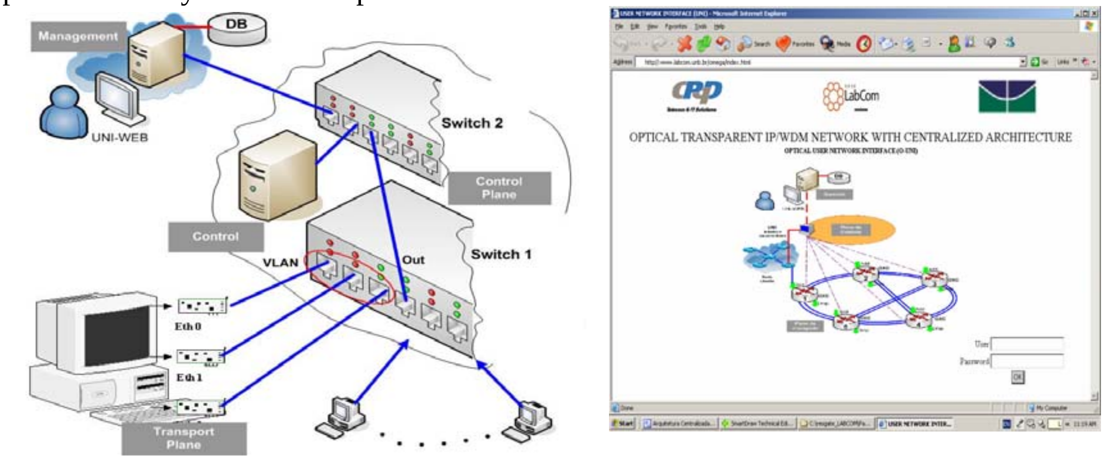

Figure 1:Layout of the implemented network and UNI-Web development.

User Network Interface (UNI Web): The routes can be graphically requested by means of the UNI-Web interface. Therefore, the computers of the LabCom Testbed, connected to the server HTTP that executes the system, can be accessed by HTTP. Thus, the proposed UNI-Web based interface facilitates the interaction of the user with the transport network, allowing an efficient and friendly operation.

Here, the customer can create or eliminate optical links, get information of the network and nodes state, of ports and switches, as well as visualizing the occupation of the wavelengths in each fiber, which petitions were not taken care of, to get administrative information, to make auditor ship of users and executed commands, among others functionalities. The Fig.1 shows the screen of the UNI-Web.

RWA-Survivability mechanism proposed: RWA is characterized as a combinational problem known as NP-complete [vi]. In networks without wavelength conversion, the lightpath have to use the same wavelength since the origin until the destiny. This is called wavelength-continuity constraint [vii][viii][ix]. These restrictions induce to an inefficient utilization of the channels and high blocked probability, so this performance degeneration is bigger to connections with more number of hops [x]. So, maximize the number of lightpaths established; subject by a restriction on the wavelength and/or number of hops at the path is the problem to be solved. Other critical challenge in the design is the survival. The optimization of the spare capacity planning to attend eventual fails is another preoccupation of this mechanism.

Will be assumed the possibility of a unique fault occurrence in a certain time interval. The probability of two fails happens at he same time is too low [xi]. The mechanism proposed is implemented in three steps:

Heuristic Implementation

1. Is pre-established a group of work route for each pair source-destiny, which will be used the modified ***Dijkstra algorithm.***

2. For each work route will be looked for disjoint routes that will form the protection routes group. In spite of this will be used a search path algorithm protection based in **search trees *n-arys***.

A protection routes group, for a work route, is a candidate routes group disjoint of the work route. For the work routes, the candidate's routes will be lesser number hops. Otherwise, for the protection routes the treatment is different, because intend to reduce bandwidth redundancy by optimizing the sharing at protection route. So, the routes are selected based in its shared capacity before latency restrictions. The capacity of be ably to share links with protection routes will be the objective.

Genetic Algorithm Implementation

At the problematic approached in this work, the mathematical methods based in ILP involves a high process period to obtain a great solution. An approximation based on genetic algorithms is proposed. Good results can be obtained by the use of the GAs, also when the problem to be solved is NP-Completed, or non-linear.

The concept of SRLG (Shared Risk Link Groups) is relevant here. This is defined as link groups which share the same network component, whose fail will endanger the entire group link [xii]. Protection paths can share links if and only if its correspondents work routes being in different SRLGs.

New Heuristic to Wavelength Assignment

Wavelength can be always allocated when two primary paths do not use the same lambda at the same link. Also, two or more protection paths can share the same lambda in a link if and only if its primary paths are in different SRLG. Beyond these restrictions, this new heuristic considers that the greater blocked probability corresponds to the routes with bigger quantity of hops, and these may have priority allocation. In this way, intends allocate the firsts wavelength, routes with more possibilities of sharing and with more number of hops, until satisfy all the main traffic requirements or end the network's recourse. This heuristic intends to minimize the total number of wavelength used.

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