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GeoDF: Towards a SDI-based PPGIS application for E-Governance

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Abstract

Research and development of Public Participation Geographic Information Systems (PPGIS) has been a branch of GIS study for more than a decade. Using WebGIS and communication tools for public participation, both citizens and municipalities benefit from a more efficient "24/7", GIS-enabled communication and information-sharing platform. PPGIS demands open access to information, and the success of such applications relies heavily upon the availability of appropriate geospatial information. The framework data and institutional mechanisms offered by (particularly local) Spatial Data Infrastructures (SDIs) have the potential to offer an open and ideal environment for PPGIS applications. This paper investigates the potential integration of PPGIS into existing SDIs to empower grassroots communities, increase citizen participation and enlarge the use of geospatial information by the general public.

Building on earlier PPGIS research conducted at UNB, a GIS-enabled online discussion forum (GeoDF) prototype is now being implemented as a pilot project in the City of Fredericton, New Brunswick, Canada. GeoDF enables citizens to provide more in-depth feedback to government through the use of enhanced, easy-to-use Web-based mapping and analysis tools. To facilitate effective communication and mutual understanding, the prototype supports the participants to submit and share feedback, as well as to initiate discussions about their concerns; participants can express their views not only with text messages, but also make sketches and annotations on the GIS map. Moreover, in order to better convey a participant's perspective, the map extent and the map layers that one is viewing is stored by the system and shared among the participants. Furthermore, the discussion contributions (i.e., the text messages, GIS map, sketches, and annotations) are organized and presented in such a way to facilitate the understanding of the evolution of ideas throughout the discussion process.

Discussions are already underway to employ future versions of GeoDF in a wider range of applications -- some potentially integrated with other web services which may also contribute to a local or regional spatial data infrastructure. This paper summarizes the process and lessons learned in refining and implementing this prototype. After describing specific benefits anticipated in extending the existing prototype to be compliant with Open Geospatial Consortium (OGC) standards, the authors discuss potential limitations of current OGC standards for SDI-based PPGIS applications. Developing such a system will help provide the infrastructure for more timely, direct, and informed citizen engagement in land management policy, planning and decision-making.

Introduction

Over the last decade, we have witnessed the growing applications of E-government, E-governance and Web-based mapping due to the Internet revolution. Many of these applications extensively use Information Communication Technology (ICT) tools to provide a whole range of services to citizens. Spatial Data Infrastructure (SDI) is recognized as the foundation of spatial data to be used in making better and more efficient decisions in the public and private sectors (Feeney 2003).

Public Participation Geographic Information System (PPGIS) is a field of research that focuses on the use of GIS by general public with the aim to involve them in decision making processes related to problems, projects, and programs in places where they live. The importance of "location" and "geographic information" makes GIS an essential component in applications dealing with planning and related topics. More and more PPGIS tools that facilitate community participation have been developed over the last decade and gain importance through community development applications.

PPGIS applications demand open access to information, and the success of such applications relies heavily upon the availability of appropriate geospatial information. The framework data and institutional mechanisms offered by (particularly local) SDIs have the potential to offer an open and ideal environment for PPGIS applications. However, in some cases, not all the required information exists in the SDIs for decision making. In order to make useful and valid decision while lack of required information, it is important to add community knowledge (Craig et al 2002) to make useful and valid decisions.

This paper presents the applicability and potential influence of geo-referenced online collaboration to more effectively incorporate community knowledge into the current PPGIS practice. After introducing GeoDF, a PPGIS tool developed at UNB, it then summarizes the process and lessons learned from refining and implementing this tool. The authors then investigate the use of information in existing SDIs to empower grassroots communities, increase citizen participation and enlarge the use of geospatial information by the general public.

Finally, the authors address the technical aspects of the potential integration of community knowledge provided by PPGIS tools into existing SDIs to provide more readily feedback to the data providers.

Public Participation GIS PPGIS research examines citizen engagement both from a technical and a sociological perspective. Public participation is a process that "allows those affected by a decision to have an input into that decision" (Smith 1993). Public participation has been one of the application areas in GIS. It generally refers to the use of GIS by the general public with the aim to involving them in the spatial decision-making processes (Schlossberg and Shuford 2006). Over the last decade, we have witnessed the growing online applications of PPGIS to facilitate community participation. Online PPGIS applications have been developed by different universities and research groups, such as Virtual Slaithwaite (Kingston et al 1999), Argumentation Maps (Rinner 1999; Keßler 2005), Dito and CommonGIS (Voss

2004). In this section, the authors present the current state of research in the field of PPGIS.

Evaluation of existing PPGIS applications In the course of the planning process, the planning problems and solutions evolve gradually as a result of ongoing discussions among the participants. It thus requires a platform that enables the exchange of views and ultimately accomplishes mutual understanding and consensus building among the participants. It is essential that the deliberation process is transparent to all participants so that they can understand each other's positions and make compromises through collaborative efforts. In other words, effective communication, mutual understanding and trust among the participants are essential prerequisites of the participatory planning approach. Tang et al. (2005) offers a detailed summary of key university-based research projects dealing with the use of Web-based systems in PPGIS applications. Table 1 lists and offers a Web URL to each of these projects.

Table 1 Web-based PPGIS selected for evaluation (Tang, 2005)

	Web-based PPGIS Project	URL
A1	Erie International Airport Runway Extension, U.S.	http://gis.csengineers.com/erie/viewer.htm
A2	Map Hackney, U.K.	http://www.map.hackney.gov.uk/HackneyMap.asp
A3	Planning the Portland Metro Area, U.S.	http://topaz.metro-region.org/metromap/metromap.cfm
A4	Orange County Interactive Mapping, Florida, U.S.	http://www.cityoforlando.net/public_works/esd/gis/interactive_mapping.htm
A5	Resource Management Mapping Service, Illinois, U.S.	http://space1.itcs.uiuc.edu/website/rmms/
A6	Siting Radioactive Waste Disposal Facilities in Britain	http://www.ccg.leeds.ac.uk/mce/mce-init.htm
A7	Shaping Dane's Future, U.S.	http://www.lic.wisc.edu/shapingdane/resources/resources-home.htm
A8	Virtual Slaithwaite Project, U.K.	http://www.ccg.leeds.ac.uk/slaithwaite/
A9	Consultative Development Control System, U.K.	http://146.87.107.105
A10	Redevelopment of Chapel Street, Salford, U.K.	http://www.ties.salford.ac.uk/pg/xiao/openspace-main.html
A11	Argumentation Map, Germany – developed by Rinner (1999)	Demo not available online. Evaluation based on Rinner's publications.

In the paper, Tang and her colleagues offer summaries of each project and assess from a technical perspective whether the current online PPGIS applications can meet the communication requirements arising from the participatory planning approach[1]. The evaluation criteria are derived from Rittel's principles of participatory planning (Rittel 1974). The evaluation results of Tang's earlier efforts are summarized in Table 2. This evaluation reveals that the existing applications have not yet taken full advantage of the spatial data handling capabilities of GIS in aiding the communication of opinions during spatially-related discussions. Moreover, most of the current systems have not put emphasis on meeting the communication needs of participatory

[1] In general, the principles of the participatory planning approach call for a planning process that involves both experts and non-experts (especially those affected by the planning project) at an early stage of the process. Refer to Tang et al.(2005) for further discussion.

planning. Improvement should also be made in the area of enabling the experts play the role of facilitators.

Table 2 Evaluation Matrix

Evaluation Criteria / Tools *(Applications)*	Enable experts to play the facilitators' role	Exchange of views	Documentation and sharing of evolution of ideas	Showing decisions in context to related decisions	Effective communication of spatial context
Email / feedback form *(Applications: A1, A2, A3)*	×	×	×	×	×
Email + sketching and annotation tools + map attachment *(Applications: A4, A5)*	×	×	×	×	✓
Email + Spatial Decision Support System (SDSS) *(Application: A6)*	×	×	×	×	×
Geo-referenced comments *(Applications: A7, A8, A9, A10)*	×	✓	×	×	×
Online discussion forum + Geo-referenced comments *(Application: A11)*	×	✓	✓	✓	×

The Prototype: GeoDF The GIS-enabled Online Discussion Forum (GeoDF) has been introduced by Tang as a prototype system for spatially-related discussions (Tang 2006). It intends to enhance communication by integrating an online discussion forum with a web-based GIS. In this prototype, the spatial context of each discussion contribution will be stored and displayed along with the text message with a view to facilitating the exchange of opinions and mutual understanding among the participants.

GeoDF Architecture Figure 1 shows the architecture of the GeoDF prototype. It is a web-based application that introduces the concept of spatial context to an online discussion forum with the support of a web-based GIS and a spatial database. The prototype is based on available components or modules instead of implementing an entirely new system from scratch. For example, ESRI's ArcIMS is selected as the spatial server whereas the online discussion forum is based on the open source bulletin board software, phpBB. The JavaScript sketching and annotations tools are built upon Bjorn Johansson (2004) and Walter Zorn's (2005) graphic tools. The map layers are file-based whereas the data from the discussion forum (i.e., spatial context and discussion contributions) are stored in a MySQL database with spatial extensions.

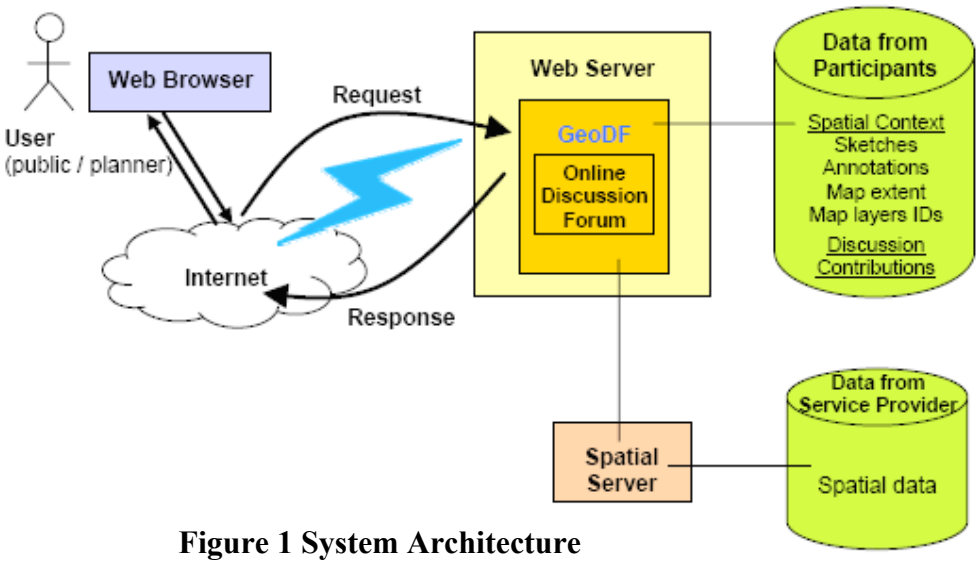

Figure 1 System Architecture

GeoDF User Interface and Functionality The target users are the general public. As the number of expected users will be in the range of hundreds to thousands, Internet, pure HTML browser, no plug-in is considered an appropriate implementation platform. Since the intended application is to support participants to discuss spatially-related issues and to track the evolution of ideas in an ongoing participation process, an online discussion forum will form an integral part of the system. Figure 2 is the main user interface of GeoDF. The right hand side of GeoDF is the WebGIS map viewer, left panel shows the tree structure of organizing discussion contributions by issues in reverse chronological order. When change to the online discussion forum view to post a new topic, users can choose the graphical representation (for, neutral or against) of their arguments.

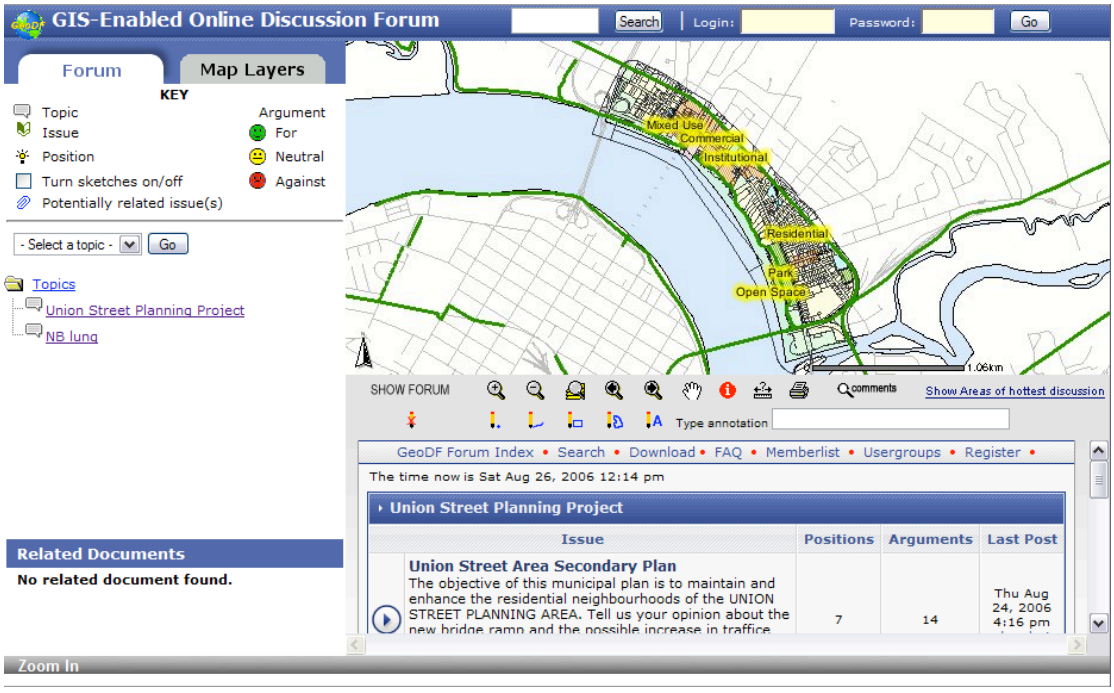

Figure 2 Main user interface of GeoDF

To support effective communication of spatial context, the online discussion forum is integrated with a web-based GIS. Spatial context in GeoDF is a collective term for the geographic extent, geographic features, geographic location and geographic relationships embedded in the dialog when discussing spatially-related issues (Tang 2006).

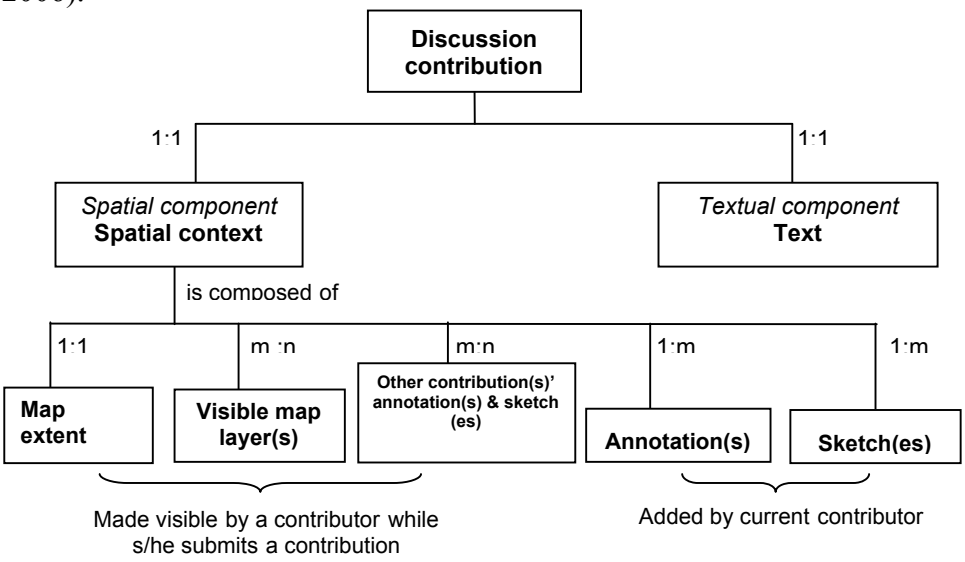

Figure 3 Concept of Spatial Context in GeoDF (Tang 2006)

As depicted in Figure 3, each discussion contribution in GeoDF is composed of two components, namely the textual and spatial components. This allows the contributors to share the spatial context information with each other and hence facilitate a fuller expression of opinions and a better understanding of each other's positions and arguments, as shown in Figure 4.

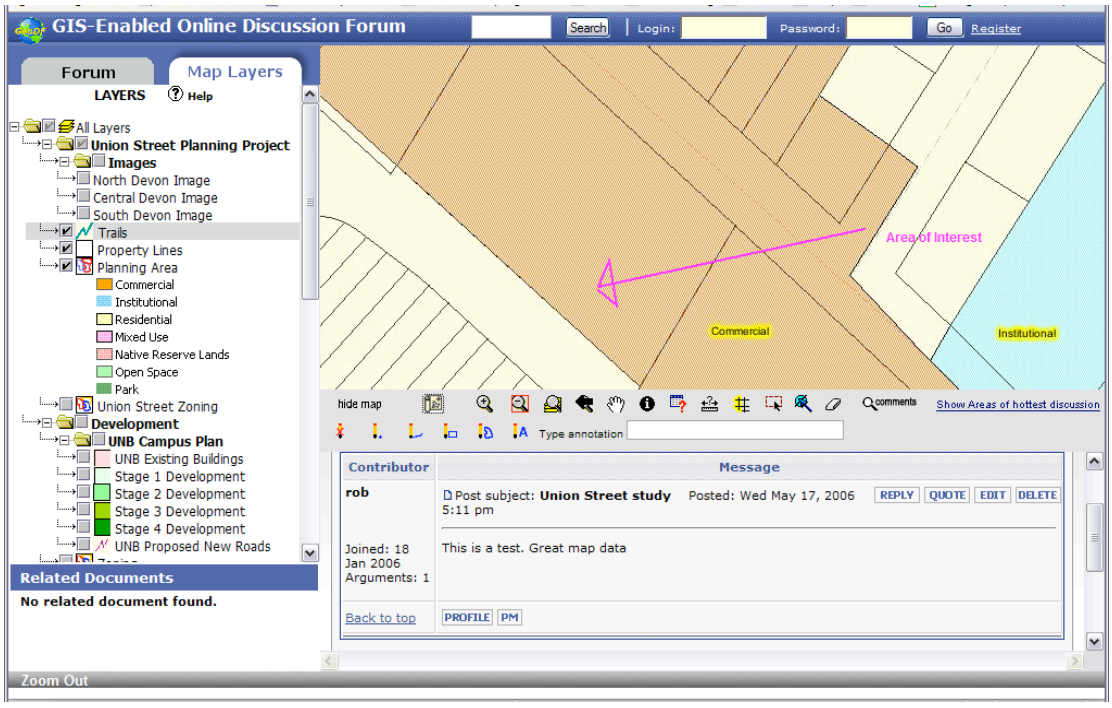

Figure 4 Spatial context of a discussion contribution

Although the usability of GIS products has improved immensely in recent years, they still require users to have or acquire considerable technical knowledge to operate them. Moreover, the emphasis of GeoDF is on facilitating communication and discussions, thus the web GIS is designed to support a light-weight application with basic browsing/querying, as well as sketching and annotation capabilities. It is also assumed that the majority of citizens are novice users of GIS and may not have the system administrator's privilege to install plug-ins. Thus, a simple HTML map viewer is considered appropriate and is compatible with a light-weight web GIS application.

As depicted in Figure 5, GeoDF users can trace the evolution of discussions and access individual contribution via the left panel under the Forum tab. With the Show Areas of hottest discussion tool, they can view at a glance which areas attracted the most discussion contributions -- the darker the gradient color, the more the number of contributions. The plan recipients can also view the distribution of contributions, and use the comments tool to retrieve contributions based on locations by dragging a box over a certain area and select which contribution(s) to display on the map.

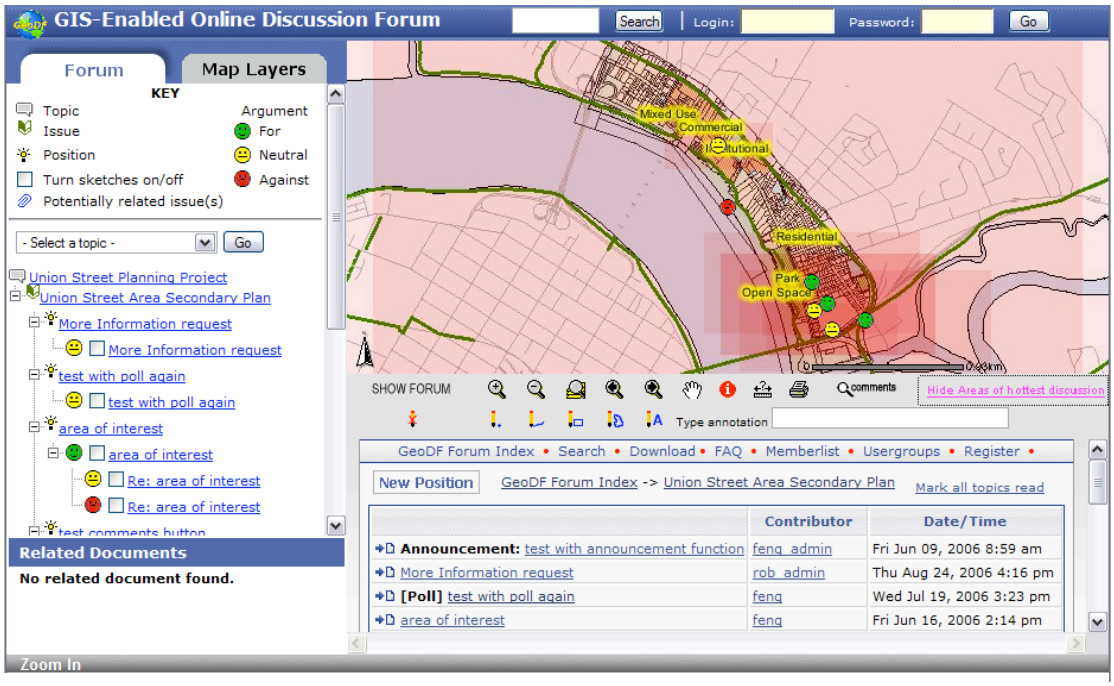

Figure 5 User Interface of spatial search for arguments (location of discussion contributions) and show hottest area of discussion

The Pilot Project The implementation of GeoDF has been continued as a pilot project -- with the cooperation of the municipal government of the City of Fredericton – to support the preparation and debate of the "Union Street Secondary Municipal Plan". The purpose of this project is to maintain and enhance the residential neighborhoods in a relatively older area on the north side of Fredericton. The reason why this secondary municipal plan was chosen is that it has the potential to generate intensive discussion and communications among the stakeholders. Within this project, opinions about existing problems and widely accepted recommendations are collected as valuable inputs for this municipal plan. A proposed new bridge ramp into the Union

Street area from the controlled access riverfront drive leads to possible increase in traffic through neighborhoods. Moreover, the demolition of older buildings to accommodate new routes adds to the debate over heritage and development.

In this scenario, there are three possible usages for GeoDF. First, GeoDF is used to gather useful spatial information from different data providers for a spatially-related discussion situation; Secondly, GeoDF is used to enable participants to express their opinion more effectively and facilitate participants to better understand each other's opinion; Thirdly, the text message together with the sketches and annotations can be viewed as citizens' resolution and recommendations for the proposed municipal plan; Last, the output gathered from GeoDF can be used by the municipalities and government as idea of citizens' major concerns and problems for the input of the final decision making process.

Lessons Learned The intention is to develop a system that could facilitate novice users to participate in the ongoing discussion of spatially-related issues. This requests for a platform that users should be able to join at any time, any location. However, for the purpose of proof-of-concept, Tang (2006) used the simplest setups for the prototype system, which included using available spatial components and discussion forum software instead of implementing an entirely new system from scratch, using the simplest database set up, using a large number of IE-dependent scripts, etc.

This setup was sufficient for the GeoDF prototyping phase. However, more issues are raised during the pilot project phase. Early testing and evaluation results pointed to issues in the following areas:

1. ***Data availability*** Both spatial and aspatial data are required for the set up of GeoDF. Spatial data are the map layers and associated attributes. As spatial data in GeoDF is file-based, map layers must be in shapefiles (*.shp, *.shx, and *.dbf) format because it is the only supported file-based format in ArcIMS. City of Fredericton has a Caris GIS environment. The data they provide is in Caris NTX format. Therefore, data has to be converted to ESRI shapefile to be used in ArcIMS. Besides, considerable data modifications have been made to improve the readability of the map data, such as simplifying the details, reclassifying detailed classes into broader ones, registering non-projected layers, and so on.

   Three digital orthophotos provided by the City of Fredericton cover the project area. The orthophotos were flown and generated in August 2005 to a resolution of 15cm. The original 24-bit images total 1Gb in size, which slows down GeoDF in transferring the data over the Internet. Modifications were made to clip the images to fit the study area and process them from 24-bit to 8-bit while preserving the original resolution.

2. ***Software licensing and maintenance*** For the purpose of proof-of-concept, ESRI's ArcIMS is selected as the spatial server. ArcIMS is one of the most popular map servers; however, it might not be the most appropriate map server for PPGIS applications. At the time the prototype was first designed, only ESRI ArcIMS 4 was on the market. When Version 9 is released, its improvement includes expanded support for the ArcIMS core capabilities of serving maps, data, and metadata, and support for Open GIS Consortium (OGC) Web Map Services

(WMS) are valuable assets for the future development of GeoDF in the context of public domain. However, the intended user groups are the general public and local communities, it is extremely expensive for the communities to host a proprietary Internet Map Server like ArcIMS and continue with renewing the software license.

3. ***Reusability and interoperability for different use case*** PPGIS applications can be found in urban planning, resource and environmental management, public health and so on. If any one of these sectors intends to use GeoDF for their community development, they will have to buy ArcIMS, install and configure it on their server machines.

   GeoDF system functions are developed on a proprietary commercial Internet Map Server. ArcIMS's HTML Viewer uses a dynamic HTML (DHTML[2]) page that provides numerous functions such as panning, zooming, layer selection, querying, buffering or measuring distances. Most of the GeoDF spatial context functionalities were implemented using Javascript on the client side as well. Therefore the client side platform is essential for GeoDF to fully function. For proof-of-concept, the prototype system did not consider the browser compatibility, the prototype simply worked with Internet Explorer on PC. Improvements were made for GeoDF to work cross browsers on PC, still not on Linux or Mac. Furthermore, the georeferenced discussion tool is designed according to ArcIMS specification and could not be reused in any other Internet Map Server or other applications. Therefore, our current configuration is hard to reuse for different use cases.

Benefits from Integrating PPGIS in SDIs PPGIS applications demand open access to information, and the success of such applications relies heavily upon the availability of appropriate geospatial information. Most of the current PPGIS applications setup is built on proprietary software; some of the tools have the ability to talk to Open Geospatial Consortium (OGC) Web Map Service (WMS) which use the WMS maps as background base maps (Keßler 2005). Keßler et al (2005) also started to "create the 'missing link' between PPGIS and SDI" in the context of SDIs. Keßler (2005) concluded that "SDIs provide a suitable environment for the integration of PPGIS applicatons".

The problems arises from the lessons learned in the pilot project testing phase can be solved to implement GeoDF as standards-compatible PPGIS tool with standards used in SDIs. The ability to access web services such as WMS, Web Feature Service (WFS) make the use of an Internet Map Server dispensable, which makes it possible for the communities to host a PPGIS system with no cost. Communities or organizations that hosts PPGIS systems can gather the spatial data from within an SDI, with detailed information on data availability, capabilities document and metadata, hence don't have to host any data on their server. The retrieval of data from WMS or vector data encode as Geographic Markup Language (GML) from WFS will simplify and accelerate data retrieval. WMS provides background maps and WFS provides feature level data manipulation which saves time on downloading the whole dataset but just the required features.

[2] The combination of HTML, Cascading Style Sheets (CSS) and JavaScript for manipulation of the Document Object Model (DOM) is often referred to as DHTML.

Besides the benefits of an SDI to PPGIS research, SDI-based PPGIS tools can also benefit standards-compliant servers in SDIs. Special data used for one PPGIS application can be shared within an infrastructure (Williamson et al 2003).The Output in GML format makes the reuse, exchange or sharing in different use cases more easily. The quality of the data can be checked by the local users and send detected errors directly to the data provider (Keßler 2005).

Current Status of SDIs in Canada and NB In Canada, SDI is described as an integrated online mechanism to deliver geospatial data, services and information for applications, better business and policy decision-making and value-added commercial activities (GeoConnections Secretariat 1999). Coleman and Cooper (2004) describe the partnerships involved between federal and provincial governments, as well as between the federal government and the private sector in building what has come to be known as the "Canadian Geospatial Data Infrastructure", or CGDI. Most parcel related data remains under the control and distribution of the provincial governments. In New Brunswick, local governments are typically responsible for providing large-scale imagery, zoning, and special-purpose utility and thematic data in digital form (Lunn 2005). The framework data and institutional mechanisms offered by some (particularly local) SDIs have the potential to offer an open and ideal environment for PPGIS applications.

Limitation of Current Standards OGC Reference Model (OGC 2003) describes a framework for the ongoing work of the OGC and their specifications and implementing interoperable solutions and applications for geospatial services, data, and applications. OGC standards cover a wide range of services and data, ranging from raster/vector maps, coverages and sensor networks to geoprocessing services, metadata and catalog (OGC 2003).

One of the major challenges of building PPGIS systems in the context of SDI is how to access distributed, heterogeneous spatial information across the borders, disciplines and sectors more effectively and efficiently. Heterogeneous spatial data usually don't match perfectly; data from SDI on regional, national or international levels have multiple representations of one object because of different scales; Data's heterogeneity at the level of data models and semantics can be found in data from different sectors and different disciplines. Unfortunately, there is no existing OGC standard for simplifying the usage of distributed, heterogeneous spatial data.

Another challenge rises from no existing standard for annotation. The key concept in the development of GeoDF is the concept of "spatial context" or "geo-referenced communication / discussion". The geo-referenced discussion tool in GeoDF is designed according to ArcIMS specification and could not be reused in any other Internet Map Server or other applications. No standard in map annotation also prevents the implementing of the system to be standards compliant. There was once an attempt to develop a standard called XML for Image and Map Annotation (XIMA). With XIMA documents, users can draw points, lines, polygons or any other kind of GML feature on an image to annotate a map (OGC 2001). Unfortunately, the development of XIMA has not been pursued any further.

Standards Compliant "spatial context" One possible solution is Geographically Encoded Objects for RSS feeds (GeoRSS). OGC has released the "OGC GeoRSS

White Paper" to the public in July, 2006. GeoRSS is simple proposal for "really simple syndication" (RSS) feeds to be described by location or geotagged. RSS has been used for news and blogs, it is a format for breaking a piece of information down into its atomic parts, like the author, date, headline and full content of the story (Source: Wikipedia). GeoRSS proposes a standardized way in which location is encoded with enough simplicity and descriptive power to satisfy most needs to describe the location of web content. GeoRSS is brief and simple with useful defaults but extensible and upwardly-compatible with more sophisticated encoding standards such as the OGC GML (OGC 2006). Figure 6 shows the general GeoRSS information model.

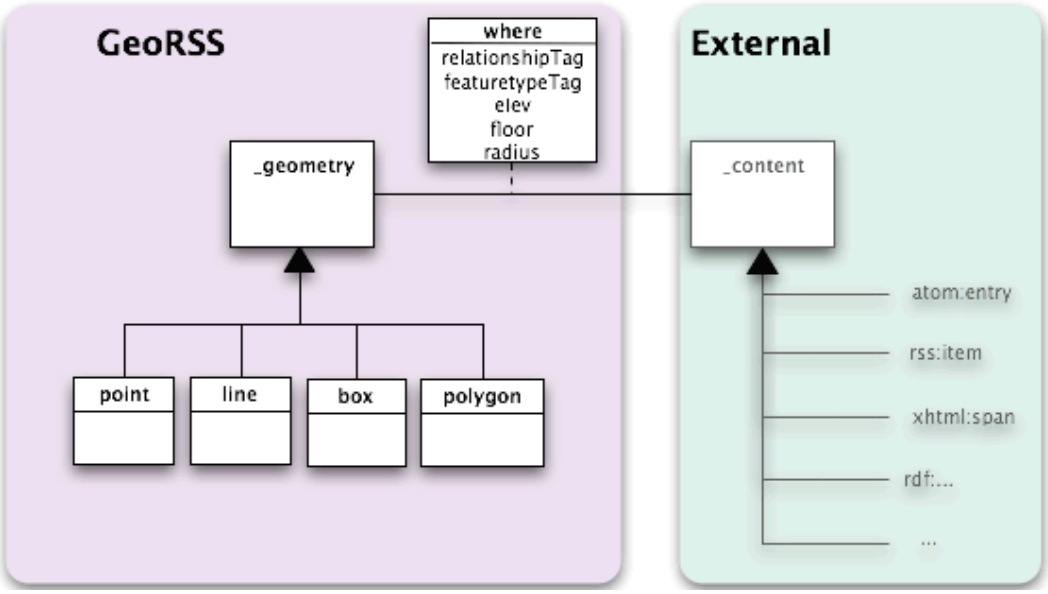

Figure 6 Gerneral GeoRSS Information Model (OGC 2006)

Towards the Future: New Development influencing PPGIS The current GeoDF prototype aims at developing a mapping based discussion tool to increase or enhance participatory planning. Our earlier testing result shows that building on proprietary software, GeoDF is hard to reuse for different use cases and the current implementation also limits the spatial data to be proprietary format, which is not an ideal implementation for public domain application.

Nowadays, the concept of Web 2.0 provides a new conceptual framework for PPGIS research. Web 2.0 refers to a supposed second-generation of Internet-based services that let people collaborate and share information online in perceived ways – such as social networking sites, wikis, communication tools and folksonomies (Source: Wikipedia). In Web 2.0, open standards and web technologies lead to some latest development in the geospatial field, some provide the ideal solution for public domain applications – open access to spatial information, online collaboration, sharing of information and transparent communication etc. Google Maps (http://maps.google.com), Microsoft Virtual Earth (http://local.live.com), CarbonTools (http://www.thecarbonproject.com) and Geoblogging (Singh 2004) are good examples of integrating existing web technologies with OGC services.

Location-based social networking Social networks would influence the adoption of PPGIS applications. Putnam (1993) claimed that civic responsibility and a greater sense of belonging come from social participation. People tend to see themselves validated, forming a strong and empowered community. Carver (2003) further suggested that it is necessary to focus on the social and cultural factors how people perceive decision problems and respond to them as individuals and as members of social groups.

In response to the social and technological phenomena occurring in Web 2.0, tools for visualization of online social relationships, known as "online social networking tools" have became available. In such tools, an initial set of users sends out messages inviting friends of their own networks to join the site. New members repeat the process, growing the total number of members and links in the network. Location is an essential tool for connecting people and places. Knowing the geographic locations of the participants is important in helping decision makers judge to what degree the influence of the participants' inputs are to the final decision. In a location-based social network, participants can share location-information about their neighborhood and connect directly with friends and neighbors Adopting the concept and technology of location-based social networking in PPGIS research will enable a PPGIS tool to have the capability to organize and geo-reference its participants.

Conclusion

This paper presented preliminary research results in the development and testing of an online public participation GIS system which integrates Web-based GIS technology and online discussion forum to enhance more effective participation. It introduced the concept of spatial context. The authors particularly highlight the lessons learned and evaluation results and lead to future PPGIS research in the context of SDIs. Developing such a system will help provide the infrastructure for more timely, direct, and informed citizen engagement in land management policy, planning and decision-making.

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