An Application for Geospatial Visualization of Optical Networks

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Abstract – **Optical based communicational networks have contributed for a major boost in human communications. Increasing demands have led to complex network bindings that are difficult to maintain. Here we present a system for storing, maintaining and visualization of optical based communication networks.**

Keywords – **telecommunication networks, infrastructure GIS, spatial data infrastructure, topology visualization.**

I. Introduction

Modern society is based on using different types of resources and distributing them to the users that need them. For such purposes, complex infrastructural objects have been built and connected in some manner. In modern age, information and data transfer have become a necessity. For transferring data, communication systems and networks (e.g. cable television service, wireless networks and other types of communication networks) have been developed. Usually such infrastructures have specific network topology and have tendency to change and grow. Maintaining such complex networks takes a lot of time, effort and money, especially if proper organization is missing.

For such uses, network managers make high benefits from using an application for storing and managing the huge quantity of data or each network. Additionally the use of geographic information system has proven to be of an imminent value. A whole section from geospatial computing (Spatial Data Infrastructures) is used for such purposes [1].

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II. Organizational Problems and Complexity in Modern Communication Networks

Basically, various types of communication networks can be viewed as "*a set of equipment and facilities that provide a service: the transfer of information between users located at various geographical points*" [2]. Modern communication relies on advanced equipment (routers, switches) responsible for correct data transfer and the communication media (either wired or wireless).

Entities that are responsible for developing and maintaining communication networks constantly face a challenge to satisfy user demands. Users want to use new technologies like live streaming, HDTV, video sharing, software as a service (SaaS), Voice over IP (VoIP), on-line storage and many other services, to make their jobs easier and their lives better. All of the previously mentioned technologies, for optimal work, demand more bandwidth than projected 10 years ago. Also, adding new users requires exact knowledge of the deployed infrastructure. Thus, communication providers face more pressure to scale and expand their network, in order to keep up with the demands of the customers.

Today, such challenges are mainly upon providers of cable television, public switched telephone networks (PSTNs), and internet service providers (ISPs).

Our focus is to model a system that would help communication providers, providing them with the necessary information for effective work. Our main focus is on optical based communication networks, although applying this solution to other wired communications wouldn't be a problem.

Backbone networks are the most important parts of the network. Usually they are made of optical connections, mainly because of the advantage of having more throughput, better reliability and less attenuation than standard copper or satellite communications. As all modern networks, they consist of active equipment (i.e. routers, fiber optic media converters) and passive equipment (i.e. optical splitters, patchcords, and patch panels), interconnected with optical fibers, serial or Fast Ethernet links.

A simplified diagram of such type of network (an ISP) is given in Fig. 1. ISPs have multiple connection points that are commonly connected with fiber optic links. Connection points serve either as an end office or as an interconnection point between two or more connection points. An ISP has at least one outer connection to the backbone network or another ISP. Other communication providers can have similar structure.

To ease network maintenance, systems like the one presented here, store and display important network properties. The scope of these systems is mainly about managing common problems with networks like querying the resources available at a connection point, tracing active and inactive lines, visualizing the connections, measuring performances and suggesting new deployment sites and ways of their interconnection.

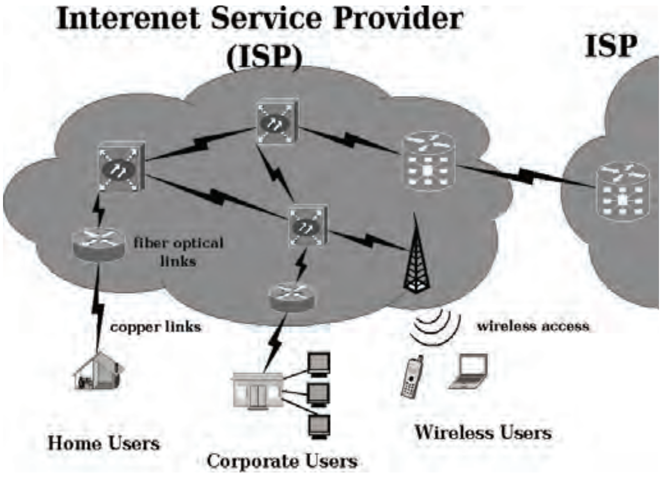

Fig. 1: Simplified diagram that shows the main parts of an ISP internal network

III. REQUIREMENTS AND SIMILAR SOLUTIONS.

As with any software development model, the basic guidelines consist of preparing the user requirements. Network engineers have been consulted for better understanding of the problems they face and possible solutions that can be implemented to resolve the problems. Here is a list of the most important features that are required to be covered:

Managing the available resources – it is required to track used and spare resources in the network. Every cable or optical fiber must be mapped and stored in the database with its according properties and spatial parameters. The ports and other resources are also mapped, so that at any time the available and used ports can be seen. Brief information of the equipment configuration can also be stored.

- **Signal tracing** - another important part is the feature to trace the signal from one point to another and measure the degradation of the signal. Special equipment is available for such purpose, so the most obvious solution is to implement a log of the performance for each link. Integration with the underlying software is a part for future development.
- **Scalability and Reconfiguration** - because the network needs to grow, it is possible that network reconfigurations will occur, introducing new connections, cutting and splicing old connections, introducing new connection points, etc. These requirements lay down serious designer questions, mostly regarding the database scalability and maintainability.
- **Maintenance and Security** – most of the personnel that use the software are the on-site network workers. Network engineers are the other users of the application. There should be a distinction in permissions, clearance and features for each category of people involved. Also, the information stored is highly confidential and security is of primary concern.
- **Topology mapping and visualization** – in order to achieve better usability, it is required to include visualization of the network topology. Accordingly, the mapping should have a graph like structure, where connection offices and connection points are represented as vertices and the links represent the edges. Also, a feature that is required is visualisation of the connection types, the slice types and visualisation of the port availability (e.g. which ports are free, to which port the specific fiber is connected)
- **Independent** – the main principle is to make the application “manufacturer independent”, but to provide common plug-in interfaces for most operations and compatibility with widespread standards.

Similar applications have been around for quite some time, and most of them are developed by telecommunication equipment manufacturers, and have features specific to the hardware (e.g. Nortel’s Network Management Software, JDSU’s ONMS & OFM-500, GRIS' Geoinformation System of Fiber-Optical Network Engineering).

IV. OUR IDEA AND IMPLEMENTATION

As mentioned, there are already developed and workable solutions that can achieve this task. If we discuss about their disadvantages, two major problems appear. First they are difficult to obtain for smaller communication providers, mainly because of the high price and they provide little or none customization for different modules. We believe that these two features should be available to communication providers so they can apply the software to their structure.

The whole application is built for web usage. The implemented application logic allows adding new resources and modifying them, concretely adding new connection points and administration centres, adding new equipment (e.g. patch panels, switches, routers, media convertors), adding new optical fibers, cutting and splicing newly created pig tails and many more. Optical links deployment and signal tracing logs are implemented, including tracing loose connections, storing signal attenuations and pinpointing broken fibers. Security is integrated as a part of the used framework and it is further implemented for granularity. Network engineers have full access to all the equipment and admin centres, assign tasks, while network workers obtain and execute tasks. Algorithms are implemented for connection point placement and calculating various measure types for the used resources [5], to ease the engineering tasks.

Known and proven technologies are being used as building blocks of our system. The whole storage engine is based on

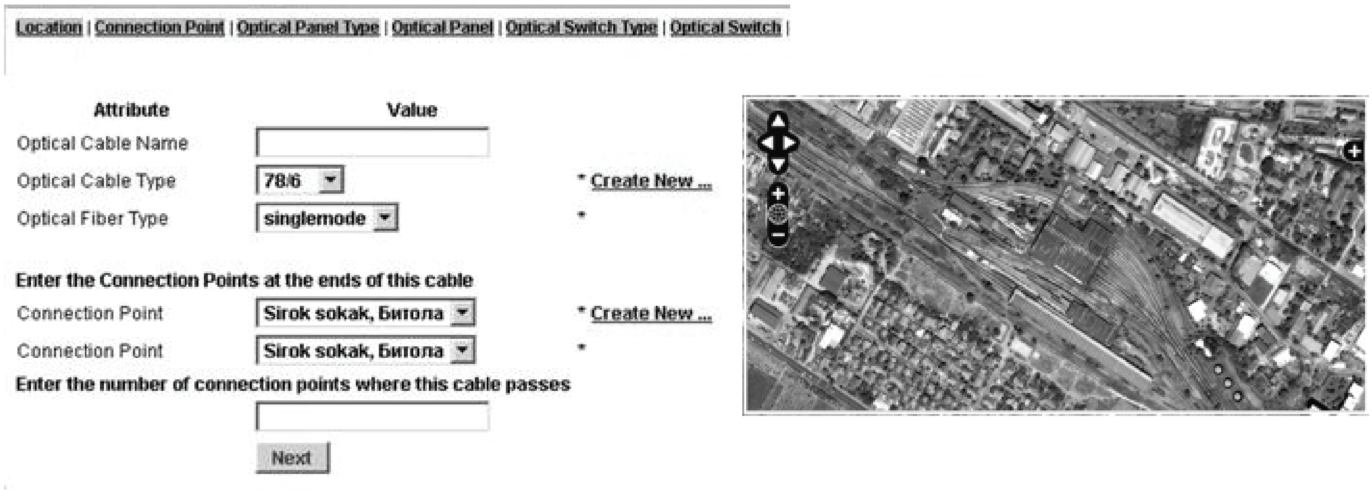

Fig 3: Early development of the web mapping

PostgreSQL and its PostGIS extension for managing spatial data. UMN Mapserver is used as support for various Open Geospatial Consortium (OGC) standards. For web interaction, Python is used for web programming (using the Django web framework) and OpenLayers is used for map manipulation (Fig. 2). More information on various platforms for GIS development can be found in [3].

The PostGIS extension allows usage of spatial database integrated queries for calculating geometric problems of proximity, adjacency and containment of spatial data. Recommendations for modeling and storing spatial data are implemented [4], according to the best practices of other spatial data infrastructure systems.

Implementation of the mapping is done via well known libraries for geographical data manipulation, and the use of Python as a language for development is because of its flexibility and good integration and usage of C and C++ libraries.

The implementation of the application is partial, with other modules besides basic functionality in plan.

The web mapping feature (at the moment of writing) is still in the development phase, but so far allows mapping of the basic resources (optical cables and connection point). Various ideas and guidelines are being implemented for the user interface design in accordance to various recommendations and experiences [6][7]. A sample screenshot of the application is given on Fig. 3.

Fig. 2: Overview of the architecture, main components and typical usage of the application

V. Evaluation and Guidelines for Further Development

As for further development, there are a lot of ideas that can be implemented. Growing networks demand implementing algorithms for suggestions for connection point placement and topology estimation, estimation of network load and prevention of network failures. Further refinement of the methods and parameters for the decision support module is planned.

Implementation issues as a typical web application are limiting user interaction, and it is considered leveraging the user interface to a RIA application. Thus, it shall include advanced AJAX and JavaScript functionalities. Other efforts of visualizing are planned for boosting the user experience. The applications can also be used for mapping non-optical communication networks or mixed optical and electrical networks, mapping wireless networks, natural resource mappings, etc. Adding support for GPS tracking is also planned.

VI. Conclusion

In this paper we introduce an application for maintaining optical networks on a regional SDI level. It faces the challenges of information storing and retrieval in a specific domain. The ideas implemented are not revolutionary, but the approach is. Open source and free technologies are used, with no need for expensive licenses from the major software vendors. Geospatial mapping is of key interest for better productivity and management, because it provides native presentation and excellent overview of the data.

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