Proposta de Algoritmo de Posicionamento de Divisor de Potência Ótica para Redes GPON

Proposal for an Algorithm for Positioning of Splitter Optical Power to Networks GPON

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RESUMO
O objetivo deste trabalho é desenvolver um método para otimizar o processo de planejamento e / ou projeto de redes GPON, dentro do recomendado pelos padrões ITU-T G.984.x.. GPON (Gigabit Passive Optical Network) para redes gigabit fibra óptica passiva. Um algoritmo para otimização destes será oferecido a partir da melhor solução para o posicionamento de separadores ópticos (divisores) e a formação de PONs. O algoritmo proposto considerará aspectos como: (i) os níveis de congestionamento de todas as PONs; (ii) o ordenamento das ONUs pertencentes a divisor congestionado e sua maior distância entre o divisor e o candidato à realocação; e (iii) o reposicionamento das ONUs.

Palavras-chave: Redes de planejamento, Redes ópticas, Redes GPON.

ABSTRACT
The objective of this work is to develop a method to optimize the process of planning and / or design of GPON networks, within recommended by ITU-T G.984.x.. GPON (Gigabit Passive Optical Network) standards for gigabit networks passive optical fiber. An algorithm for optimization of these will be offered from the best solution for the positioning of optical separators (splitters) and the formation of PONs. The proposed algorithm will consider aspects such as: (i) the levels of congestion of all PONs; (ii) the
ordering of ONUs belonging to congested splitter and its closest distance between the splitter and candidate for relocation; and (iii) the repositioning of ONUs.

**Keywords:** Planning Networks, Optical Networks, GPON Networks.

1 INTRODUCTION

The proposed optimization algorithm for optimal planning of GPON networks [1], from the positioning of optical power tabs. It takes into account aspects where each PON is formed by a single splitter, using as a metric to determine link cost, control of the maximum level of optical splitting and the use of the total length of fiber-optic links. However, the proposed algorithm is an improvement of the work described in [2], therefore presented a much more efficient heuristic to optimize the GPON network.

In summary the proposed algorithm aims to determine the optimum position of the optical separators power and OLT in order to minimize the costs of deployment of a GPON network of metropolitan dimensions.

The formulation of the problem of the representation of GPON networks from the graph theory, which can thus optimize the positioning of the power dividers (splitters), identifying the best separation rate into account the shortest distance between the ONUs in the same PON. This representation will use as absolute value of magnitude and measure the distances of existing optical links between the OLT and several ONUs so that we can determine the total costs of the project. We chose to use the magnitudes of optical links as the best reference for determination and optimization of these costs.

Since the distance of each optical fiber used in the targeting infrastructure for interconnecting the ONUs between the central distribution CO forming the PONs becomes the most significant costs in a representation of Network Design GPON.

2 CHARACTERISTICS OF PON NETWORKS AND OPTICAL POWER SPLITTERS

PON (Passive Optical Network) networks are networks with point-multi-point topologies, used in network architecture, considered last mile. It consists of optical line channel between the service provider and the numerous optical network units [3], [4]. The PON network is a way to bring the fiber as close as possible to the end user. In figure 2.4 we have a basic structure of the PON networks.
The topology of a PON network, Fig. 1, based on a tree, forms a point-to-multipoint scheme, where it connects to OLT (Optical Line Termination), which is located at the Central Local or CO (Center Office), with the ONUs terminals (Optical Network Units). Two differentiations are applied, by the IEEE ONT (Optical Network Termination) and by the ITU-T the ODN (Optical Distribution Network) [5], [6].

**SPLITTER** - passive optical splitter is responsible for dividing the power of the optical signal. It is a passive component, without the need for a power supply.

They have three or more ports, positioned between the OLT connection with the various ONUs along the PON network. Point-to-multi-point connectivity between OLT and multiple ONUs is achieved through one or more passive branching devices in the fiber path [7].

In Fig. 2, we have the example of a splitter, with the representation of M input and N outputs.

In PON networks, the values of the optical splitters are in the ratio of an input port to X output port, where X = 2, 4, 8, 16, 32, 64, 128.
The Splitter is a bidirectional optical divider, where the optical signal is attenuated by the same amount of losses in both directions [8].

The architecture of the optical division depends on the geographic location of the customers in the external plant. From a management point of view, the cost of managing multiple splitters is greater than the use of a single optical splitter. In Fig. 3, there are the representations by power division. Being (a) the representation of the division in a single stage, and (b) the cascade representation, thus achieving a greater relationship in the use of the optical division. However, for each subdivision there is a loss of power, impairing the reach between the OLT and the UNs. In (c), we have the most extreme representation of the use of power dividers, where the ONUs is connected along the way in a 1: 2 ratio.

In PON networks, when the optical division rate is higher, the existing cost in the plant for the OLT will be subdivided among all the ONUs. However, this power division directly affects transmission rates, where the ideal loss for a 1: N rate is given in dB. In the case of using high division rates, there is a need for transmitters with higher power and high sensitivity receivers. Some studies point out that the ideal division ratio is around 1:40, this ratio of the optical division is directly linked to the bandwidth of each UN. The higher the split rate, the lower the bandwidth dedicated to each customer or ONUs.

Currently, the transmission power is directly linked to the limitation of the laser technologies used and to the safety requirements standardized by the regulatory authorities.
3 CLUSTERING

As in treated problem [8], the GPON network will be divided into PONs with a unique level of optical splitter. Thus, the problem is to determine which PON each ONU will belong. The ONUs grouping process in PONs is done by clustering.

The clustering techniques in this case are to analyze the information generated from the location map to a distribution of different points of users on a PON network, sorts them into groups (clusters). Grouping data is a special type of unique classification, where each point belongs to exactly one cluster. It is the unsupervised type (intrinsic), as it uses the proximity matrix, without the need for any prior knowledge on the classification of points. This process is in its formation partitional type, which occurs by attaching points in group / cluster [8].

An initial solution to the problem of clustering can be performed using classical algorithms such as k-means [4], [9] and using the distance between the ONUs as similarity metric. The optical splitter for each PON can be determined as the geometric mean of the ONUs which have the property to minimize the total distance between the splitter and the ONUs [10]. However, this approach does not result in optimum results, since it does not find the level optical split in each PON, which is dependent on the amount of ONUs connected to the same splitter. Additionally, the distance between the OLT and the splitters must also be optimized. Thus, the proposed algorithm uses a heuristic approach where ONUs is distributed and relocated iteratively in clusters. In addition to these features the algorithm will have other important features for its operation to be a heuristic algorithm that deals with the transformation of a clustering problem in an optimization problem and requires convergence criteria are established to avoid local minimum solutions [8], [10].

In the proposed algorithm, the grouping of ONUs in PONs is done using k-mean algorithm that consists of a set of n points in a parameter k as input and a set of X consisting of k points centroids (center cluster) that minimize squared error distortion $D(v, x)$ for all possible choices of X [8],[11],[13].

The position of the splitters is determined as the geometric mean of each PON, and the OLT as the geometric mean of splitters. Based on the position of splitters and OLT is done calculating the total length of optical links between the OLT and splitters, and between the splitters and ONUs.
4 HEURISTICS RE-CLUSTERING

The initial solution obtained by K-means does not take into account the highest level of optical division imposed for each PON. The re-clustering consists of moving the ONU of PON to another whenever the optical division of a PON is exceeded.

Then the position of the splitters is recalculated as the geometric mean of the new PONs, and clustering is redone connecting the ONUs in splitter that is closest to, and not through the K-Means. The resulting PONs have a new geometric mean, and this process can be repeated iteratively generating many different solutions to the problem. The best solution found during these iterations is considered the solution of the problem.

5 PROPOSED ALGORITHM

The Proposed Algorithm part of a random input ONUs, allocated on a Cartesian plane, identified by their geometric positions. The algorithm determines the position and type of each splitter, identifies how the ONUs are connected to each Splitter and calculates the total cost of the network.

For both the proposed algorithm, it uses a finite number of iterations to verify a minimum and a maximum of links that may have a splitter from smaller or larger split ratio. This process generates a set of interactions the algorithm resets splitters network using the geometric mean, defines the connection UN proximity, forming clusters. Thereby determining the network costs in the number of interactions.

The main difference between the proposed algorithm and the one presented in [2] is in the ONUs repositioning heuristics. While [2] adopts a pseudo-random process to reposition the ONUs in the PONs, the algorithm uses a strategy based on the ranking made by repositioning away. Note that a UN move of a PON to another can result in very long optical links, the UN selected to be repositioned do not have a good workaround. Thus, according to the proposed strategy, the UN selected to be repositioned is one that will represent the least impact in terms of cost of relocation. The method is defined as follows:

a) Determine the congestion level of all PONs
b) Require all according to the following criteria ONUs:
   1) UN belonging to more congested splitter
   2) Distance between the UN and the second closest splitter (ie the relocation candidate).
c) Repositioning the ONUs according to the above criteria until no PON has exceeded its maximum level of division.
Proposed algorithm

1. NP {} #list of the positions of ONUs
2. SP {} #list of the positions of Splitters
3. OLT {} List of OLT positions
4. Position the Splitters Randomly network
5. For each UN KNIFE
   6. Determine (position) of Splitters
   7. Determine (distance) between the ONUs and Splitters
   8. Determine (Position) OLT
   9. Return (size) of fiber in meters
10. End For
11. Determine the number of ONUs by Splitter
12. Start Leasing of clusters (k-means) {
   13. ONUs are grouped by distance
   14. Splitter each has its position defined by the geometric mean of the positions in the same PON
   15. the OLT position is defined from the geometric mean of the positions of Splitters
   16. Determines network costs
17. }
18. Start the best solution {
   19. Best Solution ← {SP, OLT, {}, costs}
20. }
21. Re-clustering {
   22. Reposition the splitters in the PON
   23. Notes the convergence within the Best Solution
   24. If Exist two consecutive solutions at the same cost
   25. Converge as Best Solution
26. }
27. Returns Best Solution Found
28. End

6 RESULTS

The proposed algorithm gains compared to the literature [2], [8], [12] are related to the performance of the algorithm, in obtaining the best solution to the computational placement of optical spacers.

For applying the steps of the proposed algorithm, we start with a scenario with 500 ONUs and these randomly generated, and processes being applied 100 times to get the best deal of the generated optimization problem to meet all ONUs in the lowest possible cost. Since these costs directly linked to the design of optical links that connect all PONs.

Registration of input data:

Number of ONUs {500}
Each position of UN Randomly Generated {}
Number of kluster {?? }
Capacity of each cluster $C \times \{K\}$, where $C \{2, 4, 8, 16, 32, 64\}$

Maximum Interactions $\{100\}$

For this initial training of eight clusters was adopted, however the best solution for cost optimization was met by the proposed algorithm for training 22 clusters.
7 CONCLUSION

The Proposed algorithm, as well as seeks to minimize the costs of planning a GPON network. However we treat the total cost from the summation of all the optical links forming the PONs, since the latter, according to the best optical split ratio that meets the demands of all ONUs.

The proposal deals with the problem of determining the best optical division ratio from the provisions of PONs using for this purpose two known algorithms such as Fermat-Weber location problem and Weiszfeld algorithm for the location a single center for the Fermat-Weber problem.

The algorithm differs from used in the formation of clusters from K-means is a simple iterative method for dividing a data set into a number of groups according to specific need.
The algorithm has the Euclidean distance that of the default proximity measure used, which easily shows that the function of existing costs will always decrease from each iteration of the algorithm to find the best solution.
REFERENCES


