

GML based model of Indian NSDE format for Geo Spatial Data Interoperability

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Abstract

The problem of data heterogeneity is the major issue for consideration in geospatial domain. Numerous organizations have huge geo data but in heterogeneous data formats, which makes it difficult to utilize these data for an application on a common platform. To overcome such problems and to make data interoperable, many countries have developed their standard data formats. Government of India also has taken initiatives with the establishment of National Spatial Data Infrastructure (NSDI) and has recommended NSDE (National Spatial Data Exchange) data format to be used by “*all the Indian GIS data providers*”. With these specified standards, the problem of heterogeneity among data of different organizations could be solved, but easier and faster access of data is another requirement. This can only be achieved by transferring maps through Internet and hence this data should be encrypted into a language that can be understood by web browsers, like XML (Extensible Markup Language). The Open GIS Consortium (OGC) recommended Geography Markup Language (GML), an XML dialect, is specially designed to solve most of the issues in geo spatial data interoperability [Henning, S., 2001; Chang, C. et al]. By mapping from the NSDE format to GML document, the existing local GIS bases are moved into global domain. In Indian context, GML version of NSDE format is not yet designed. Thus it would be of great help for users in India to take benefit of new era of distributed environment like Internet. The proposed schema is designed to fulfill the requirements of NSDE and the GML specifications. Another aspect

taken into consideration is the conversion of NSDE format to GML version of NSDE. The paper details about our experiences in converting NSDE data file to GML documents, with emphasis on the requirements and design choices in mapping the NSDE data format to a GML application schema. An attempt has been made to design the schema for non-spatial information and some of the basic spatial features. It can be further extended for any type of spatial and non-spatial information. For demonstration purpose GML data is visualized by converting GML to SVG. The other benefits of GML are also discussed.

Introduction

With the rapid development in GIS (Geographic Information System) and its applications, more and more geographical databases have been developed by different programs and applications, but data sharing and acquisition is still a big challenge for the development of GIS applications. It is not that data are not available. There is a huge amount of geographical data stored in different places but in different formats, so the aim of data reuse for new applications and data sharing gets limited with the very thought of dealing with heterogeneity among existing systems in terms of data modeling concepts, data encoding techniques and storage structures, etc. [Devoegele et al, 1998].

The situation is even worse in a large and developing country like India. There is huge amount of spatial data but stored in heterogeneous forms. This diversity in data storage can be seen in government departments also. There were no standards or specifications for storing or exchanging different data. The Department of Space and Technology, Govt. of India has recently taken initiative to resolve this issue with the introduction of NSDI in India. In that NSDE (National Spatial Data Exchange) is specified as a standard format for data exchange and sharing for governmental GIS procurements [Indian NSDI Document]. However this does not fully solves the problem of Interoperability at the global level. So there should be some format for data exchange above all the national level efforts for interoperability.

There are many aspects of NSDI like Institutional, political, economical, security, technical and many more to name. This paper is mainly concentrated on the design issues of an Interoperable data exchange format and translation of the NSDE data format to NSDE-GML format, to make sharing and presentation of data possible through web.

Motivation

The problem of heterogeneity cannot be ignored specially in developing countries like India. India is prone to many disasters, which has adverse impact on its socio-economic conditions. It could be improved with some pre disaster operations or post disaster mitigations. However for efficient planning different data from several departments are required. But the spontaneous rescue operation cannot be performed in such a heterogeneous spatial data environment. This situation is even worse in reality than it is represented in words. So it is the high time for the development of better data dissemination and maintenance.

However, the Indian govt. has taken initiatives in the direction of developing interoperable data sets with the introduction of Indian NSDI. It has specified a data exchange format (NSDE) so it can be expected that atleast the govt. department will have their data in this format. The situation can further be improved if some fast data-sharing medium like Internet is taken into consideration, so the data can be shared and viewed on web Browser [Bishr, Y. et al, 2000; Bertolotto, M. et al 2001; Badard, T. et al 2001]. For this data should be in a language, which can be understood by browsers, OGC recommended GML is popularly accepted as the language for spatial data exchange and sharing over the web [Lake 2001; OGC 2001].

The Indian Govt. has taken initiatives to encourage the interoperability among Indian GIS data providers and users, but all this is at discussion level, so the people of GIS community has to come forward to make it a reality.

Introduction of NSDE

The NSDE format is evolved from the Digital Vector Data (DVD-3) format, which earlier was designed as the National Standard Exchange Format for Survey of India digital Cartographic vector data. This format catered for point, line and polygon topology describing relationships among spatial features. The proposed format has provision to include digital images acquired by satellites and Digital Elevation Model (DEM) and coded raster data. Furthermore the NSDE format also accommodates various types of thematic data sets along with the associated attribute data in tabular form [NSDE Format].

A sample NSDE file is shown below, these are the coordinate list of a line feature along with other information of a datafile of NSDE (For details see NSDE

LINE	1	1	7	7	4400.	
	1296840.24	3368704.39	1296427.27	3368558.64	1296014.30	3368024.21
	1292007.13	3365782.31	1291162.92	3365310.00	1290784.10	3365098.06
	1289916.97	3362242.67				
	34	1120				CINTBR

Figure 1 -Sample NSDE file

format).

As Indian NSDI came into existence in Jan 2001 [Indian NSDI document] only so the NSDE format is not yet in use practically so the above shown sample data is generated with the help of DVD sample data and arbitrary data values. The road map and facility locations map for Dehradun City of India is generated.

Why NSDE to GML required?

Although Indian NSDI has taken an appreciable initiative in the direction of interoperability at national level, still there are some problems, which are the real hurdles of Interoperability, and as NSDE is at the initial stage of its adoption by Indian geospatial data users. So it is the time to work out to enhance the popularity of NSDE.

Problems with NSDE:

- Designed to cater Indian data providers' specifications only.
- Not an open format. So not compatible with other data types.
- Not based on the Internet Technology. So slow data transfer.

- Complicated structure. So time consuming data conversion.

Benefits of using GML:

The creation of a standard data exchange format, Geography Markup Language (GML) is an important step taken by the geospatial community towards data interoperability. The GML schemas are written in XML grammar, and are used for modeling, transportation, and the storage of geographic information including both the spatial and non-spatial properties of geographic features [OGC, 2003]. It is developed as Data Exchange Standards Interface by Open GIS Consortium (OGC) to achieve data interoperability and to reduce costly geographic data conversions between different systems. In the OGC spirit, interoperability is achieved by means of common specifications that programs and data must follow [Buehler and McKee, 1996].

Earlier also some initiatives were taken in the direction of maintaining Interoperability in GIS data sharing and exchange. Geographic Data File (GDF) and the Spatial Data Transfer Standard (SDTS) are two such examples. But the complexity, slowness in the development of practical profiles, restriction of each dataset to a single profile, lack of a clear definition of geospatial features, and ambiguity in the means of specifying cardinality of relationships in a data model are some of the reasons for its unpopularity [Arctur et al, 1998]. On the other hand, the GML holds promise to support mapping from a wide variety of sources and enables on-line sharing and exchanges of geospatial data in a simple format.

The development of the World Wide Web creates a unique environment for sharing geospatial Data. Users can use the World Wide Web to download data for viewing, analysis or manipulation [Lake R., 2001; Bertolotto, M. et al, 2001]. Many of commercial Internet GIS programs, such as ESRI's MapObject, and ArcIMS, AutoDesk's MapGuide, Intergraph's Geomedia WebMap, GE SmallWorld's Internet Application Server and ER Mapper's Image Web Server, are developed to offer better tools for data sharing over the Web. But like the desktop GIS software these Internet GIS programs also

have problems of proprietary software designs, data models and database storage structures.

Unlike current proprietary commercial Internet GIS programs, the OpenGIS GML specifications are the public open standard for coding and sharing spatial data. GML is a good alternative to expensive, proprietary web-based mapping solution:

- GML is an open source standard. Users can use it for free. But for other commercial Internet GIS programs, users have to buy them at high amount. Also because of their proprietary data structure many data conversion processes are required.
- GML data are stored in text format, which is a universal format. Thus it is easy to integrate GML data into other data across a variety of platforms and devices [Lake R., 2000].
- As a standard data exchange format GML reduces the costly conversion processes among different format databases.
- GML is capable of facilitating real-time data sharing and exchange at the feature level on the Web because it uses XML grammar, which is widely supported on the Web. GML can enable an accessible Geo Web [Lake, 2000, 2001; Aloisio, 1999; Kim, 2001].
- Most current Internet GIS programs deliver data in the GIF and JPEG format. On the other hand, GML can deliver vector data over the Internet by styling the data into Scalable Vector Graphics (SVG) format [Chang, C. et al; Vies, M; Lake 2001].
- Styling GML data into SVG, GML-based data can provide users a more sophisticated interactive graphic interface and deliver higher quality graphic maps over the Web than most other online alternatives.

GML is more flexible than other alternatives. It only defines a basic geographical feature schema and geometry schema, which are convenient for users to use. [OGC, 2003; FME, Lake R., 1999, 2000, 2001], Based on these schemas users can define their own specific schemas for their spatial data documents. It has been widely recognized that GML will play an important



role as a future Web data exchange standard [Lake, 1999; Meneghello, 2001].

How Interoperability is assisted in GML?

GML provides a common model for writing schemas (so called object-property or feature-property model). This ensures that software that can read a GML schema can read ANY GML schema and interpret that schema to determine which elements are features and which are properties. This is not possible with a relational DBMS encoding where one cannot tell after the fact which tables represent entities (or classes) and which represent relationships. This can always be determined in GML simply by processing the schema.

GML gives extensibility as per the user demand. One person may define a feature called ROAD where another might use STREET. GML does not constrain how such objects are named, or define what properties they have. Users can however readily compare schemas on the Internet and provide *mapping* for data of one schema to another. This has been done already in a number of pilot implementations and will become a standard part of future Web Feature Servers. To visualize in FME, a product of Safe Software Inc., a mapping file is required [Murray D., 2002; FME Mapping file]. For Ordnance Survey, UK data already there is a built in *OS (GB) Master* file and for the TDN, The Netherlands data there is one mapping file *Top10vector.xmp* [FME]. For other generic schema such mapping files can be designed.

GML provides a set of core components for things like geometry, topology, reference systems, coverage, observations, units of measure, and map styles that are used in the creation of application schemas. Schema parsers can determine what type of GML components are being used even when a schema is derived from the core GML components, these core components are key to

achieve interoperability at the geometry level, topology level, etc, while the object-property model is key to interoperability at the feature level.

In terms of portrayal - there is a need to determine some sort of portrayal rule - e.g. how should one portray a road or river? A black line? How thick? A shaded polygon? What type of shading? etc. These are determined by properties of the road and river and by the users styling choices. GML does not constrain on it and as such it does not affect interoperability.

Interoperability is critically dependent on Extensibility; this ability of GML enables the representation of user defined object types. (Email Discussion with Rone Lake, Galdos Inc).

Requirements in NSDE-to-GML Mapping

This section covers the requirements and design choices experiences faced in mapping the NSDE data format to a GML application schema. The overall approach can be understood by following figure:

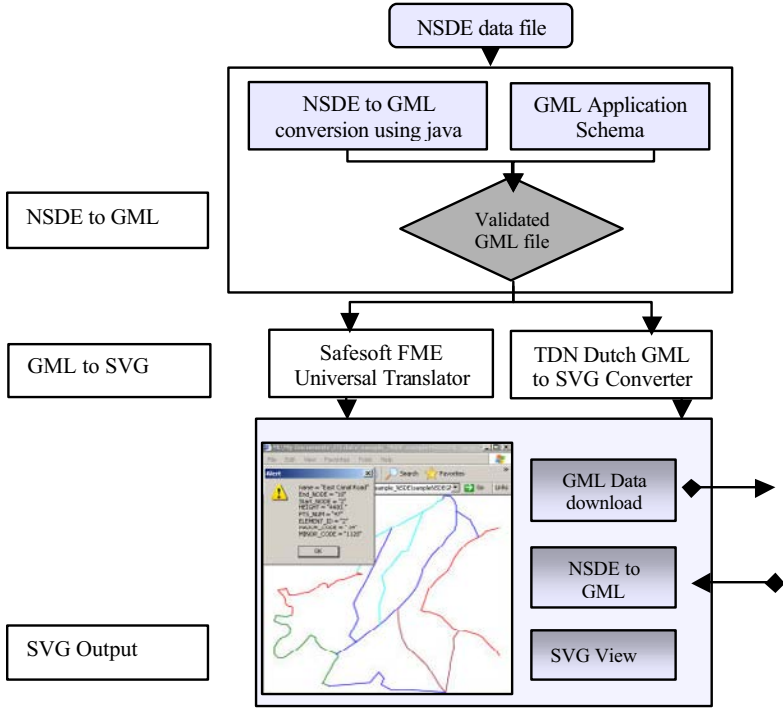


Figure 2-NSDE to GML approach

Sample NSDE data generation

As discussed earlier a sample of the road map and facility locations map of Dehradun City of India is generated with the help of DVD data and arbitrary data values. NSDE has (VOLDIR, GENINFO, QUALINFO, TOPOINFO) and n numbers of DATA CAT and DATAFIL files, where n is the number of themes. For the demonstration purpose VOLDIR, GENINFO, DATA CAT, DATAFIL files are generated.

GML Application Schema Design

Like XML, GML is also extensible and allows users to define their domain specific elements, feature types and geometry types. Here also a schema is designed to fulfill the requirements of NSDE and the recommendation of OGC. To distinguish the elements of NSDE application schema from any other schema “*nsde*” namespace is used. GML schema elements already have “*gml*” namespace before each element. The schema is designed with a moderate approach. Not all the information is mapped, for the full fledged schema further developments are going. For Metadata and attribute information GML gives flexibility to define own tags, so these are designed according to NSDE specifications. For spatial information also user defined feature types and geometry types can be defined. In the present schema, three feature types are defined and no geometry is defined at present. Two schemas, one for metadata kind of information and other for feature information are designed using XMLSpy editor.

Feature Schema:

As per the OGC recommendations all the features of a schema are kept in NSDE application *featureCollection*. It is made complex type (*nsde:featureCollectionType*) and belongs to the substitution group *gml:featureCollection* (acts as a placeholder in the definition of an actual element

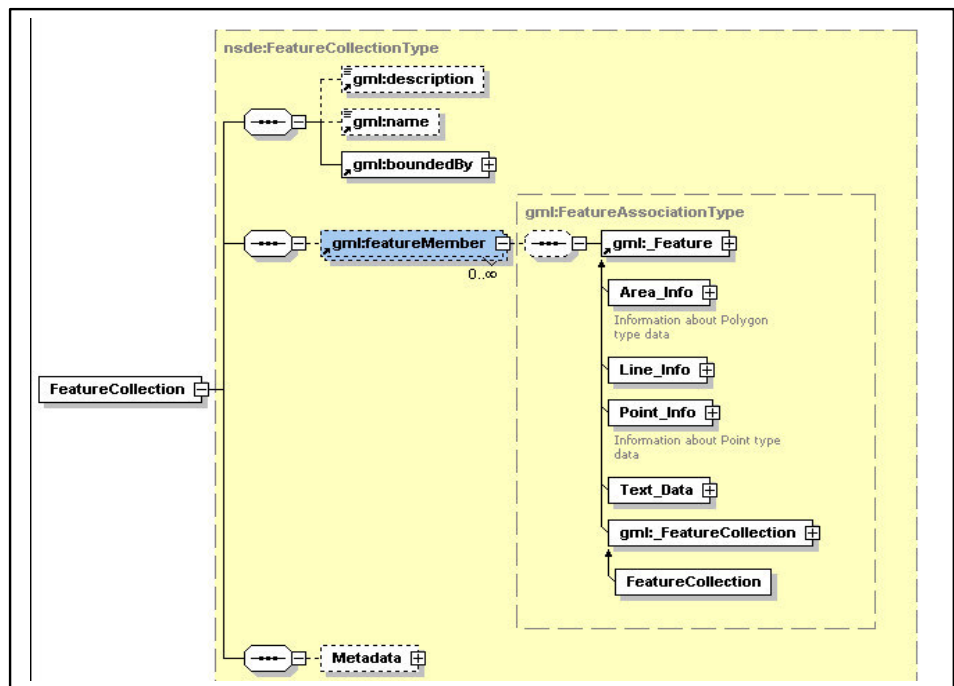


Figure 3 - Overall Feature Schema

Screen shot of XMLSpy

type) [See OGC specifications]. There are four application specific feature types (*Area_info*, *Line_Info*, *Point_Info* and *Text_Info*). These feature types are derived from *gml:AbstractFeatureType* and thus inherit the property of it. All these feature types have *gml:_feature* as the head of a substitution group [see OGC specifications]. Figure 3 is the graphical representation of overall feature schema.

Figure 4, is the graphical representation of the details for line feature type (Line_Info type). Area feature, point feature has similar structure with their specific properties of being a polygon and a point respectively. Each feature type has both attribute information and the spatial information. The attribute information elements are as per the application and for the spatial information

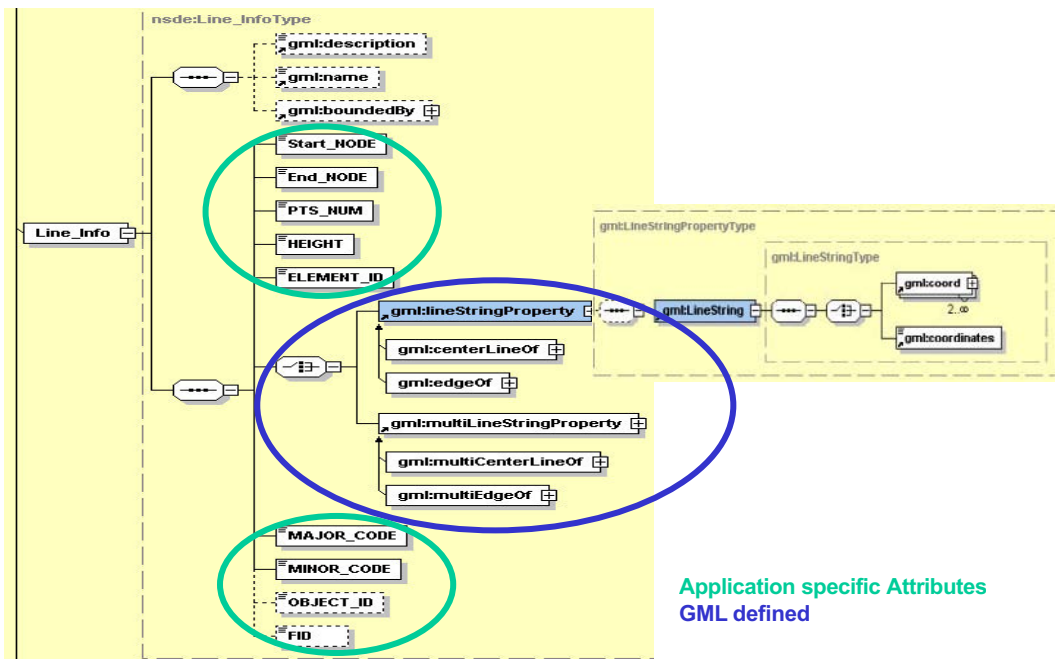


Figure 4- Line_Info details

GML tags are used.

NSDE to GML document Using Java:

Writing a GML document is as simple as writing a text file. For converting the NSDE data file to GML document, Java program is used, which read the NSDE file and writes a GML document similar to text file with the file extension “. gml”. The rational behind using java is that it is well known for being a platform independent language; it makes byte codes, which can run on any platform using the java virtual machine [Goldfarb, C.et al, 1998; Maruyama H. et al, 2001].

The output GML document is given in Figure 5: Here the first two rows in the figure above are the namespace declaration, next two lines are the

declaration of the schema to be used for the validation of this document. Then is the Line feature information detail with its attribute as well as coordinates.

nsde:FeatureCollection																									
xmlns:nsde	http://www.itc.nl/nsde																								
xmlns:gml	http://www.opengis.net/gml																								
xmlns:xsi	http://www.w3.org/2001/XMLSchema-instance																								
xsi:schemaLoca...	http://www.itc.nl/nsde/shp2gmltestMod.xsd																								
gml:boundedBy																									
gml:featureMember (10)																									
nsde:Line_Info																									
1	nsde:Line_Info																								
	<table border="1"> <tr><td>gml:name</td><td>Outer Ring Road</td></tr> <tr><td>nsde:Start_NODE</td><td>1</td></tr> <tr><td>nsde:End_NODE</td><td>7</td></tr> <tr><td>nsde:PTS_NUM</td><td>7</td></tr> <tr><td>nsde:HEIGHT</td><td>4400.</td></tr> <tr><td>nsde:ELEMENT_ID</td><td>1</td></tr> <tr><td colspan="2">gml:lineStringProperty</td></tr> <tr><td colspan="2">gml:LineString</td></tr> <tr><td>srsName</td><td>''</td></tr> <tr><td>gml:coordinates</td><td>1296840.24,3368704.39 1296427.27,3368558.64 1296014.30,3368024.21 1292007.13,3365782.31 1291162.92,3365310.00 1290784.10,3365098.06 1289916.97,3362242.67</td></tr> <tr><td>nsde:MAJOR_C...</td><td>34</td></tr> <tr><td>nsde:MINOR_CO...</td><td>1120</td></tr> </table>	gml:name	Outer Ring Road	nsde:Start_NODE	1	nsde:End_NODE	7	nsde:PTS_NUM	7	nsde:HEIGHT	4400.	nsde:ELEMENT_ID	1	gml:lineStringProperty		gml:LineString		srsName	''	gml:coordinates	1296840.24,3368704.39 1296427.27,3368558.64 1296014.30,3368024.21 1292007.13,3365782.31 1291162.92,3365310.00 1290784.10,3365098.06 1289916.97,3362242.67	nsde:MAJOR_C...	34	nsde:MINOR_CO...	1120
gml:name	Outer Ring Road																								
nsde:Start_NODE	1																								
nsde:End_NODE	7																								
nsde:PTS_NUM	7																								
nsde:HEIGHT	4400.																								
nsde:ELEMENT_ID	1																								
gml:lineStringProperty																									
gml:LineString																									
srsName	''																								
gml:coordinates	1296840.24,3368704.39 1296427.27,3368558.64 1296014.30,3368024.21 1292007.13,3365782.31 1291162.92,3365310.00 1290784.10,3365098.06 1289916.97,3362242.67																								
nsde:MAJOR_C...	34																								
nsde:MINOR_CO...	1120																								
2	nsde:Line_Info																								

Figure 5 – GML document

GML data visualization

As the GML document is simply a text file with well-defined tags of data elements. It depends upon the application how one wants to make use of it. So to visualize this data, it is to be transformed to a form, which can be interpreted by a graphic viewer like Adobe SVG viewer as plug in with HTML or available standalone desktop software [Neumann A. et al, 2001; FME; GML v2 Reader/Writer, FME; Quak et al, 2002].

Varieties of graphical render programs are available for the various XML graphical formats as: plug-in for the browser like (Adobe SVG viewer), native in the web browser, like Internet Explorer 5.0 + built in VML processor, stand-alone viewer like FME Universal Viewer, Ionic Software with java applet SVG viewer, or library of functions

For the demonstration purpose the GML data is viewed in following ways:

GML to SVG conversion using FME:

FME (Feature Manipulation Engine) universal translator is a product of Safe Software Inc. It can translate most of the popularly known formats to the other formats. So it supports the GML to SVG translation as well. The FME supports GML and has its schema defined according to GML 2, but to read and translate a generic GML application schema a mapping file is required, which communicates the meaning of user application schema to the FME application schema [Murray D., 2002; FME Mapping file]. With the help of FME universal translator the GML document can be translated to graphical formats like GIF, VML, SVG and most of the other GIS data formats. However SVG has dominating benefits over other formats, like XML, SVG is also plain text based data format so can easily be edited using simple text editors. Unlike other raster based graphic formats like jpeg and gif, which shows blurred image on zooming, SVG gives better clarity and sharp output. Besides Zooming, Panning, SVG has unparalleled interaction properties. SVG images can be styled to respond to users actions with highlighting, tool tips, and many special effects. In SVG the text remains text so the user can edit and search it easily. As SVG is XML based language so the querying for the particular feature is possible in SVG file. Animation and graphic filter effects in SVG make data more presentable [SVG 1.0 Spec.; Neumann A. et al (2001)].

The SVG output can be seen in Figure 2 as the colorful output map. SVG works at the feature level so each feature can separately be rendered. Same GML data can be presented in different rendering schemes using different stylesheets. Also the querying for the features can be done.

How Indian NSDI can benefit from this System?

The work is aimed to serve the Indian NSDI specified NSDE data file users. The GML application schema is primarily designed as per the NSDE format. So the NSDI nodes or any NSDE data file user can use this system for online exchange or transfer of data in a platform independent interoperable format (GML) by translating NSDE data to GML document. If this system can be connected with

NSDI servers then the NSDE to GML translated data can directly be uploaded to the server and the other nodes can take benefit of this data by downloading it through a proper channel by following the set of protocols recommended by Indian NSDI for data security. As online GML to SVG conversion is still at the research level so online GML to SVG conversion can be done offline and then the SVG file can be uploaded and viewed on web browser with the help of this system.

The platform independent, non-proprietary geospatial data exchange format GML and the high quality and colorful SVG map transformed from the GML-based data can attract the government and private sectors geo data users for using the existing data.

Conclusions

This paper introduces the issues of data interoperability, advantages of GML, its mechanism for data interoperability and the design issue of a GML application schema model for the exchange and sharing of spatial data in Indian organizations as per the Indian NSDI specified NSDE format.

Sample data of Indian NSDI specified national Spatial Data exchange format (NSDE) is taken for conversion from NSDE to GML. The GML application schema is designed as per the NSDE format [see NSDE format]. For the demonstration purpose an NSDE sample data is converted to GML document using java coding. For the GML data visualization SVG can be used. The SVG maps can be viewed on Internet Explorer and the Interactivity can be made as per the efficiency of the programmer.

As interoperability standard, GML allows us to bridge the gaps among different data sources, vendors, databases and formats. GML gives users the capability to easily and dynamically publish and exchange data in an open, non-proprietary industry-standard format on the Web, thus maximizing the re-use of geospatial

data, eliminating time-consuming data conversion and reducing associated costs. A range of programs on different platforms via the Internet can access the information. GML holds promise to lead an exciting interoperable future via online interactive Web maps and spatial Web services. But because the development of support software systems for GML-data is still at its beginning stage, the advantages of GML-based data are not fully adapted by GIS data providers. Only few data providers like Ordnance Survey UK and Dutch topographic data services have implemented the use of GML In the database.

As a new interoperability approach, GML still has some limitations. GML is not intended to solve all geo-processing interoperability problems. It still cannot fully solve the problem of semantic interoperability. For example, GML provides users the ability to create application schemas to model their data, but different users (i.e., data providers) may use different names to represent the same feature, one can design a GML schema with a *building* feature while another user may use a *house* feature for essentially the same entities. Thus the second user must know the schema created by the first user in order to integrate the data from the first user into his. The same problem arises in the case of software also, as software cannot read the entire range of possible schemas in the world and thus a mapping is required between the application schema and the software schema, otherwise users and software cannot fully understand what the GML represents without understanding these schemas.

The initiatives towards Interoperability are appreciable; still there is much to do. The real data Interoperability is to provide seamless communication between remote GIS databases without having prior knowledge of their underlying semantics. A real interoperable GIS database should provide transparent communications at data model and application semantics level [Bishr, 1998].

Recommendation

In the present scenario it is not possible to make full use of available software for GML data generation and GML to other GIS data format conversions. As these software do not support generic schema so cannot always represent the whole

meaning of the GML elements. However mapping between the user application schema and software application schema can be done partially, but then this is required to be done for all software. So further research is required for the development of generic GML reader and viewer. The high cost of proprietary GML reader and viewer software repels the use of GML, so to encourage the attitude of Interoperability among GIS data providers and users these software can be provided for free.

Indian NSDI specified data format is also not fully object oriented, as It is the early stage of its designing so it will be better if instead of simply line, area and points, the NSDE format is defined in terms of objects like ROADS, BUILDINGS etc. It seems that grouping some of the similar features distinguished by MAJOR CODE and making MINOR CODE as one of the attribute to distinguish features within the group can do this. So the semantic heterogeneity can be resolved to some extent by defining the feature names as Road, Building etc. Indian NSDI can use the proposed system for online exchange of data through a platform independent Interoperable format. However this can further be improved by making fully object oriented application schema and free source software for NSDE (GML) version to SVG conversion on the fly and most important is connecting this to the NSDI clearing house/ warehouse or server for geospatial data sharing.

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