System for Management,Visualization and Maintenance of Infrastructural Resources

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Abstract — **Infrastructural resources are very significant in the developed world. The complexity of managing such networks increases proportionally with the growth of their size. In this paper we present a system for efficient mapping, visualization and maintenance of telecommunication infrastructural resources. It tackles the problem of combining and allocating network equipment and resources.**

Keywords **- Telecommunication Networks, Infrastructure GIS, Spatial Data Infrastructure, Topology Visualization.**

I. Introduction

Telecommunication has emerged as the revolutionary technology responsible for connecting distanced places into one global connected world. For such purposes, complex infrastructural objects have been built and connected in some manner including cable television networks, ISP networks, telephone networks, etc.

The main characteristic of such infrastructures is the network topology, making the main challenge: "to cope with the tendency to change and grow". Therefore, maintaining such complex networks takes a lot of time, effort and money, especially if proper organization for efficient use of the available resources is missing.

The benefits from using geographical information systems for such tasks have been presented and confirmed in multiple instances [1]. Networks that transfer data and information are the focus of our work, thus our aim is developing a web based system that can help visualize, maintain and manage communication networks.

II. Problems in Modern Communication Surveying

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 communication media (either wired or wireless).

Satisfying growing user demands has proven to be a difficult task. Newer technologies like video and live streaming, HDTV, video sharing, software as a service (SaaS), Voice over IP (VoIP) and on-line storage (to name a few) demand constant and reliable communication links. Cable television providers, telephone networks (PSTNs), and Internet service providers (ISPs) are faced with such challenges. Furthermore, all of the previously mentioned technologies, for optimal work, demand more bandwidth than projected 10 years ago. Thus, communication providers face more pressure to scale and expand their network, in order to keep up with the demands of the customers. The geographical locations of the exponential growth of the network must be easily and precisely recorded for later maintenance and upgrades.

III. Challenges with Development of Spatial Data Infrastructures and Similar Solutions

ISPs and other communication providers rely on wired and wireless infrastructures, connecting end users with low bandwidth mediums, while connecting offices with high speed links like optical fibers and coaxial cables.

Backbone networks are the most important parts of the network. Usually they are made of optical connections, because of the advantage of having greater 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 (like optical splitters, patchcords, and patch panels), interconnected with optical fibers, serial or Fast Ethernet links.

A simplified diagram of ISP connections 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 have a similar structure.

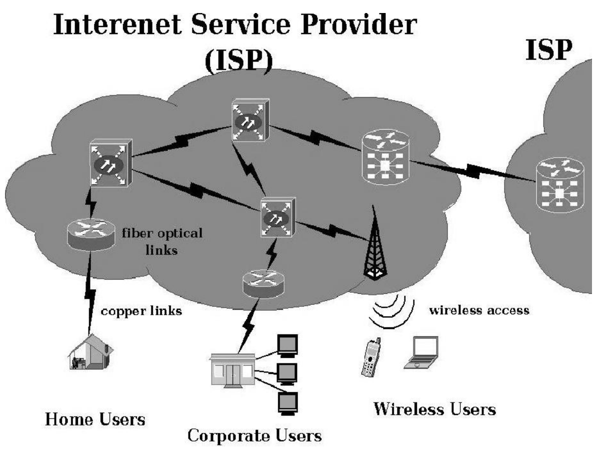

Fig. 1: Simplified diagram that shows the main parts of an ISP internal network.

To ease network maintenance, systems like the one presented here, store and display important network properties, provide various calculations and ease surveillance. The main scope of the system is about managing common problems with managing networks of such type:

- Querying the resources available at a connection point (like free fibers, unused switch ports, etc).
- Tracing lines from one connection to another, for discovering line breaks and increased attenuation.
- Visualizing the overall topology and connectivity of the infrastructure, creating coherent view for easy problem solving.
- creating a module for suggesting new deployment and reusing old underloaded links and equipment

Consultations with network engineers pointed unique features and disadvantages of other solutions. Accordingly, necessary features have been isolated in modules and most of them have been implemented in our system.

- 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 along with its properties and spatial parameters. The ports and other resources are also mapped for further analyses. Brief information of the equipment configuration can also be stored. This includes various geographical and urban constraints (buildings, mountains, previous infrastructures)
- Signal tracing - another important part is the feature to trace the signal from one point to another and measure its degradation. Special equipment is used for that purpose, so the most obvious solution is to implement a log of the measured performance for each link. Integration with the underlying software is a part for future development.
- Scalability and Reconfiguration - due to network scalability, network reconfigurations are possible, introducing new connections and connection points. These requirements lay down serious designer questions, mostly regarding 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 users 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, required features include visualization of the connection types, the slice types and visualization of the port availability (e.g. which ports are free, to which port the specific fiber is connected).
- Independency – 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). This paper introduces a light, fast system based on open source technology, aimed at providing companies with a highly customizable set of functions, easily tailored to the companies requirements, implementing customized algorithms for introducing intelligence in fiber tracing, route choice, and positioning of network resources.

IV. Implementation

The whole application is built modularly, including separate parts for web and mobile use, a data storage module, core logic module, prediction module and a visualization module (Fig. 2).

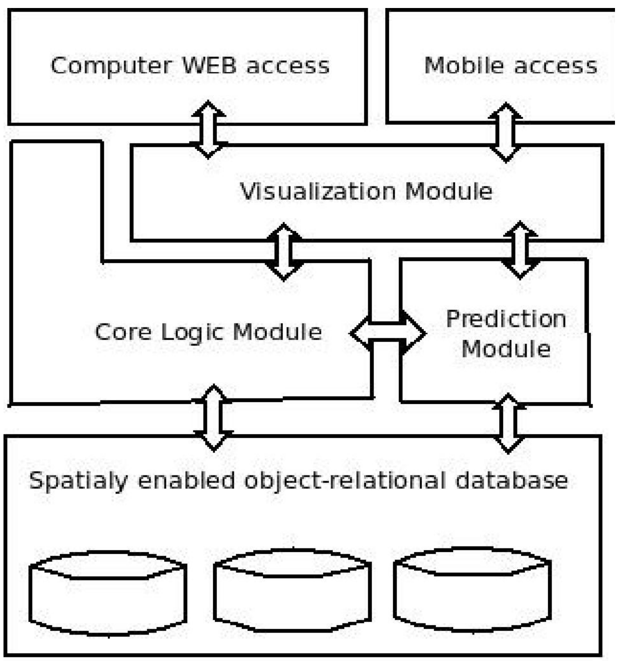

Figure 2: The modular design of the software system

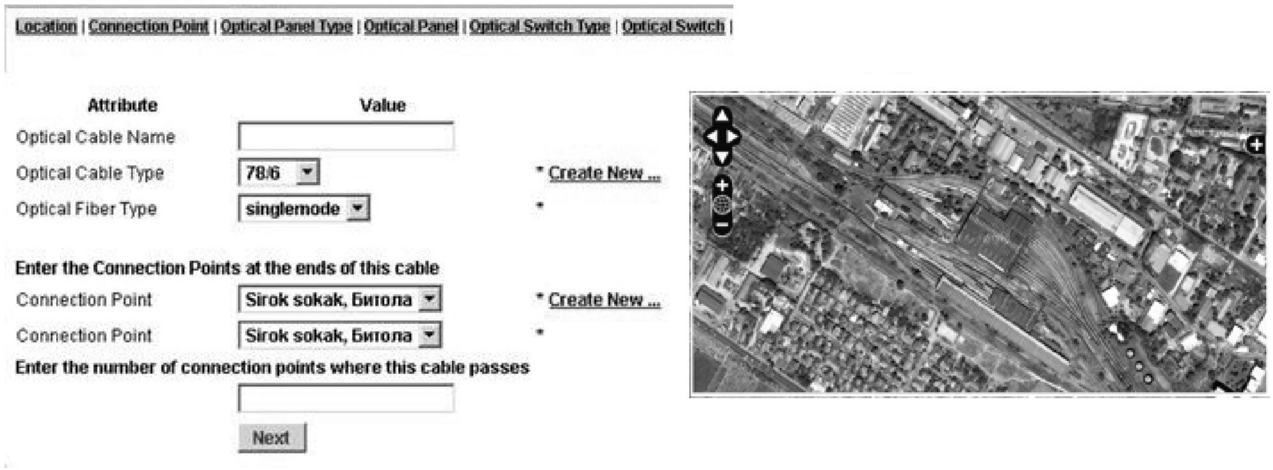

Fig. 3: Visualization and interaction is integrated in a GIS manner

The module separation provides guidelines for independence of functionalities and achieving pluggable nature. The implemented core logic module allows adding new resources and modifying them, specifically adding new connection points and administration centers, adding new equipment (e.g. patch panels, switches, routers, media converters), adding new optical fibers, cutting and splicing newly created pick tails and many more. Optical links deployment and signal tracing logs are implemented, including tracing loose connections, storing signal attenuations and pinpointing broken fibers.

The data storage module relies on scalable object-relational and spatial functionality, providing low level implementation of core functionality [3].

The visualization module is responsible for processing the data, mapping it and rendering it to the user. The rendering is done as an interactive cartographic module, providing means for user interaction besides the visualization (Fig. 3).

We have created two different user interfaces, for accessing trough smart-phones and computers. Smart-phones can have customized functionality for on-site work, including GPS tracking. Various ideas and guidelines are being implemented for the user interface design in accordance to the small size of the viewing device on the smart-phone, limited computing abilities and specific GIS requirements [4][5].

The module for prediction is of special interest. It is supposed to help network engineers make better decisions and protect the overall network and system stability. Maximum flow algorithm is used along with node and link annotations[6]. Mode research is made for improving the algorithm using other areas of graph theory (clustered graphs and dynamic graphs), system modeling and control theory [7][8][9]. Various attributes are calculated used in the calculations, mainly to prevent overload of certain parts of the network. This module is still under heavy development in order to satisfy the requirements for different topologies of networks.

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 administration centers, can assign tasks, view the topology and access the prediction module, while network workers obtain and execute tasks.

Known and proven technologies are being used as building blocks of our system. The whole storage engine is based on 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. More information on various platforms for GIS development can be found in [9].

Implementation of the mapping is done through well-known libraries (Proj4, GeOS) for geographical data manipulation. Python is used as a development language because of its flexibility and good integration with C and C++ libraries.

The simplified architecture of the whole system is shown on fig. 4. In the picture, different modules are implemented on different servers, although that is not necessary.

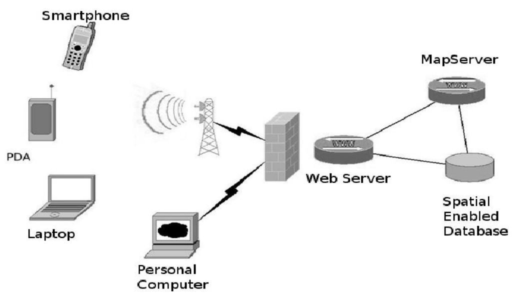

Fig. 4: Overview of the architecture, main components and typical usage of the application.

V. EVALUATION AND CONCLUSION

In this paper we introduced an application for maintaining optical networks on a regional Spatial Data Infrastructural level. It faces the challenges of information storing and retrieval in a specific domain. 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.

Similar software packages are available only commercially, and are extremely expensive, so obtaining them is very difficult. As for further development, there are a lot of ideas that can be implemented. Growing networks demand refining algorithms for decision support and topology estimation, estimation of network load and prevention of network failures.

Next phases should include refining the software and making a stable release that is comparable with the commercial software mentioned before.

VI. References

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