

# DEVELOPING A FLASH-BASED TOOL FOR GIS APPLICATIONS ON THE WEB

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## ABSTRACT

Geographical Information Systems (GIS) introduce methods and environments to visualize, manipulate, and analyze geospatial data. There have been growing demands to provide more diverse geospatial information through the Internet and to mobile devices through the so-called Web Services. Due to the voluminous geospatial data, limited communication bandwidth, and mobile device capability, it takes much time to transfer geospatial data from server to client. To transfer the geospatial data more effectively, the data size should be reduced while certain GIS Services capacity such as visualization and spatial querying to be retained. In this paper we will discuss our group's effort to develop and implement GIS Web Services Tool using popular Adobe Flash, which supports vector drawing with comparatively small data volume, Web animation and its programming capability enables to make a high-quality visualization of information in real-time on the Web. To solve the interoperability problems across organizations and providers, a standard XML data format is used. The paper presents preliminary results in applying the Tool for forest mapping and urban environmental mapping applications as well as future direction.

## Keywords:

Distributed Geographic Information (DGI), Web Mapping, GIS, Macromedia Flash, Forestry Applications, ...

## INTRODUCTION

While Geographical Information Systems (GIS) introduce methods and environments to visualize, manipulate, and analyze geospatial data, the spatial information generated are yet to transmit to and meet the needs of wide public, who are increasingly interested and actively participating in public decision making process. The typical cases could be: a Forest Management Agency may want to increase public accessibility to proprietary forest maps or a City People Committee wants to increase public involvement in an urban environmental planning process. For that purposes, Internet holds promise for exponential increases in efficiency and effectiveness of the ways we obtain, use and share geographic information in all its forms, including maps, graphics, text and data [4]. The emerging field of *distributed geographic information* (DGI) applications is gaining popularity among researchers and

GIS vendors, who are developing software evolving from simple raw data download, metadata search, data preprocessor to pre-drawn maps on a Web page (web mapping) and network-based collaborative GIS (e.g., web-based GIS query and analysis, net-savvy GIS software) [7]. Advantages of the Web Services in GIS area can be grouped into three categories: (i) *distribution* of geospatial data and applications across platforms, operating systems, computer languages, etc.; (ii) *integration* of geospatial functionality and data into their custom applications; and (iii) *infrastructure* being built to enable the Web Services architecture – including development tools, application servers, messaging protocols, security infrastructure, workflow definitions, etc. [2] Basically, the technologies being developed to make DGI applications possible include servers, clients and network communications (which control the flow of information between servers and clients). The classic model includes a client program (a *Web browser*), which makes a request to a server program, and the server processes that DGI request and returns the information to the client (Figure 1). As DGI applications normally require a great deal of computer processing, various server/client models are used to share the processing load and overcome limited communication bandwidth. Typical architecture of a DGI application to post maps on web is presented in Figure 1.

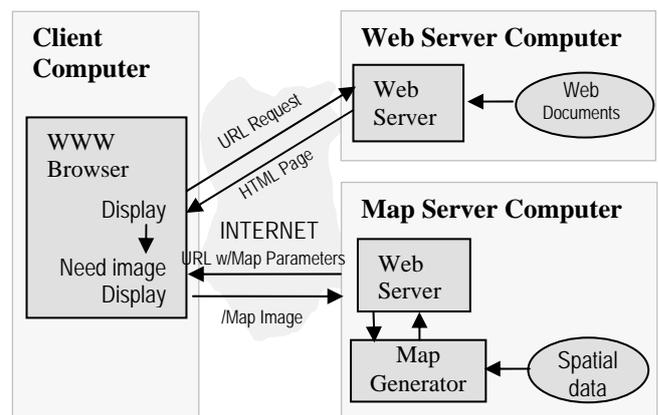


Figure 1. Architecture of a DGI site with remote map generator [7]

As maps are good media for communicating to both the expert and the novice, the most common way in which geographic information is distributed is through maps.

Thus, Web Mapping is the most important part of a DGI site. There are several approaches in Web Mapping ranging from simple static map display, dynamic maps browser to mapping with query and analysis. The static map display solution is to create map graphics (e.g., GIF, JPEG or DXF image) and distribute for viewing in a user's browser as part of an HTML document or by itself – no geographic processing at neither server nor client's browser. Dynamic maps are, on the other hand, drawn on the fly according to certain parameters, such as scale, location, and themes to be included. This approach is responsive and interactive providing maps on demand for diverse internet users. Technically, there are two ways to implement such interactive Web Mapping: (1) as bitmap images produced on-the-fly by a server specializing in geographic processing, and (2) as images drawn by the browser through specific interpreters / plug-ins. The first technique is the most reliable as it guarantees that the Web Mapping application will be viewable immediately by all browsers. Currently, most leading GIS vendors such as ESRI, Intergraph, Autodesk, MapInfo use heavy GIS map servers and specific applications on the Internet server to provide web mapping services. All geographic processing done at a heavy server, which is more efficient and easier to keep updated. In general, it is suitable for large-scale applications with large investment in strong map server, associated GIS software and sensible bandwidth. For small-scale applications, it may be a bit expensive and not so easy to implement. Also, it offers the least viewing quality, printing quality, display speed for large sizes and limited interactivity. In most of the cases, the client's browsers can not change the way maps are displayed. And every time when users zoom in on a map, a new request is made to server, and a new map is generated and returned to the user interface increasing network traffic.

The second technique, which transfers part of the processing tasks to the client workstation (most of interactive graphics processing). For that, browsers have begun to include supports / specific interpreters for Java applets, DirectX / ActiveX and plug-ins (additional client programmes of varying sizes and levels of cartographic specialization), which add functionality to the browser on demand. This growing alternative decentralizes a DGI server and remedies the heavy network traffic in practical applications. The geographic processing applets or plug-ins have removed the need for a special GIS software at the server (Figure 1), and increased the interactivity for diverse users' needs. It is suitable for small and medium-scale applications as expensive server, network and GIS software are not required. On the other hand, since it relies on a client browser, an entity that is by definition less uniform and controllable than a server, it must abide by three simple rules if it is to reach a wide audience: (i) a widely distributed plug-in; (ii) a reasonable plug-in size (under 1Mb, at worst); and (iii) guaranteed compatibility of the viewing technique (plug-ins, Java) with all browsers.

This paper presents our group's effort in developing Web Mapping with focus on light, inexpensive Adobe Flash

solution, which we are coupling to problems in forest applications.

## FLASH-BASED WEB MAPPING

### 2.1 Adobe Flash

Developed by Macromedia since 1996 and then, continued by Adobe since 2005, the Flash (SWF) file format was designed to deliver vector graphics and animation over the Internet. Although yet to be standardized by the World Wide Web consortium (W3C), the Flash swf format is a very popular format supporting web and mobile services [5]. Like other plug-ins, once installed, Flash supports many basic functions once and for all. A very efficient plug-in (weighing in at 400 Kb as compared to 2.3 Mb SVG plug-in, for example [2]) supported by all browsers, it was designed to meet the following goals:

- **On-screen Display** – It supports anti-aliasing, fast rendering to a bitmap of any color format, animation and interactive buttons;
- **Extensibility** – Can be evolved with new features while maintaining backward compatibility with older players;
- **Network Delivery** – The files are compressed to be small and support incremental rendering through streaming, so that can be delivered over a network with limited and unpredictable bandwidth;
- **Simplicity** – The format is simple so that the player is small and easily ported;
- **File Independence** – Files can be displayed without any dependence on external resources such as fonts;
- **Scalability** – Files work well on limited hardware, while taking advantage of more expensive hardware (with high monitor resolutions and bit depths) when it is available;
- **Speed** – The files are designed to be rendered at a high quality very quickly.

The Adobe SWF authoring tools are particularly effective in three areas: (i) support for creating animation and interaction without programming, (ii) integration of sound and video, and (iii) integration with server-side applications and development tools, both those of Macromedia / Adobe and others (including commercial products or open-source community's *ming*, *xml2swf*...). Flash starts to develop excellent integration with other web technology (e.g., ASP, PHP,...) and applicability of standard XML tools. This explains rapid evolution of Flash development community with more than 96% of the online population using Flash player in more than 400 million web browsers [5].

For development of GIS services on the web, Adobe Flash swf file format has distinct advantages, including:

- Programmable vector graphics (rather than raster) in web browsers – Vector-based web maps can include many forms of interactivity that are handled at the

- web browser with minimal need for refreshes from the server;
- Availability of event handling primitives that allow flexible design of interactivity;
- Support object-oriented / event-driven programming through *Action Script* (2.0 or 3.0) – Full access from a programming / scripting environment to the geometric and event models, so that arbitrary kinds of animation and interaction can be programmed and develop *Rich Internet Applications* (RIA);
- XML schema & database connection enabling the integration of spatial and attribute data in a distributed database for various GIS functionalities – The ability to query the server as needed for incremental updates to the map.

With all above-mentioned capabilities, Adobe Flash has major implications for GIS on the web with high level of flexibility and interactivity in web mapping for communicating geographical information to the web-browsing public at large. Based on the Adobe Flash architecture, our group has designed and developed the first prototype of Web Mapping application as described below.

## 2.2 Web Mapping: Architecture and Functions

In our development of GeoViet’s Web Mapping for forest mapping applications, we focus on *geographic processing services* providing operations for processing or transforming data in a manner determined by user-specified parameters. Through the use of Web Services, we are able to integrate GIS services with other families of services, including information, data management, and remote application execution and management.

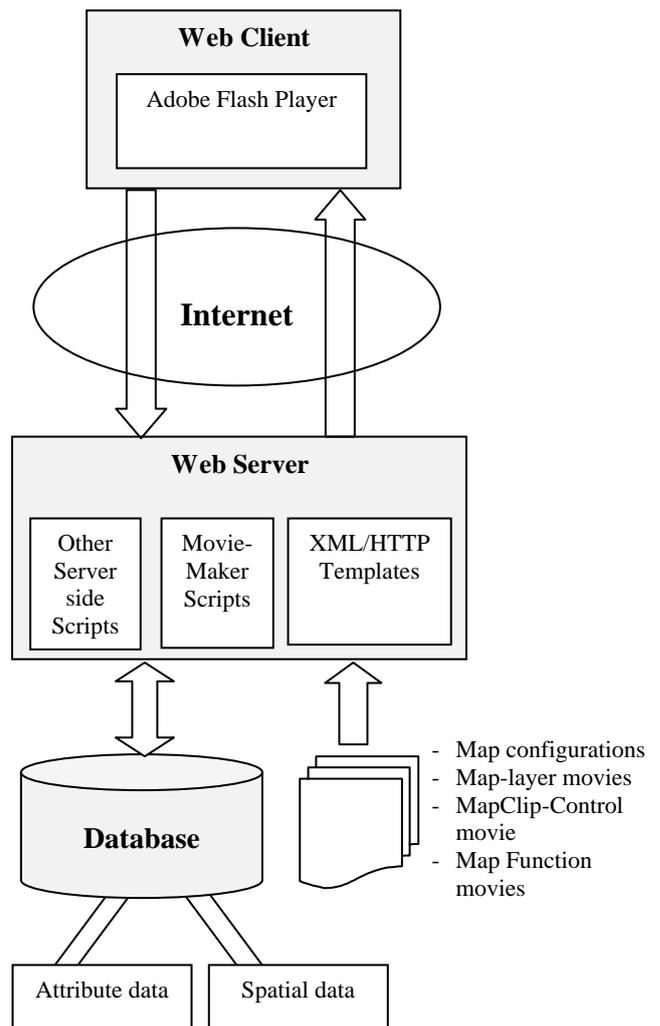
Similar to other GIS services, geographic information in our development is organized into 2 groups as follows:

- Spatial information – which is organized into a hierarchy of flash movies – each movie contains spatial features and then, each feature is again presented as a sub-movie. The movie can be created once at the beginning from map data (static movie) or generated dynamically through server-side scripts (e.g., ASP, PHP) running on spatial data in response to the request from client’s browsers;
- Attribute information associated with spatial features, which can be various (one spatial object can have numerous properties stored in columns in the associated database server). This information can be queried and/or changed the visualization of a spatial feature through interaction handler or scripts.

The overall architecture and functions of the Geoviet’s Flash-based Web-Mapping applications is presented in Figure 2. The system composes of:

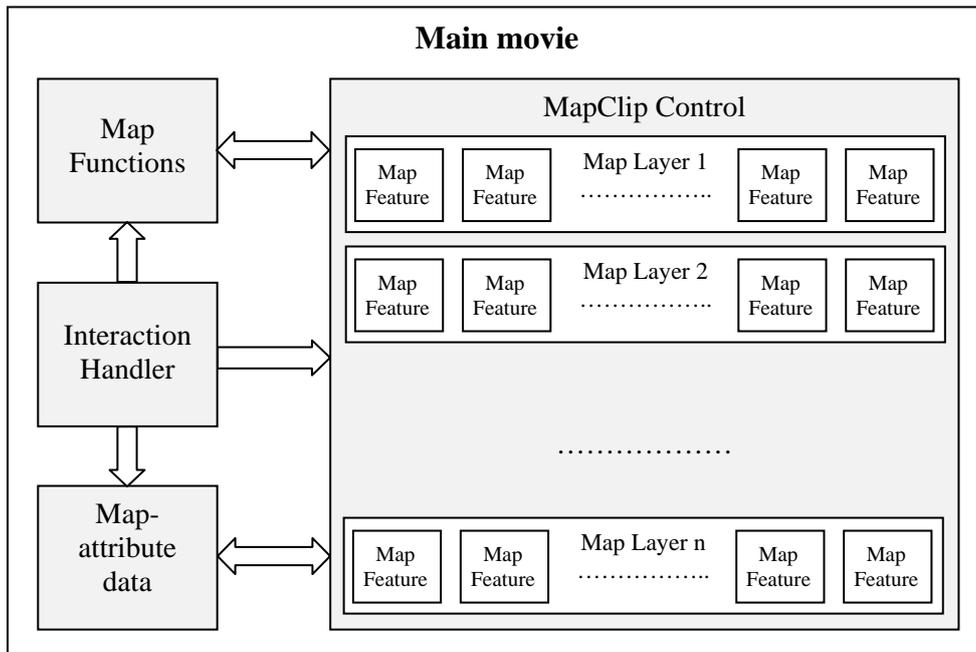
- **Web Server** – connected with a database server for managing the geographic database (maps and associated attribute data). The Web Server is equipped with following scripts or templates:

- *Movie-Maker Scripts*: for generating Map Layer movie when Server receives requests from Clients;
- *Map Configurations*: storing all configuration parameters for a map such as boundary coordinates, layers with names and properties...;
- *Map Layer Movies*: movies for base geographic information (static map - created once at the beginning of map loading process);
- *MapClip Control Movie* and *Map Function Movies*: objects – alongside *Movie-Maker Scripts* – to integrate movie maps and process all map functionalities on Web-browser interface;
- *Other Server-side scripts*: for querying, searching and retrieving attribute data on requests through database interaction (through XML schema).



**Figure 2.** Overall system architecture of the GeoViet’s Flash-based Web-Mapping applications.

- **Web Client** – through a browser with Adobe Flash Player – a free efficient plug-in. The Flash player basically acts like a GIS software to display the base map. It reads coordinates and transforms them within the coordinate system of the user's screen. It can zoom in/out and follow mouse movements to navigate the base map, etc.



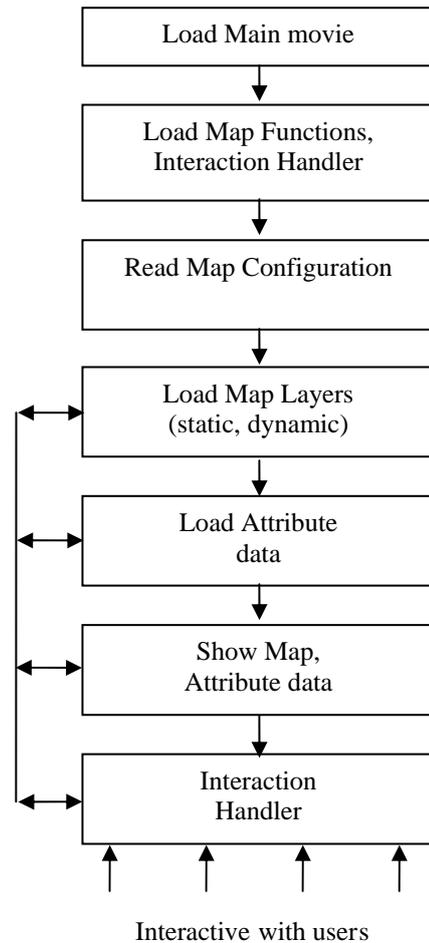
**Figure 3.** Design and structure of geographic information on Web Client / Browser side

On the *Web Client* side, the design and structure of geographic information organized as movies, functions with interaction handler (Figure 3) as follows:

- *Main Movie*: created from HTTP Template according to pre-defined map configurations;
- *MapClip Movie*: containing all map layers – each layer is a movie (either static or dynamic) downloaded from the Web Server. Each feature on a map is again a sub-movie with a unique identifier (ID) for linking with attribute data. Also, all those sub-movies are the subjects for interacting with users (e.g., on mouse click).
- *Map Functions*: responsible for all map processing functionalities such as zoom in, zoom out, pan, distance measurement, etc.
- *Map-Attribute Data*: Attribute data associated with those maps layers are read into the main movie through database service or XML socket. Attribute data are linked with spatial features within the *MapClip Movie* through their ID.
- *Interaction Handler*: to receive users interactive requests through the *MapClip Movie* and implement the respective *Map Functions* on spatial data (*MapClip Movie*) or attributes (*Map-Attribute Data*).

As the interactive geographic processing is handled mostly at the *Web Client*, our Web Mapper could reduce considerably the heavy processing load for the Server as well as remedy network traffic in on-request transferring of the map data.

Figure 4 presents the complete process from the moment an user makes an interactive request (e.g., with a mouse click) on the Web browser till (s)he receives needed response in forms of maps or feature properties as follows:



**Figure 4.** The Web Mapping process

- After getting required parameters from the user, Web Browser sends requests on geographic information to the *Web Server*;

- Based on XML/HTTP Template, the **Web Server** creates an appropriate website with embedded movies and transfer back to the requested Web Browser. Loading and processing steps are as follows:
  - First, *Main Movie* is loaded then, *Map Functions* and *Interaction Handler* and finally, the configuration file (*Map Configuration*) will be loaded;
  - Based on map configuration parameters, the *Main Movie* continues to load in map layers: for static movies, map layers are loaded directly from swf files; for dynamic movies, Web Server will call for *Movie-Maker Script* to query database in order to find and create needed movies before transferring back to the Web Client;
  - Attribute data in correspondence with maps layers are retrieved through connecting to the database and building a query (e.g., SQL query) using the parameters it receives from database;
  - On the Client's interface, geographic information is presented as maps (spatial features) or table/grid (attribute data). For example, each background polygon can be managed separately, by changing its colour according to the value of an indicator that is extracted on demand from the database. Univariate proportional symbols are drawn automatically on demand.

All users' interactive requests are received and processed directly by *Main Movie* at the Web Client, while for requests to re-load data (either spatial or attribute data) the *Main Movie* will send the requests to Server for new data loading and processing.

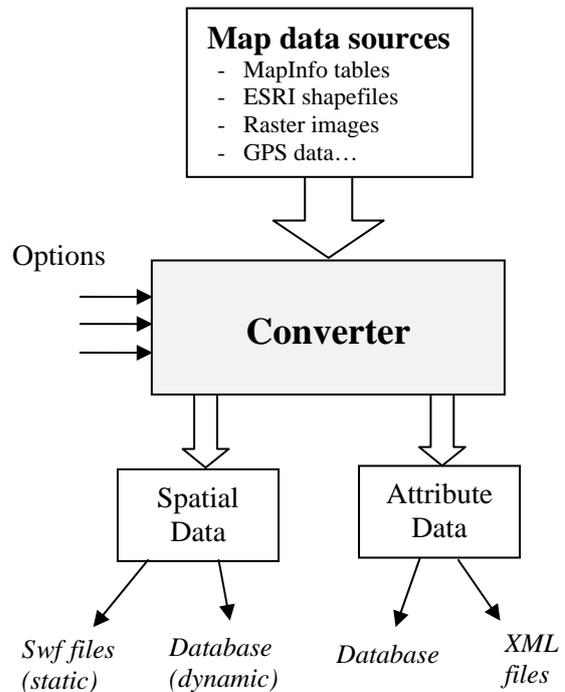
### 2.3 Web Mapping: Data Converter

Building a Web Mapping applications is usually inherited from GIS desktop services and based on existing geographic information available in common GIS format. Our system development also includes a *Data Converter*, which is used to convert GIS data from various sources (e.g., MapInfo tables, ESRI shapefiles, raster images or data from GPS survey, etc.) to prepare maps and associated data for the GeoViet's Web Mapper. The Data Converter module is presented in Figure 5.

For specific applications and depending on map data types / features complexity, optimal design of structure layers is conducted, then, layers are organized and converted into appropriate schema. For spatial features, the Data Converter can convert to 2 groups of layers:

- *Static layer*: convert directly into swf file movie;
- *Dynamic layer*: converter will retrieve spatial data from database – when a layer is requested, the *Movie-Maker Scripts* will query database and create corresponded movie;

For attribute data, the format acceptable to Web Mapper can be in database format and as XML files schema.

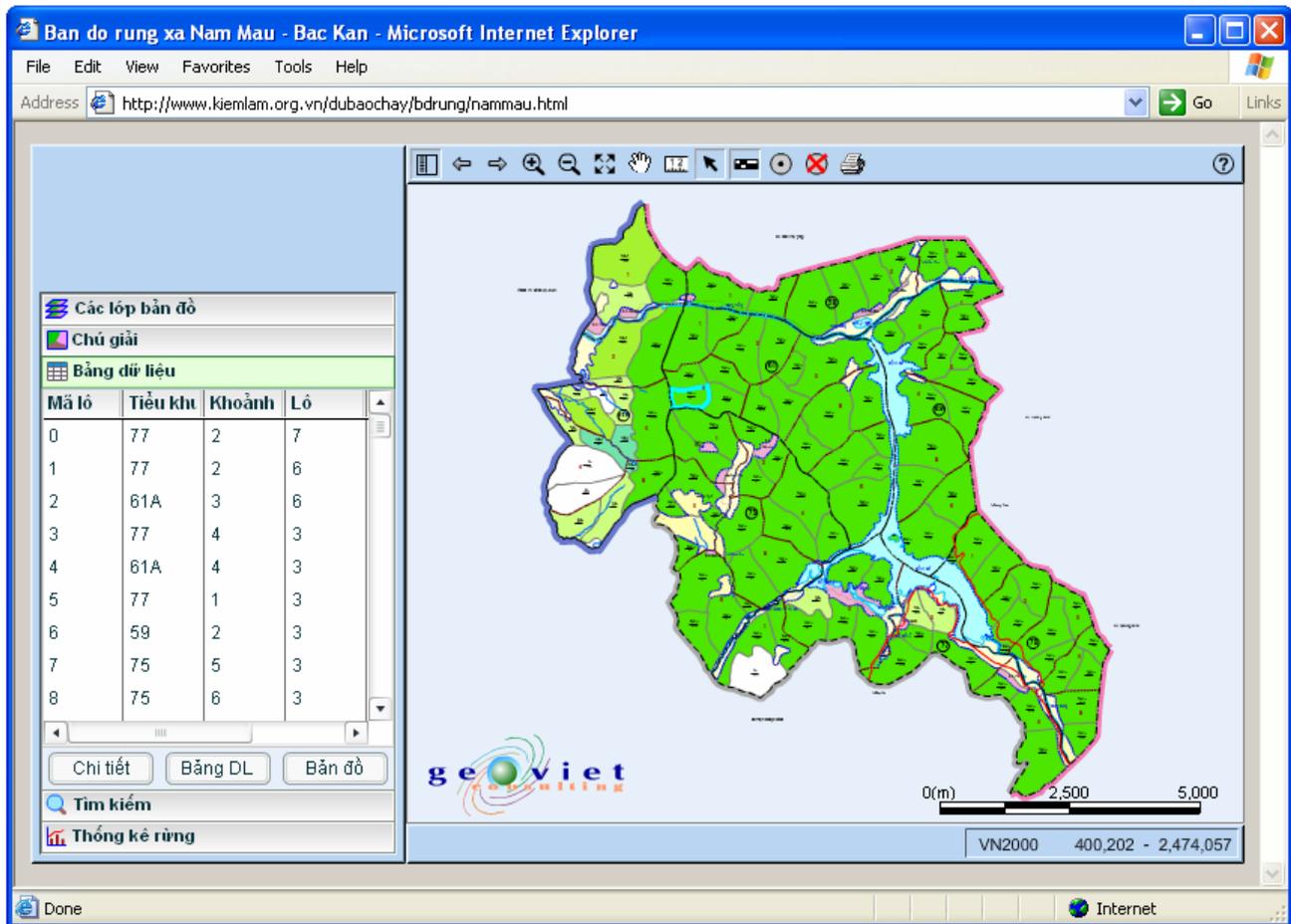


**Figure 5.** Data Converter module for the GeoViet's Web Mapper

### FORESTRY APPLICATIONS CASE

To strengthen the management of the country's precious forest resources, the Forest Protection Department (FPD, Ministry of Agriculture and Rural Development of Vietnam) is in the process to develop database of forest maps at the commune level [3]. Among the many objectives of this program is to increase public accessibility to proprietary forest maps in order to involve more local people in the participatory forest management while maintain the government authorities at various levels. Thus, a decentralized DGI site would be desirable, and the GeoViet's Web Mapper was designed and developed for this specific purpose.

The interface of the GeoViet's Web Mapper (version 1.0) is presented in Figure 6, which composes of a map frame and a left frame. The map frame is for displaying maps and for users to interact with spatial features (forest plots, administrative units, special locations, etc.) using combination of mouse and control icons. The left frame is for displaying legend, list of map layers, plots' properties (associated attribute data) and for querying and interacting with associated data in simultaneous linking with the map frame. The left frame also displays forest mapping statistics as a result of complex queries. The GeoViet's Web Mapper applied for managing forest data in the Nam Mau commune (Bac Kan province) currently uploaded on <http://www.kiemlam.org.vn/dubaochay/bdrung/nammau.html> and any user with internet access can interactively view and search for forest plots of interest and associated information. The details of users' interaction on the browser will be demonstrated at the Symposium.



**Figure 6.** Web Mapping for forest maps at the commune level using GeoViet's flash-based solution.

## DISCUSSION AND FUTURE WORKS

Based on a combination of Adobe Flash and XML schema, we were able to develop a first version of a Web Mapping applied for practical forest applications. It offers an extra-compact, efficient and inexpensive solution to distribute geographic information to wide public through web. The overall advantage is direct and flexible geodatabase access, no GIS software required on server while GIS Services capacity such as visualization and spatial querying were retained. As interactive geographic processing mostly done at the Client side, the processing load for Server is reduced as well as the network request/response traffic is lessened. No special Map Server required, our system can be installed at any ordinary Web Server. Using popular Flash swf file format, our system can perform most of basic functions of a Web Mapping application with specific strong features as follows:

- High-quality but compact graphics based on vectorial format that ensures a perfect on-screen zoom-in and printed appearance;
- Create cartographic images from all types of data, using appropriate viewing modes;

- Layers structure allowing a large amount of important geographic information to be displayed / hidden / interacted;
- Layers design and organization adaptable to specific applications so that the heavy layer is loaded only once as static movie;
- Highly interactive with a variety of Flash features allowing interaction with map features, graphics (zoom, pan, select, hide/show, overlay...) as well as associated attributes (select, query, summary...).

The GeoViet's Web Mapper is a work in progress and we plan to develop further as standalone applications with adequate on-line GIS services. As GIS services normally include data services [8], we are working on database integration so that the system could effectively provide and offer access to customized portions of the data for various group of internet users. The effective database connection will also provide us with solutions to other group of applications such as urban environmental mapping, statistical and thematic mapping (e.g., mapping of population density, poverty rates at commune level).

Technically, we are working to improve Web Mapper interfaces and performance including: automatic loading of geographic information according to the Zoom level as

well as requested level of maps details; and label features based on the Zoom level with label position automatically located. Further, data processing and analysis functions for geographic data will be developed such as: overlaying, on-line data entry/editing and adaptable thematic mapping.

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