Cost Minimization by improving Structures and Elements in All-Optical Metropolitan WDM-Networks

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Abstract

The high cost for WDM qualified components like laser transponders and optical switching matrices obstract the introduction of the configurable optical network technology. Minimization of cost can be achieved by efficient network planning with no limitation of reliability or flexibility for future upgrade.

Introduction

A promising way to cope with the fast growing data traffic in metropolitan networks is using the all optical WDM technology to build flexible, dynamically configurable networks for multiple subscriber access nodes. All optical networks work without any electrical components in the traffic paths. They benefit from data format and data rate independent transmission due to optical transparency as well as from having no packet handling, no delay queues and no packet jitter. An obstruction to introduce this technology is the high cost for WDM qualified laser transponders in the tributaries and optical switching matrices within the nodes for routing the optical pathes that carry non static traffic.
One way to save cost for switching matrices is to use one separate transponder with a unique wavelength for every traffic pattern that occurs at a tributary, regardless of the traffic patterns duty time. The expensive switching matrices are replaced by simple patch fields. As well as having no flexibility in this scenario the most number of transmitters are used and network resources are utilized with least efficieny.
We suppose to impove the network by sharing transponders and wavelengths according to their duty times, and providing an estimated amound of flexibility in the switching matrices. We developed a network planning tool that is optimized for all-optical WDM-Networks. The tool minimizes the number of installed transponders and switching matrices and generates wavelength allocation tables to utilize all network resources with maximum efficiency and least cost.

Case Study Application on a Metropolitan WDM Network

- hannover beispiel mit karten/plz,netz & zahlenwerten

Our approach consists of two separate parts that are described in the first two paragraphs: A traffic model and the simulation modules. The next paragraphs describe the simulation scenario that is used, the simulation results and future developments.

Traffic Modelling

The first part is a model for typical traffic that is based on metropolitan behaviour. In particular, such traffic is characterised on one hand by the subscribers' service and time profiles and on the other hand by the subscribers' geographic distribution over the metropolitan area. In the past, the entire relevant data traffic was generated by a few large business subscribers. In the near future this traffic will be produced in addition by private users and small business users, which subscribe to telecommunication and information services via the internet. We identified business and private users as the two potential types of subscribers. Time profiles and service use have been estimated for a standard European population in the near future, but have to be updated when communication behaviour changes. To create the subscribers' distribution we divided the metropolitan area into areas according to their postal zip code and analysed phone directories and business catalogues on CDROM that always contain the zip code area information. While private subscribers were not weighted, business companies were weighted according to the number of their employees that was provided by the business catalogues. These kinds of data are publicly available for international bigger cities. Thus the advantage of this data base is the opportunity to investigate metropolitan areas worldwide. To fit with the computing algorithms we divided the metropolitan area into squares of equal size. All these traffic informations are combined and spread over the area by generating a „service subscriber activity profile“ for every single cluster.
In the traffic modelling the activity profiles are accumulated in order to generate a set of traffic patterns for every single access node. A traffic pattern contains all relevant information for traffic between two nodes A and B: the A-node identifier, the B-node identifier, the type of service, the type of required protection, the ratio of forward and reverse traffic and an flexible time profile with absolute traffic amounts in Gbit/s. This set of traffic patterns between metro nodes only describes intra metropolitan traffic. To consider traffic entering the metropolitan area from the outside and the source traffic generated within the metropolitan area with external destination we extended the traffic model by nodes that have traffic entrance and traffic exit functions. Thus, internetwork connections are considered with the same structure of traffic patterns.

Network Simulation

The second part covers the simulation modules that can use the previously generated traffic patterns as well as patterns that were manually edited for test purposes or were derived from customer requirements. Furthermore, a description of the network topology with nodes, links and a network routing table can be selected from a library to create the computing network model. By using the same metropolitan traffic-pattern on different topologies or different routing schemes we can compare alternative topologies to the classical WDM ring structure. The time-driven simulation maps the traffic pattern to the optical paths by occupying as many parallel wavelengths as the desired traffic amount needs at this point in simulation time. All wavelengths have the same transport capacity which is adjusted by a global simulation parameter. A 1+1 protection is considered by occupying a second path between two nodes. For each node conjunction two link entries exist in the routing table, one for the working path and one for the protection path. Thus, the simulation tool allows to maintain disjoint protection and working paths.

Our first simulation scenario is based on a static network topology with a static routing table. The allocation of the physical wavelength to the optical paths is flexible and is changed during the computing process. While loading the traffic to the paths of the network, the internal wavelength assignment tables recognize wavelength collisions. If no collision is detected for a specific wavelength configuration, the switching profiles for all optical switching matrices are computed in order to derive the effort required in terms of switching capability and the ratio of fixed and flexible optical pathes. To find improved configuration schemes we set-up the wavelength assignment tables using a linear as well as a random scheme. A future goal of the research work is to reduce the simulation time. For this purpose, we will have to find schematic or optimisation algorithms.

Wavelength allocation

- rekursive permutation, kollisionscheck

An interesting result form the simulations is the relation between the amount of expensive transponders in the tributaries that can be saved and the associated increase in costs for switching the optical paths, all within one selected configuration. Moreover, we expect to obtain statistics for the optical paths like used path lengths and the number of passed nodes that degrade the signal quality by inserting filter and switching elements into the optical path. The results shall be included in the fin paper.

Conclusions

Future developments will lead to a module that is able to simulate error situations where the routes are switched to the protection paths. The goal is to evaluate the effects on other traffic in the network. The object oriented network model supports the implementation of an error generator for complete fiber bundles. This is possible because the model distinguishes between optical paths, links, fibres, channels and ducts where several fibres can be installed. We also have to find out which particular actions contribute to the costs of the nodes reconfiguration capability, in addition to the ratio of fixed and flexible paths through a node’s switching matrix. Potential candidates are the frequency of switching with or without consideration of management interaction.

Acknowledgements:

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