Multi-purpose Publishing of Geodata in the Web

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Abstract. The appearance of the Web platform as a new publishing environment – parallel to the traditional print media – necessitates content providers to create methods for the *multi-purpose publishing*. The recent introduction of the Mobile Internet as a medium for distributing information further strengthens this need. The same applies also for the delivery of geospatial data. The Extensible Markup Language (XML) technologies are generally seen as the answer, and are increasingly being applied also in geospatial applications. A mechanism for transforming XML-encoded data, the Extensible Stylesheet Language Transformation (XSLT) specification, is presented as a tool to provide multi-purpose publishing functionality for the Web and the Mobile Internet-based spatial services.

1. Multi-purpose publishing

The Web platform has provided for the publishing industry a new distribution environment, in addition to the traditional printing methods, and has forced them to develop methods for the so called *multi-purpose or multi-channel publishing*. The idea in this new approach is to separate the information content from its presentation characteristics. Automated processes can then be developed to produce several different presentations from a single content source. The recent introduction of the Mobile Internet as a medium for distributing information further strengthens this need. It is generally seen that the use of various light-weight mobile devices to access information resources in the Internet will surpass the use of the traditional wired access methods in the coming years.

The dependency of the document encoding format on the characteristics of the individual end user visualization environment has been recognized as a major problem in the increasingly popular Web publishing of electronic content. As a consequence, new methods for the network-based dynamic publishing must be developed. The idea in the multi-channel publishing is based on the principle that the content of the document to be published is stored in presentation-independent form and the visualization details are processed in real-time during the request-response processing, taking into account the target visualization platform of the request.

The HTML language, so far widely used as the encoding mechanism for Web delivery, has proved difficult to adapt to the needs of the multi-channel publishing framework. The language contains a mixture of concepts for encoding of content and the presentation alike. The Cascading Stylesheet (CSS) technology, being applied in HTML pages currently, is an attempt towards separating the styling information from the document contents, but the drastically varying display and interaction capabilities of the future Web access devices necessitates a more significant variation than can achieved through this mechanism.

The Extensible Markup Language (XML) technologies are generally seen as the answer for this new challenge. In this approach the information content is going to be encoded in an application-specific XML vo-

cabulary. The presentation document can then be produced for each delivery channel by applying an appropriate stylesheet to the original data. A stylesheet language developed in the XML context is called the Extensible Stylesheet Language (XSL). The XSL specification is much more rich in functionality than the former CSS technology. Specifically, the part of the specification related to transforming an XML document into another XML document, XSL Transformation (XSLT), provides an interesting opportunity for fundamentally changing the content, order, structure and vocabulary of the original data. Various commercial XSLT-based multi-channel publishing products are already available in the market.

2. Multi-channel Publishing of Geodata

The same multi-channel delivery challenge is facing also the providers of geospatial data. The Web environment has already been accepted as a significant new delivery media (Kraak and Brown, 2001; Kähkönen et al, 1999), but the recent introduction of the Mobile Internet is again changing the landscape of the geospatial data distribution. Various studies are being made on the use of mobile devices to access geospatial data resources (Reichenbacher, 2001). Specifically the so called Location-Based Services (LBS), that rely on the known location of the mobile user, are right now intensively investigated (Niedzwiadek, 2000). Many of the LBS solutions being developed would benefit from the use of a displayed map, thus calling for the availability of appropriate geospatial data sources with multi-channel publishing capabilities.

In the spatial data domain the ideas of multi-purpose publishing are equally relevant, particularly when talking about Web-based visualization of geospatial datasets. In the traditional GIS environment the principle of separation of the content from its presentation characteristics is quite well established, but in the existing map-related Web services the same does not apply, at least when seen from the end user perspective. In most of the cases the map visualization is processed on the server and the user agent only gets a raster image displaying the map contents in a fixed, predefined style. This approach effectively prevents the resulting maps to be integrated with each other for further value-added service or analysis.

The XML technologies are increasingly being applied also in geospatial domain (Gould, 1999; Lehto, 2000; Zalavsky et al, 2000). Standards for XML-based encoding of spatial data are being developed both by the ISO TC211 and the Open GIS Consortium (OGC). A mechanism for transforming XML-encoded data, defined in the XSLT Specification, could thus be applied as a tool to provide multi-purpose publishing functionality for the Web and the Mobile Internet-based spatial services. The XML-based graphic languages available for visualization of spatial data include Scalable Vector Graphics (SVG) and Extensible 3D (X3D).

3. XML-based Encoding of Spatial Data

Recent developments indicate a drastic change in the mechanisms of Web-based spatial data delivery. The general trend towards XML-based data processing is being recognized also in the spatial data domain. Various standardization communities have been working to develop XML vocabularies for encoding spatial data. An interesting example of these is the Open GIS Consortium's Geography Markup Language (GML) recommendation (Lake, 2000). Originally published as OGC's Recommendation Paper in May 2000, the GML version 2.0 is available as an officially accepted OGC Implementation Specification since April 2001 (OGC, 2001). The GML recommendation establishes an XML vocabulary for expressing OGC Simple Features Specification-compliant data in XML syntax.

Several GIS vendors are developing GML support into their software and a few products are already commercially available. It can be assumed that in the near future the GML specification, or some derivative thereof, will become *de facto* standard for spatial data encoding in the Web. Once the format of spatial data content encoding becomes standardized, an opportunity will open for finding a standardized method also for defining visualization characteristics. The most promising technology for this purpose seems to be the XSLT specification, together with the XML-based visualization languages currently under development (Lehto and Kilpeläinen, 2000).

4. XSLT as a Tool for Map Visualization

The XSLT technology provides powerful tools to define a transformation from the data content encoding language to an appropriate presentation language. The basic functionality that the XSLT mechanism provides is transforming an XML document into another XML document. Therefore the various XML-based visualization languages are the most appropriate form of output from an XSLT process. The languages most interesting for geospatial applications are the Scalable Vector Graphics (SVG), the supposed *de facto* format for Web vector imaging, and the Extensible 3D (X3D) language, the XML-based successor to the popular Virtual Reality Modeling Language (VRML).

The transformation process is depicted in the Figure 1. The input source for the process is provided in the form of an XML dataset as a tree structure and the transformation declarations defined in a XSLT file, designed appropriately for each destination environment. The transformation is carried out by an XSLT Processor component. The result is again an XML tree structure, expressed in a vocabulary understood by the target device.

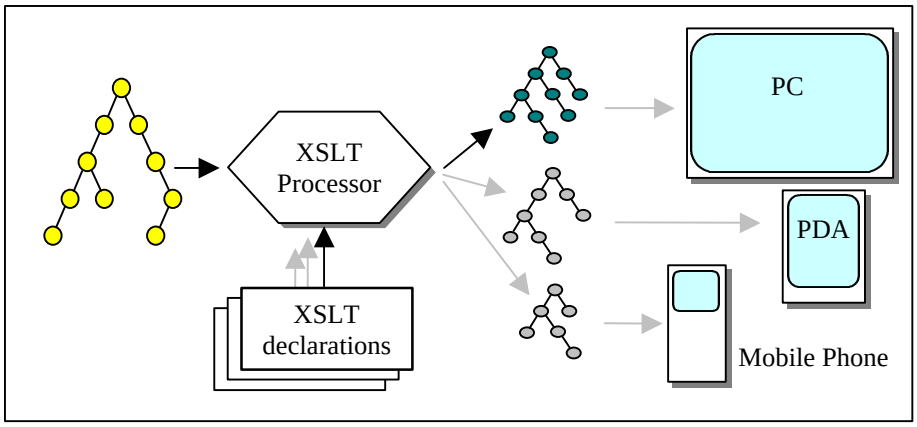

Figure 1. The XSLT transformation process

As the stylesheet technology becomes widely adopted as a visualization mechanism for Web-based spatial applications, it will, for the first time in the history of GIS, provide a standardized means for defining map symbology. The traditionally difficult, if not impossible, task of transferring symbology information from one system into another might become feasible by each vendor providing mappings from their proprietary style libraries to the one common visualization mechanism.

5. XML-based 2D Map Images

Widely seen as the general standard for vector graphics in the Web, SVG definitely deserves to be carefully scrutinized as a visualization tool for spatial data (Gould and Ribalaygua, 1999; Neumann and Winter, 2001). The SVG specification (SVG, 2001) seems to provide a rich enough graphic engine for two-dimensional vector map display, which is frequently mentioned as a prospective use case for the technology. The specification covers all the most important line interpolation algorithms, raster image backgrounds are supported. Also the text-related functionality is rather powerful – enabling e.g. placement of a map text label along a curved line. The specification also supports sophisticated filtering and advanced interactivity. As an XML document, an SVG image is freely scriptable through the standard Document Object Model (DOM) interface, enabling animated and richly interactive JavaScript-driven map displays to be created. An example of an interactive session involving a simple SVG image is shown in the Figure 2. The map display shows zoom-in operation of an SVG map in a Pocket PC based SVG viewer application.

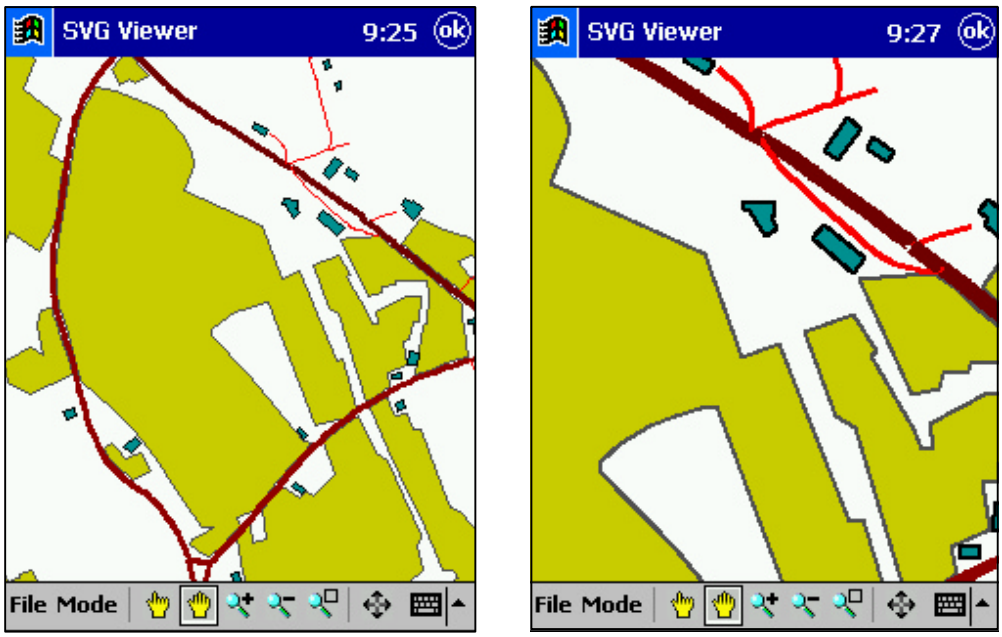

Figure 2. An interactive SVG map session

6. XML-based 3D Spatial Models

The three-dimensional graphics have a relatively long and well established tradition in the form of the VRML modelling language. For some reason the development has somehow stagnated lately and operative 3D services are still largely missing. The current work on Web-based 3D graphics is centred around the creation of an XML-based version of the VRML specification (Web 3D Consortium, 2001). This development opens promising scenarios for multi-purpose publishing of geodata. A 3D geospatial dataset might be rendered either as an X3D model, for a visualization platform capable of handling the processing load involved, or as an SVG image in the case of a less powerful user agent. Both renderings could be achieved simply by applying an appropriate XSLT transformation on the original data.

The use of light, hand-held devices to access geographic information will always create a demand for the simplest possible form of visualization. In the near future these devices will not be capable to process vector-based map images, let alone spatial 3D models. However, XSLT transformations could be used to produce appropriate visualizations also on those limited-display appliances. The spatial dataset created as a result in a synchronous request-response dialog can be easily filtered by a well-designed XSLT transformation, and the resulting SVG image then rendered as a raster file in a format supported by the target user agent. The resulting file can then be transferred to the mobile device for display.

7. Prototype Developed at the Finnish Geodetic Institute

The Finnish Geodetic Institute (FGI) has developed a prototype system to test the idea of XML-based multi-purpose publishing of geodata. The system is based on three-tier architecture, in which a Smallworld data store forms the bottom level (with Smallworld Internet Application Server, SIAS), and the Java servlet-based middle layer carries out the XSLT-related processing (employing Xalan XSLT Processor run on Tomcat Java Servlet engine). The visualization on the user interface level can be based on various different platforms and applications. The exemplary client applications used in the FGI include the SVG Viewer plugin of Adobe and the OpenMap Java library from BBN Technologies (Figure 3).

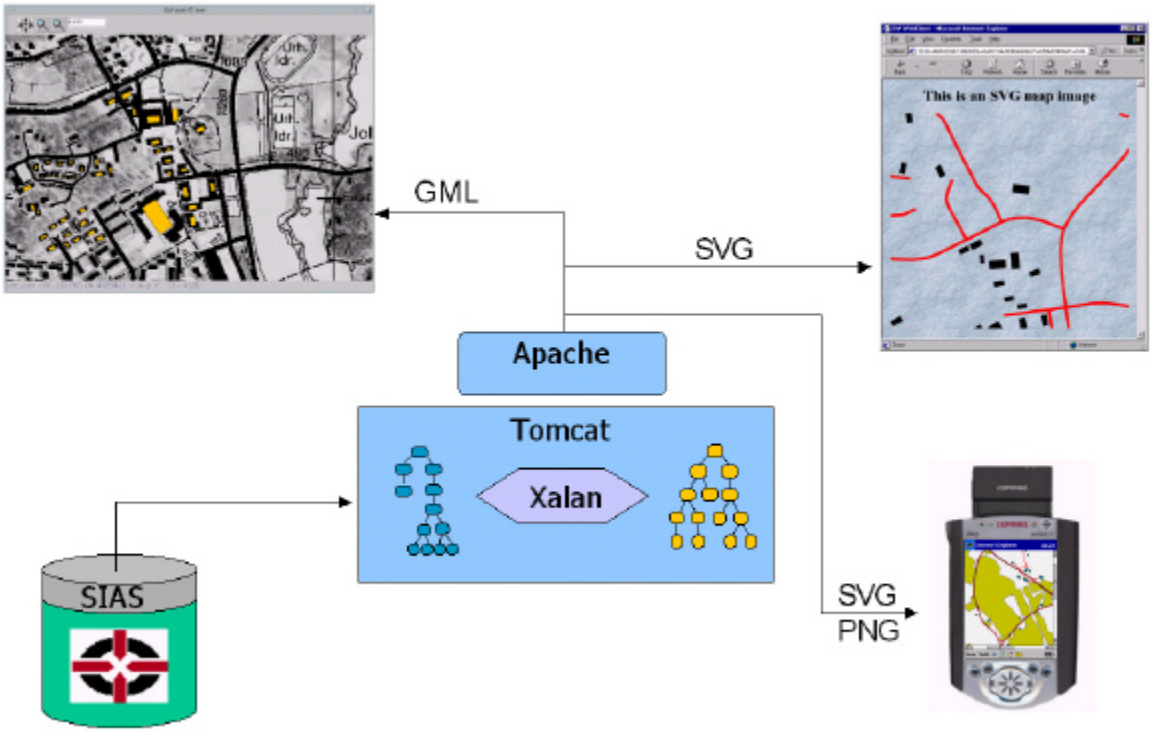

Figure 3. The prototype system architecture developed at the FGI

The first experiences of the prototype are encouraging. The use of freely available components, like the XSLT processor and the XML parser facilitate the programming work considerably. Although the system is based on a nascent technology, most of the available components are fully functional and reliable. Performance issues clearly constitute a problem. This is partly due to the inefficient character encoding applied in XML, partly to the poorly optimized beta category software. The focus of the research in the FGI has been on the transformation aspects of the XML-based geospatial data processing. In this respect a considerable progress has been achieved by developing a set of Java-based XSLT extension functions that carry out the most complicated processing tasks involved. The work continues with a special attention being paid on the issues related to the use of maps in mobile devices.

8. Concluding remarks

As XML-encoded data transfer becomes more widely used in the Web and Mobile Internet-based map applications, the need to evaluate all relevant XML processing technologies in the context of spatial data becomes evident. The idea presented in this paper is to apply the general XML stylesheet mechanism to produce various visualizations from a single geospatial data source, appropriately formatted and styled for different end user access devices. A standardized XML transformation mechanism, XSLT, is applied to carry out the needed modifications to the source data. The technology provides an interesting opportunity to establish a general framework for multi-channel publishing of geospatial data – a necessity in the open network services, where the client access platform cannot be predicted.

References

Gould M., 1999. “XML-based mechanism for open exchange of Geographic Information and Metadata”, *GI/GIS Technology Watch*, JRC-SAI.

Gould, M. and A. Ribalaygua, 1999. “A New Breed of Web-Enabled Graphics”, *GeoWorld*, Mar 1999

Kraak, M-J. and A. Brown, 2001. *Web Cartography, developments and prospects*. Taylor&Francis Inc, London, 209 p.

Kähkönen, J., Lehto, L., Kilpeläinen, T. and T. Sarjakoski, 1999. Interactive Visualisation of Geographical Objects on the Internet. *International Journal of Geographical Information Science*, Taylor & Francis Ltd, 13(4): 429-438.

Lake R., 2001. “GML 2.0 – Enabling the Geo-spatial Web”, http://www.geojava.com/company/galdos /articles/GML3.htm

Lehto L., 2000. “XML in Web-based Geospatial Applications”, AGILE Conference, Espoo, Finland.

Lehto L. and Kilpeläinen T., 2000. “Real-Time Generalization of Geodata in the Web”, IAPRS, Amsterdam.

Neumann A. and A. Winter, 2001. “Time for SVG – Towards High Quality Interactive Web-Maps”, *Proceedings of the 20th International Cartographic Conference (ICC 2001), Beijing, China, August 6-10, 2001*.

Niedzwiadek, H., 2000. “Where’s the Value in Location Services?”, http://www.geojava.com/company/ ImageMatters/ valueinlocationservices.html

OGC, 2001. “Geography Markup Language (GML) 2.0” www.opengis.net/gml/01-029/GML2.html

Reichenbacher T., 2001. “The World in Your Pocket – Towards a Mobile Cartography”, *Proceedings of the 20th International Cartographic Conference (ICC 2001), Beijing, China, August 6-10, 2001*.

SVG, 2001. “Scalable Vector Graphics (SVG) 1.0 Specification”, www.w3.org/TR/2001/REC-SVG-20010904/index.html

Web 3D Consortium, 2001. “X3D Specification Task Group”, www.web3D.org/ TaskGroups/x3d

Zaslavsky I., Marciano R., Gupta A. and C. Baru, 2000. “XML-based Spatial Data Mediation Infrastructure for Global Interoperability”, 4th Global Spatial Data Infrastructure Conference, Cape Town, South Africa.