Integrating Telecom Outside Plant Systems Through the GML Standard

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Abstract. This paper introduces the Telecommunication Outside Plant Markup Language (TOPML), an OpenGis GML (Geographic Markup Language) application schema designed to describe telecommunication outside plant data in which geographical information is an important issue. TOPML uses the standard OpenGis GML schema to include geographic properties to georeferenced telecom network elements. The use of TOPML can be a key factor for cost reduction on data gathering, conversion process of georeferenced data and system integration. By using TOPML, telecom systems can now communicate in different ways such as Web Services. The TOPML can be transformed into an SVG format, allowing geographic data visualization in the Internet. Additionally, with TOPML and the definition of services following the OpenGIS specifications, the telecom outside plant systems can move towards a standard interoperable environment. The results of this paper are being implemented in the CPqD Outside Plant System, a geographical information system that automates the telecommunications outside plant management

1 Introduction

Technology innovations and business drivers are in constant shift in the telecommunication area. This constant evolution leads to alterations in telecom outside plant management systems internal properties such as the addition of new equipments, services or business rules **[7][10]**. These new pieces of information also have to be exchanged among other systems, usually resulting in new communication interfaces **[8]**.

In order to decrease costs concerned with the alteration of application programming interfaces (APIs) and integration mechanisms, it is necessary to use generic APIs and data importation and exportation mechanisms.

The construction of these generic mechanisms and APIs can be accomplished with the utilization of XML (Extensible Markup Language) **[9]**, by means of which the schema of the elements can be shared among the communicating systems.

Telecom outside plant management systems has been used in the automation of many operation carriers processes. These systems should be integrated with many other systems, like workflow, customer care and ERP (Enterprise Resource Planning) systems. In order to facilitate data handling and data exchange, it is required to describe these data in XML during data importation and exportation.

Georeferenced data is an important characteristic in the representation of telecom outside plant elements, such as the basic urban mapping elements and telecom network elements like underground duct placement, connectors, cables, poles and terminal boxes.

Thus, the goal of this paper is to present an XML encoding to describe the several types of existing elements in an outside plant management system. The XML schema shall allow the representation of the geographic properties. So the GML [2] language is used. GML is an Open GIS Consortium (OGC) **[5]** standard to act as an XML encoding for the transport and storage of geographic information, including both spatial and non-spatial properties of geographic features.

The concepts and the telecom expertise obtained from CPqD Outside Plant system will be used as the basis to gather data about outside plant elements. The CPqD Outside Plant is a system that handles geographic data and may manage most of the operations available in a telecom outside plant. Information on several elements of outside plant may be obtained from the information handled in the CPqD Outside Plant system.

The rest of this paper is organized as follows. Section 2 is an introduction on telecom outside plant and on the CPqD Outside Plant system. Section 3 presents the TOPML language. Section 4 describes the possible contributions of TOPML for the integration of telecommunication systems. Finally, section 5 presents the conclusions of the paper.

2 Telecom Outside Plant

A telecom outside plant or telecommunication network is a combination of several elements required in order to support telecommunication services (such as voice and data), both in local and long-distance scenarios. A telecom outside plant is the basis for the whole telecommunication activity, as it connects the final user to the world through the use of several technologies such as: copper pairs, coaxial cable, optical fiber or wireless, microwaves and satellite.

Telecommunications outside plant is the name given to the set of cables and equipments external to the central office, responsible to connect the customer to the central office, and interconnect different central offices. This set of equipments includes not only the metallic and optical feeder and distribution cables, but also the poles that support the aerial network, and other intermediary devices such as distribution boxes, amplifiers, splitters, etc.

An important characteristic of a telecom network management system is the use of georeferenced data to precisely locate the several existing elements in an outside plant, like poles and distribution boxes, and elements of the basic urban mapping, such as streets and blocks. So, an outside plant management system should be a geographical information system (GIS) that adds geographic data to database elements, and functions that allow specific uses in outside plant management. The use of GIS can provide the following benefits:

- Establish a standard representation for the network elements;
- Calculate project costs, based on distances and length of cables and fibers in the network;
- Search for paths among connected network elements;
- Search automatically for the best paths to serve a specific subscriber.

Currently, many operation companies still have all their outside plant usage recorded on paper notebooks. Some companies have their network management systems in a non-integrated way. In addiction, the continuous growth of the cities, together with advances in technology and reduction in equipments costs, allowed for the explosion in telephone service demand, greatly increasing the difficulties to keep the network data up to date. Fortunately, the advances in technology also brought new tools to help with the required revolution in the operating companies environment. The CPqD Outside Plant is a system that automates the process related to outside plant network.

2.1 CPqD Outside Plant System

The CPqD Outside Plant is a system comprised of several modules developed by CPqD Telecom & IT Solutions for the telecommunication outside plant management. It was developed to automate the process related to outside plant, from the planning, design and construction phases, and continuing with the network operation and maintenance (see **Figure 1**).

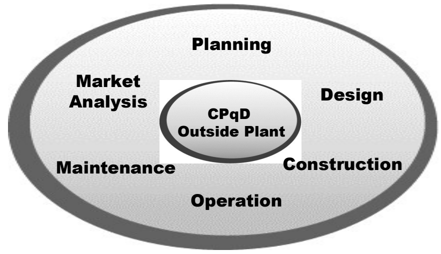

Figure 1 CPqD Outside Plant scope

CPqD Outside Plant puts the power of GIS technology to work for the network infrastructure operator. Assignments and management of existing facilities, capacity planning for future requirements, and engineering of new facility implementation can be conducted in concert, sharing consistent views of the operating environment, service delivery facilities, and spatial and non-spatial representations of customer locations and service demands. This system has been used in the process automation several operating companies.

Figure 2 shows an example of one of CPqD Outside Plant modules to display the outside plant network.

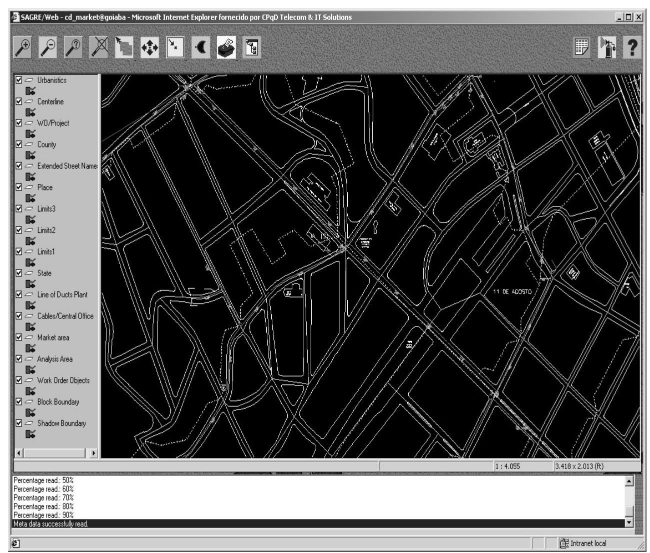

Figure 2 - CPqD Outside Plant System

The composition of the CPqD Outside Plant base is usually carried out through conversion of data contained in hard copies or field survey. This conversion was made feasible by the description of CPqD Outside Plant elements into a proprietary format called DAT.

The CPqD Outside Plant has approximately 400 objects described in DAT format. Many of these objects have geographic properties such as, for instance, all objects related to the basic urban mapping.

Likewise XML, the DAT format also uses meta-information on its objects. This format was defined and used as a standard for data exchange with CPqD Outside Plant system. Some of the disadvantages of this format include:

- Lack of mechanisms to organize the relationship of the outside plant element properties.
- DAT file validation is carried out only on data conversion, when the meta-information file is checked. The DAT file mechanisms for reading and validation are complex and hard to maintain.
- The DAT file is hard to understand. The meta-information file shall be analyzed in order to identify the meaning of each data inserted into a DAT file.
- Reuse of data types is impossible.
- Difficult communication with external systems. Typically, translation to a more descriptive format is required in order to export data to other systems.

Figure 3 presents the DAT format, the config.dat file acts like an schema to the DAT files. For instance, it restrics the quantity of atributes per line.

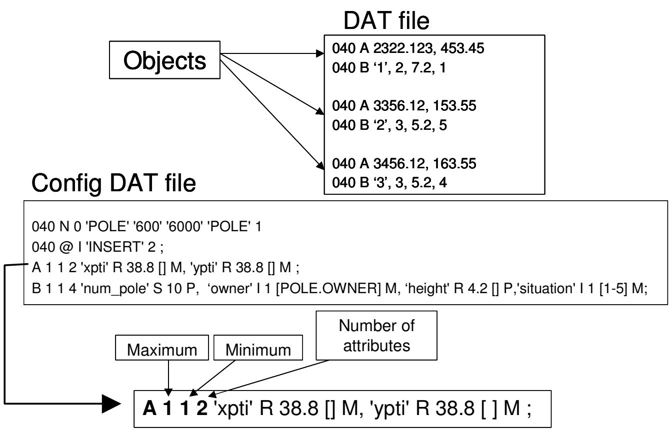

Figure 3 – Dat format example

In order to prevent these problems, a new format was defined. The use of GML was chosen to represent the outside plant elements. The following sections present the new format.

3 GML and TOPML Schema

GML was chosen as many of the existing objects in a telecom outside network have geographical information. The use of GML may standardize the representation of the telecom network objects that have spatial information, making even more easy its handling and dissemination. Subsection 3.1 presents the GML language. Subsection 3.2 presents TOPML language to represent the outside plant elements.

3.1 GML

The Open GIS Consortium, an international industry consortium of more than 230 companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications, adopted GML as the standard for description of geographic content.

OGC has defined the GML language to standardize the exchange and the storage of the geospatial data. GML documents are in the heart of the enterprise information systems to make the data compatible between them [11].

GML provides an XML-based encoding of geospatial data; it can be viewed as a basic application framework for handling geographic information in an open and non-proprietary way. By using related XML technologies (e.g. XML Schema, XSLT, XLink, SVG) a GML dataset becomes easier to process in heterogeneous environments. Since GML documents are both human-readable and machine-parsable, they are easier to understand and maintain than proprietary formats.

GML upholds the principle of separating content from presentation, so it does not address the visualization of encoded data. A styling mechanism is required to display GML data on a particular device. For example, to display a map in a web browser you could transform the data into SVG (Scalable Vector Graphics) [4] using an XSLT [1] processor.

GML brings an alternative to expensive proprietary software, making it possible for many smaller companies to beat industry barriers and deploy GML in a variety of applications. Next section shows the use of GML in the telecommunication's industry.

3.2 TOPML

GML, as a common standard for geographic data and with all of its benefits, can be an important technology for describing spatial information in the telecommunications industry. TOPML is an XML encoding that uses GML to describe the telecom outside plant data.

GML uses the W3C XML Schema Definition Language to define and constrain the contents of its XML documents. The root element of a GML document shall be the AbstractFeatureCollectionType type, which expresses a collection of AbstractFeatureType types. Thus, the remaining elements shall be AbstractFeatureType type. With this, the elements defined in the GML may be used to define the geographic properties of a telecom outside plant element.

Following, the XML Schema is presented to represent this constraint. Notice that the document root shall be the TOPDocument element and that its sub-elements shall be a _TOPFeature type. The Feature

Filter pattern described in the GML specification document [2] was used to define this constraint.

```
<!-- global element declarations -->
<element name="TOPDocument" type="top:TOPDocumentType"
substitutionGroup="gml:_FeatureCollection"/>
<element name="topObject" type="top:TOPMemberType"
substitutionGroup="gml:featureMember"/>
<element name="_TOPFeature" type="gml:AbstractFeatureType"
abstract="true" substitutionGroup="gml:_Feature"/>
<!--   type definitions for objects -->
<element name="TOP_ELEMENT"
type="top:TOP_ELEMENT_TYPE"
substitutionGroup="top:_TOPFeature"/>
<!--  type definitions for model -->
<complexType name="TOPDocumentType">
    <complexContent>
       <extension
base="gml:AbstractFeatureCollectionType"></extension>
        </complexContent>
</complexType>
<complexType name="TOPMemberType">
    <complexContent>
        <restriction base="gml:FeatureAssociationType">
          <sequence minOccurs="0">
             <element ref="top:_TOPFeature"/>
          </sequence>
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
        </restriction>
     </complexContent>
</complexType>
```

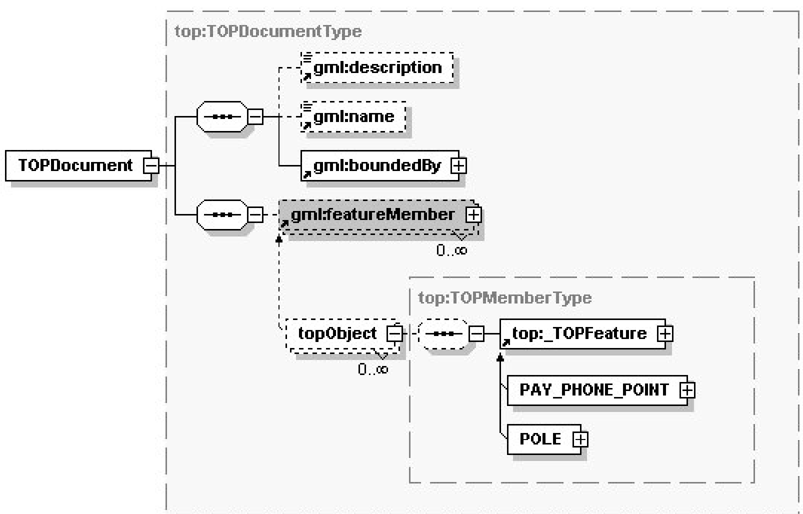

Figure 4 – **TOPML schema structure**

Figure 4 describes the structure of the XML Schema that was created for the TOPML application schema showed above.

Consider, for instance, a pole object, where there is a geographic property indicating its location and a set of attributes describing it, such as for instance, its identification number and height. The definition of a type in the XML Schema, according to TOPML schema would be as follows:

```
<complexType name="POLE_TYPE">
<complexContent>
<extension base="gml:AbstractFeatureType">
  <sequence>
     <element ref="gml:location"/>
  </sequence>
  <attribute name="number" type="string" use="required"/>
  <attribute name="height" type="float" use="optional"/>
  <attribute name="situation"  type="integer"  use="required"/>
</extension>
</complexContent>
</complexType>
```

Notice that in the case of a pole, its geographic property is a point, represented by a *location* element. The *location* type is one of the geographic properties defined by GML. Other properties are lines, polygons and several combinations of these properties [2].

An example of XML element that follows this schema is shown as follows.

```
<POLE situation="5" number="A12" height="2,5">
   <gml:location>
      <gml:Point>
         <gml:coordinates>12.33,20.33</gml:coordinates>
      </gml:Point>
   </gml:location>
</POLE>
```

In the example given, it may be noticed that the *location* element is composed by a *Point* element, which on its turn contains another *coordinates* element to describe the point coordinate. All possible cases of outside plant elements will be analyzed to find the right geographic property.

For the construction of the TOPML language, the concepts applied in the CPqD Outside Plant system are being applied as the basis for the collection of data about outside plant. The CPqD Outside Plant is a system that handles geographic data and is able to manage most of the operations available in a telecom outside plant. The CPqD Outside Plant has approximately 400 objects described in a proprietary format. Many of these objects have geographic characteristics such as, for instance, all the objects related to the underground network.

Therefore, mapping rules were defined to map the CPqD Outside Plant proprietary format schema into the TOPML schema, enabling to reuse all knowledge already carried out in the elaboration of the CPqD Outside Plant data conversion specification.

In order to make mapping process easier, the names of the attributes used in mappings shall be the same ones as defined in the proprietary DAT format. In the future, these names will be standardized in the proposed TOPML schema to be according with names used by the telecommunication community.

Any XML parser that is in accordance with XML and XML Schema standards may make the validation of TOPML instance documents. Thus, any other system that has the TOPML schema may perform data reading. Alternatively, a TOPML document may be transformed into any other format through XSLT **[1]**.

4 Integration of telecom systems with TOPML

Currently, most operation carriers have all registers from the outside plant in hard copy or have non-integrated computer systems, showing several inconsistent and scattered databases throughout many company areas. This implies the possibility of errors due to these databases being outdated, which may lead to errors in the network facility designation.

In this context, the great challenges to the widespread use of GIS in telecom is the reduction of costs concerned to data gathering and to system integration solutions.

The integration of a geographic information system to another system requires a detailed definition of the processes, the responsibility of each application, the information and data formats, the information exchange mechanisms, the architecture, and the integration technology. So, it is necessary the definition of an integration infrastructure to make the integration in an organized way and make easier the product evolution.

In this scenario, some activities were developed aiming at the establishment of a proper infrastructure to integrate a GIS for telecom outside plant management with other existing systems in the telecommunication area. Standard models are intended to be used for GIS interoperability, such as the Service Architecture defined by OpenGIS consortium **[6]**.

Some APIs and mechanisms were developed in order to make the most requested integrations to the CPqD Outside Plant system feasible. Thus, the conception of an integration infrastructure was started by using the generated knowledge and by preserving some of the already existing components in the CPqD Outside Plant system. This way, some of the APIs that were developed to meet the integration of GIS for outside plant management with some telecom carriers legacy systems were implemented. Some examples of the built interfaces include:

- Service Order Management System for Privative Lines,
- Feasibility Analysis Systems for the Installation of ADSL Services.
- Service Order Management Systems for Pay Phones.
- Supervision Systems for Pay Phones.
- Geographic Positioning Simulation Systems.

The TOPML language is being applied to the defined integration APIs and to the data importation and exportation mechanisms. The built importation mechanism performs validation and reading of TOPML documents and its data insertion into a database. This mechanism is configurable through a metadata file also described in XML. This file defines which objects will be imported, their format and type, in addition to their database schema. So, to import data of other objects, change an object data format, or import data in different database tables, it is enough to change the metadata file.

These results are very important for the GIS integration in the telecommunication domain and enabled to keep the CPqD Outside Plant in line with the market expectations, giving greater agility in the product deployment and decreasing maintenance and development costs of specific APIs.

The integration infrastructure will be consolidated through the use of the results achieved by the international efforts in standardization of telecom operation system interfaces **[3]** and geographic information systems interoperability **[5][6]**.

5 Conclusions

The current paper will contribute to the definition of a standard to represent data on telecom network. This will be feasible by the use of the GML standard and the outside plant concepts taken from the CPqD Outside Plant system. The definition of the TOPML language may also facilitate system integration as other systems may work with the proposed language, avoiding the creation of specific solutions, typically based on the creation of text documents with proprietary formats. Thanks to GML standard, TOPML can act as the basis to a standard format to describe telecommunications outside plant data.

TOPML is part of a project aimed at the use of the OpenGIS specifications, like the OpenGIS Service Architecture, in the definition of an open architecture to build interoperable telecom outside plant systems. This architecture will enable interoperable data services through interface standardization. Moreover, this architecture and the TOPML application schema will define an abstract framework, which can be implemented in multiple ways.

By using TOPML, telecom systems can now communicate in different ways such as Web Services. The TOPML can be transformed into a SVG format, allowing geographic data visualization in the Internet [11]. The integration mechanisms based on XML can be more stable and easier to maintain, modify and extend. A standard format defined along with the use of GML can make the information exchange easier, which also improves data mapping and extraction process. Additionally, with TOPML and the definition of services following the OpenGIS specifications, the telecom outside plant systems can move towards a standard interoperable environment.

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