Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 56 (2015) 363 – 368

Procedia Computer Science

The 10th International Conference on Future Networks and Communications (FNC 2015)

Towards a novel optical access networks management solution: addressing general management complexity

Tiago Gonçalves*, Karolina Baras, Lina Brito

Madeira Interactive Technologies Institute, University of Madeira, Funchal 9020-105, Portugal

Abstract

Past technological advances and an increasing need to communicate have led to the creation of the current telecommunications networks. A critical part of a telecommunications network is the access network, since it must bridge the clients with the services provided, ensuring an efficient connection between them. In the last few years, both governments and organizations from several countries have adopted large fiber optics implementations in their access networks, given its broadband capabilities. However, the structure of such networks can become very complex, forcing organizations to use means that allow them to efficiently manage such complexity. Several software solutions available on the market are capable of providing management features for these networks, but the complexity of these solutions can negatively affect management, making it lengthy and error-prone. In this paper, we describe the initial development of a software solution, consisting of a set of integrated tools that will make optical access networks management more efficient by addressing the complexity limitations of the current solutions. One of the tools, presented in this paper, was tested with a local ISP (Internet Service Provider) and showed to be capable of overcoming the limitations faced by the organization on managing their optical access network.

Peer-review under responsibility of the Conference Program Chairs

Keywords: Operation Support Systems; Network Inventory Management; Optical Access Networks; Fiber Optics; Web based Services

* Tiago Gonçalves. Tel.: +351-967665342 .
E-mail address: 2038209@student.uma.pt

Peer-review under responsibility of the Conference Program Chairs
doi:10.1016/j.procs.2015.07.220

1. Introduction

Access networks connect clients to the services provided by specialized organizations and must not turn into bandwidth bottlenecks. Given this fact, there has been an increasing use of fiber optics in access networks[1]. Typically, these networks are expanded rapidly to meet customers' demand and are composed of massive amounts of components.

The lack of means to keep track of and manage network related information can make network operations slower and increasingly error-prone. To prevent such effects, several software solutions can be used for network management. However, these solutions support a large amount of features and information sustained by detailed models, which make them very complex to use. Consequently, management and operations supported by such solutions remain significantly lengthy and susceptible to errors.

In this paper, we present one of the tools of the *Optical Network OSS* (Operation Support System) consisting of an integrated tool set with the purpose of addressing the management needs of current and future optical access networks (OANs). The described tool is called *General Management System* (GMS) and aims to achieve more management efficiency than the software solution previously used by a local telecommunications operator. However, network management dynamics adopted by operators in general were studied in order to develop a tool that is not exclusively designed to meet the specific needs of the considered local operator. Therefore, the proposed tool provides flexibility, being applicable to any ISP. This flexibility is achieved by adopting a more comprehensively organized approach, which provides models to tackle all possible OAN architectures and supports tasks considered the most important in the scope of OANs' management. Remaining tasks and detail are excluded from the proposed solution, since they are meant to be supported by other tools of the tool set. The complete set should support generalization and organization of all management information in a more comprehensive manner than other solutions. These strategies are meant to greatly increase the management efficiency of current ISPs.

The rest of the paper is organized as follows: section II describes the problem at hand; section III analyses the state-of-the-art software solutions available on the market; in section IV the current state of the proposed solution is described; section V exposes an initial evaluation of the proposed solution in a real context and section VI presents final insights about the solution and future work perspectives.

2. Problem Description

2.1. Optical Access Networks

Current access networks over fiber optics integrate two main physical components: fiber optic cables and network points. Fiber optic cables include potential fiber groups and the fiber strands, which should both be easily identified by color or position[2]. Standards established by ANSI/TIA/EIA[3] (American National Standards Institute/ Telecommunications Industry Association/Electronic Industries Alliance), ISO/IEC (International Organization for Standardization/International Electrotechnical Commission) and EN (European Norms) recommend the usage of a color code and position numbers.

Network points within an OAN can be of 3 general types: initial distribution points, terminal points and intermediate points. Intermediate points provide flexibility in the expansion and modification of an OAN and can be classified as: splitting points or joining points. Within splitting points, the optical signal is divided, through optical branching components, from one or more input fibers to several output fibers[1,2]. Within joining points, fibers can be joined with other fibers through simple unions, which correspond to unions between two fibers, or through optical interconnection components, that allow the interconnection of fibers.

These general structural concepts of OANs consist in a refined version of existing concepts in this scope and aim to provide a clearer understanding of these systems. Network specific information regarding these concepts and their properties needs to be modeled, persisted and updated quickly and effectively, in order to support essential OAN management tasks. These tasks are mainly concerned with service fulfillment and assurance and they consist in maintaining specific OAN inventory, provisioning services to customers and managing faults[4,5]. Support for such tasks will improve the quality level of the network service for its customers. Hence, operators adopt means that aid them with the management of all the network complexity.

2.2. Managing an Optical Access Network

A local telecommunications operator adopted a simple software-based solution to support the operation and management of their OAN. That solution corresponds to *Microsoft Visio*, a general-purpose diagramming application. *Visio* was used by the operator to create network synoptic plans and joining point schematics.

A synoptic plan corresponds to a segment of the OAN, which integrates one initial distribution point, several intermediate points and several terminal points, as shown in Fig. 1.

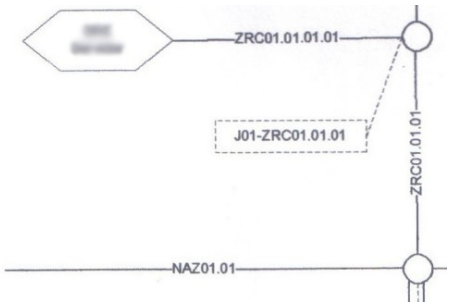

Fig. 1. Part of a network synoptic plan, maintained by the local operator.

Joining point schematics are representations of the essential elements that exist within a joining point: the cables within that point, the fiber groups, fibers, unions between fibers and the existing equipment.

The local operator's network has greatly expanded throughout the years, currently serving over 63650 customers and covering an area of 90000 habitations. Given such expansion, the need for a new management solution emerged.

In general, *Microsoft Visio* presented significant limitations in OAN management such as: The need to transfer network representations between users, which slows overall access to network data; Usability issues while managing fiber and network layout views, given that *Visio* does not provide direct support for OANs. These limitations cause slow and error-prone management that cannot allow the ISP to address customer demand efficiently.

3. State of the Art

Currently, the market presents some software solutions designed to solve the problem described previously. Through a detailed analysis of such solutions, it was possible to select the ones considered the most adequate to solve the issues in question. In the scope of OANs, these solutions present the following set of functional components: Inventory management; Operation state management; Exporting data in tabular or graphic formats. Inventory management is the most crucial component, since it is centered in provisioning processes[6]. These processes are the basis for activation and maintenance of customer service.

Further analysis of selected tools led to the identification of a set of main advantages and disadvantages, regarding OANs' management. On the one hand, the main advantages discovered correspond to: Allowing features that support management more efficiently than any other tool applicable; Providing highly detailed network representations that can potentially accelerate and detail planning tasks and narrow the time taken in operational tasks; Performing automated monitoring of network components and their operational state. On the other hand, the following disadvantages were found: The highly detailed network representations can diminish the focus over the most important properties of the networks; The large complexity of the user interface and interaction schemes; Automated network monitoring implies integration with other solutions that combine software and hardware, which can be costly and may not be viable for some organizations.

Considering the previous analysis, it is clear that these tools have limitations caused by their complexity that can still make management and operation tasks on OANs lengthy and susceptible to errors overall. Hence, based on refined structural concepts and mostly focusing essential features regarding inventory management and data exportation, we present a new approach, which attempts to improve overall efficiency using those features by

combining more comprehensive organization and generalization techniques. However, it is important to note that the described tool will be part of a complete solution and, individually, it will not guarantee more efficient support for planning, operation state management and operation tasks over the networks. Namely, features regarding operation events planning and fault localization and recovery are currently not supported in the proposed system.

4. Design & Implementation

Optical Network OSS General Management System is a web-based software product that provides a more comprehensively generalized and structured approach for OANs' management. It can also support several users with different permissions over network data, simultaneously. The system can be installed and configured on a web server running any operating system. This product includes the concept of network synoptic plans and introduces the concept of network zones. A network zone is a set of synoptic plans and aims at providing a more organized and clear view of the entire access network. The system supports synoptic and zone management so that network complexity can be more efficiently addressed. For each synoptic plan, the GMS provides the ability to manage its core components: an initial distribution point, intermediate points, fiber optic cables and termination points. All these elements are represented through vector graphics and the representations are intentionally narrowed to their semantic essence. When compared with complex representations used by other tools, we believe that this approach can, not only accelerate management and operation procedures, but also avoid operation mistakes caused by errors committed in the documentation processes of the management systems. Fig. 2 presents an example of the graphical representation of a synoptic plan that a user can build with the GMS.

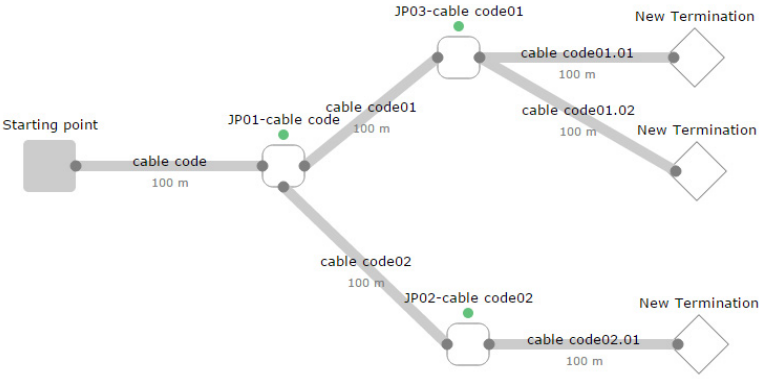

Fig. 2. Network synoptic plan created on the *General Management System*.

The proposed application also enhances the creation of component representations by allowing a contextual creation of elements (e.g.: one can quickly create an intermediate point from a cable end). This feature implies just one mouse clicking task to create each new network point. For the creation of fiber optic cables, just two or three mouse clicks per cable are required, since cables are created based on types. Cable types define a set of main properties, such as the number of fiber groups, the number of fibers per group and the cable color code. Both cable types and color codes can be created and modified in the system. In general, the contextual creation approaches were implemented to accelerate creation tasks beyond state-of-the-art solutions.

All synoptic plan components created through the system assume default identifications and additional data that can be modified at any time. In particular, contextually created cables and intermediate points receive identifications based on a schema, developed to organize these components in the representations. The application of such schema on a synoptic plan is illustrated in Fig. 2. We expect an improvement on overall inventory localization tasks with the adoption of the proposed schema.

For the intermediate points, the GMS provides interfaces to view and manage the fiber connectivity within. Fig. 3 and Fig. 4 respectively present the view and management user interfaces for intermediate point connectivity.

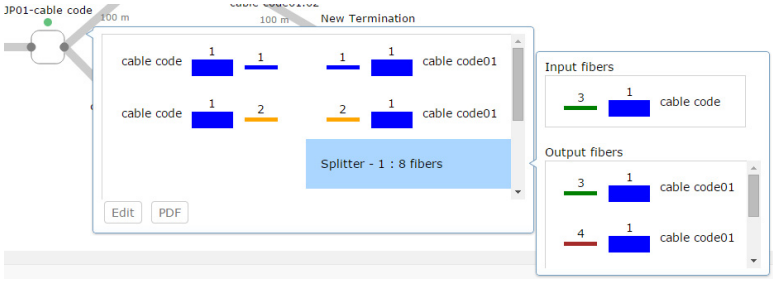

Fig. 3. View user interface for intermediate point connectivity on the *General Management System*.

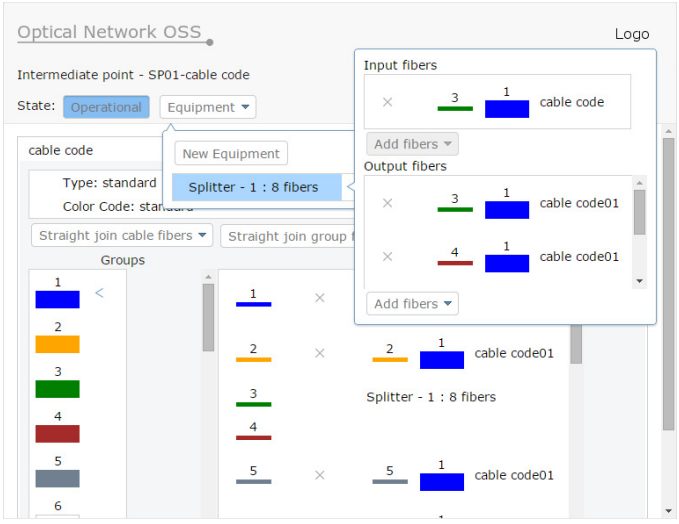

Fig. 4. Management user interface for intermediate point connectivity on the *General Management System*.

In these user interfaces, the representations for cables, groups and fibers were generalized and kept similar to the concrete elements in the network following the identification standards. The equipment representations are also generalized, focusing mostly on presenting optical signal dynamics since they impact the overall network structure. When matched with representations of previous solutions, this approach can potentially accelerate and reduce errors in the interpretation and connectivity management within intermediate points.

5. Evaluation

At the end of the development process, an initial version of the GMS was deployed by the local ISP. After approximately two months of operation, questionnaires were given to the users to obtain information that would allow both a comparison between the current system (GMS) and the previous system (*Microsoft Visio*) and an evaluation of the current system. In this study only three users were considered, since these were the only users with full management capabilities within the organization. In the questionnaires, we asked the users about their average execution times for each of the main operation support tasks using the current and previous systems. Additionally, we requested the users to rate each of those tasks, regarding their ease of execution in the new system, on a scale of 1 to 10. Table 1 presents the total averages for the provided average execution time intervals on each task through each system and the averages for the ease of execution ratings also regarding each task.

Table 1. Averages for provided average execution time intervals and ease of execution ratings.

Operation support task	Microsoft Visio	GMS	Ease of execution
Consult an optical access network synoptic plan	11 minutes 40 seconds	1 minute	8
Create an optical access network synoptic plan	2 hours	10 minutes	7.7
Track unions between fibers and between fibers and optical splitters inside an intermediate network point	25 minutes	5 minutes	8.3
Create all unions between fibers and between fibers and optical splitters inside an intermediate network point	50 minutes	5 minutes	7.3

We also requested users to provide an average number of monthly operation errors committed, having obtained a total average result of 6.3 errors, using *Visio* and of 2 errors, using the new solution.

From the previous results, it was possible to determine that the GMS reduced time on essential operation support tasks up to 91% and average monthly operation errors up to 68%. Considering this evaluation, the system was improved and enhanced to provide more efficient support.

6. Conclusion & Future Work

In this paper we described the development of the *Optical Network OSS General Management System,* a web-based software product that provides a comprehensively generalized and structured approach for OANs' management. Namely, it provides a user-friendly environment for creating and maintaining synoptic plans and network point schematics of the optical networks, defines approaches balancing similarity with reality and focus on the essential for the network representations and supports robust simultaneous execution of management tasks. We also report on the evaluation made by the local ISP that is already using the proposed tool for their OAN planning and inventory. Considering the results obtained after the deployment of the first version of this software, it can be concluded that the solution is clearly more efficient than the previous solution adopted by the local ISP. We also believe that, in its current form, the proposed solution can greatly accelerate management and reduce errors in operation and management tasks, when compared to tools currently available on the market. However, future work needs to be considered so that the entire *Optical Network OSS* tool set is conceived according to common organizational dynamics, roles and amount of responsibilities in the scope of network management. After its development, the complete solution should be evaluated against other tools, when applied to a real context. Ideally, the evaluation could consist of deploying all relevant tools in several ISPs and delivering questionnaires similar to those used in the initial study. However, this approach may bring several challenges, such as, possible costs related to software acquisition for a larger scale testing and lack of availability of ISPs personnel. A more viable approach could be to design a framework for testing the available tools based on a field study conducted in several ISPs that would provide us with the core features of OAN management software.

Acknowledgements

This project has been supported by FCT – Fundação para a Ciência e Tecnologia, within the Project Scope: UID/EEA/50009/2013.

References

1. Lopes S. Fibra Óptica na Rede de Acesso: Cenários de Evolução. (Master thesis). Universidade de Aveiro; 2011.
2. ITU Telecommunication Standardization Sector. Optical fibres, cables and systems. 2009. [Online]. Available: http://www.itu.int/dms_pub/itu-t/opb/hdb/T-HDB-OUT.10-2009-1-PDF-E.pdf. [Accessed in 23th May 2015].
3. ANSI/TIA/EIA 598-A Optical Fiber Cable Color Coding. 1995.
4. ITU Telecommunication Standardization Sector. ITU-T Recommendation M.3010. 2000. p. 17.
5. Luoma E, Frank L, Pulkkinen M. Overview of Telecom Operator Software Market. In: Tyrväinen P, Mazhelis O, editors. *Vertical Software Industry Evolution Analysis of Telecom Operator Software*. Physica-Verlag HD; 2009. p. 36.
6. Misra K. Network Inventory Management. In: *OSS for Telecom Networks An Introduction to Network Management*. Springer London; 2004. p. 134.