

## **The Internet GIS Infrastructure for Interoperability: MAP(Mapping Assistant Protocol)**

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**Abstract.** Now there are many applications and researches of Internet GIS for effective sharing of spatial data. This paper describes problems in various service models and many requirements of the GIS services in the Internet. And it suggests the new Internet GIS infrastructure supporting the interoperable Open GIS including recent WWW standard technologies. Its requirements are secure communication, following standard specification of OpenGIS with the most suitable structure between client and server and including web technologies, such as extended markup, data cryptography and fully efficient transaction on the WWW. The suggested model is composed of the enhanced HTTP server with the GIS D/B access library, and the standard web client supporting display of spatial and vector data. The MAP server includes the own gateway to GIS D/B and communicates with MAP client by general HTTP connection. The MAP client changes to display the spatial dataset by a new mime-type from server, and the MapML(Mapping Markup Language) based on XML helps to display spatial data translated from WKS (Well-known Structure) from GIS D/B. The MAP client can browse vector data defined by MapML, which developed from a part of new standard by the Scalable Vector Graphic W/G of W3C. This model is implementing on apache server, amiya browser, grass database and MapML environment.

### **1. Introduction**

Recently it's going on studying and developing applications of Geographic Information System(GIS) and the Internet for effective sharing of spatial data. Most solutions is based on the client/server environment as like other internet applications. As monolithic GIS are developed toward distributed object computing, it is possible to query and display vector and raster data from the GIS database in the Internet. There are two implement trends,

server-side using Common Gate Interface(CGI) pushing raster data by GIF/JPEG and client-side using Plug-in, Java, ActiveX.

But they have some limits in the extensibility and availability, and don't satisfy requirements of many GIS managers as well Internet users. The reason for no implement standards is not only to process spatial data in the Internet but to include various specifications between Internet and GIS. Although many GIS vendors and researchers suggest their own Internet GIS solutions, it is difficult to make interoperable specifications among them.

Since 1995, the Open GIS Consortium(OGC) have developed OpenGIS projects which define a comprehensive suite of open interface specifications that enable developers to write interoperable components that provide these capabilities for the transparent access to heterogeneous geodata and geoprocessing resources in a networked environment. Recently, some specifications have been suggested based on object-oriented service model of the OpenGIS including OLE/COM, CORBA (Common Object Request Broker Architecture and Specifications) and SQL, but there is no public specification in the Internet and world-wide web until now.

The purpose of this paper is to define many requirements of the GIS services on the Internet and find what problems in suggested Internet GIS models. And it suggests the new Internet GIS infrastructure called the MAP(Mapping Assistant Protocol) model what supports the Open GIS interoperability including WWW standard technologies. Also it contains recommendations of the World Wide Web Consortium(W3C) about the markup language and includes recent activities of the scalable vector graphic working group in W3C.

## **2. The Analysis of Internet GIS Models**

### **2.1 Developing Trends**

There are two trends to approach integration between Internet and GIS. One is vendors, ESRI (MapObject Server), Autodesk (Map Guide) and Intergraph (GeoMedia). They have developed their own techniques with their data format and GIS systems, which display spatial data to the web browser, plug-in program and client program via web server or its application based on HTTP(Hypertext Transfer Protocol). They are based on PC environment (WindowsNT), have a good user interface and show rapid data-access speed. But, it's dependent on their product, operating system, and own data-format. Also they still have the limitation of a static web service because of HTTP based-model.

Smaller vendors and academic researchers have been concentrated on a Java-based mapping system such as ActiveMap, Jshape, and GeoStar. They have their own Java class

APIs supporting many functions for displaying vector data (zoom in/out, pan, query and search) and raster data (base map). Once user connects web page via HTTP, he downloads Java applet or application, the Java program connect to GIS D/B server via Java Database Connectivity (JDBC). The Java program acts independently within the operating system and can implement various custom functions. But, the speed of this is still very low and has bad user interface compared to windows program. Also the data format is dependent, therefore, it's difficult to implement many products by vendors unless the class library is opened. There are many patterns according to their platforms, Table.1 shows these various models by Java platform or their own application, plug-in program or web browser.

**Table. 1** The classification of Internet GIS based on its platforms (E: exclusive application, W: web application, J: Java program)

	I	II	III	IV
Browser	E	W	J	J
Server	W	W	W	J
GIS D/B	E	E	E	E
Example	Map objects GeoMedia	Xerox Map Map Guide	Jshape ActiveMap	GeoStar WebGIS

In the case of the WEB-GIS model, there is the spatial engine made by Java language and the Java applet of remote user communicates with GIS database via this engine. Of course, the ESRI have developed Spatial Database Engine (SDE) to integrate their GIS systems.

## 2.2 Problems and Requirements

The main problem of existing models is the lack of an optimum structure between server and client with a good performance and easy linkable structure with Internet technology. So many developers must design and customize their system to show spatial data to users, also users have to install other specific applications to view them. Therefore, they don't have a systematic frame because both Internet and GIS technology was intermixed in client/server environment. Internet technologies including WWW are rapidly developed, namely HTTP, Extensible Markup Language(XML), Socket Secure Layer(SSL) is very available to circulation of spatial data. If we don't conjugate with them, it will be separated.

Also there is no satisfactory specification to the Internet environment of OpenGIS which offered only specifications of OLE/COM(Windows platform), CORBA (Java platform), which is independent on platforms, implement language and location of objects in distributed computing platform and SQL (Database platform). But, CORBA isn't

compatible with the Internet environment, in aspects of data transferring and security. Java and HTTP-NG are only method to combine web and CORBA. In case of OLE/COM, it depends on specific platform, ActiveX technology. Therefore, detailed discussions are required of the compatible development between web and OpenGIS. In summary, some requirements exist for spatial data services using web, which is different with other client/server systems.

First, it must be based on the standard protocol. Many local networks protect their own systems using firewall solution, so it helps not only to pass the firewall but also to elevate the stability in communication between server and client. Especially, HTTP has made advances by adding various Internet services using server API. Second, it must be based on WWW environment. It means that infrastructure must extend web browser or server. Most web browser don't support map displaying tools, for example, zoom in/out, panning and thematic mapping etc, so many models cannot help using Java applet, plug-in and ActiveX technology. In the case of web server, it usually has to connect GIS D/B using CGI.

Thirdly it must have rapid speed. And it has to include data compressing and cryptography, a graphic markup-language to display the vector graphics, and client caching of them. Fourthly it must be safe in communication on Internet. The standard protocol based on Internet, the TCP/IP is always exposed in hacking such as sniffing. So it must use cryptographic protocol for data security as like SSL in the web. Also it's necessary to use user-certificate authority and digital sign technology of the electronic commerce for selling and buying spatial data on the Internet. Fifthly it must design open client to use open API according to standard specifications such as OpenGIS and W3C recommendations for interoperability in distributed computing environment. Sixthly it must have an easy user-interface without downloading and customizing.

**Table. 2** Implement methods of Internet GIS. Italic items are components of proposed model.

Implement methods	
Browser	Image map, Java, ActiveX, Plug-in, <i>Graphic Browser</i>
Server	CGI, ASP (Active Server Page), CORBA, <i>Web Server API</i>
Protocol	OLE DB Interface, CORBA IIOP, JDBC, <i>HTTP</i>
GIS D/B	OODBMS, RDBMS + Spatial Engine with Open GIS SQL Spec.

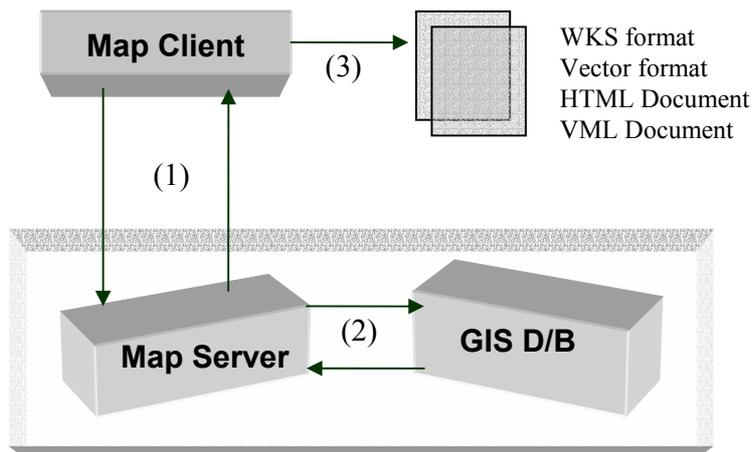
Table.2 shows various combinations of implement methods by systems. In this paper, the proposed model, MAP extends functions of existing web browser and server to add graphic library and server APIs to satisfy OpenGIS model. A protocol uses enhanced HTTP1.1 including packet message of GIS data which accessed by server modules.

### 3. Proposed Model : MAP

The new infrastructure is based on standard WWW interface which have been developed in the largest service network. The existing models cannot come up with developing speed of WWW. Many web technologies have been rapidly suggested for various services, in case of the desirable Internet GIS model, it must take in these technologies. It is made up of three parts. They are enhanced HTTP server with GIS D/B, web client with displaying vector graphics and a new markup language, MapML(Mapping Markup Language) for compartment and transferring spatial data.

#### 3.1 Overview of MAP

The Mapping Assistant Protocol (MAP) is defined enhanced HTTP for exchanging GIS data. This have following processes for data communication in the Internet. (1) MAP client requests specific document to MAP server. It's possible to use either HTTP or MAP. (for example, map:// + server : port number / + document). MAP server checks mime-type of a request. If it is HTML, server sends HTML document and if it's MAP, it does the GIS dataset written by MapML. The MAP client lays out windows to display vector data by given Document Type Definition(DTD). (2) MAP client requests vector data blocked by given data-set, server gets these data formatted by Open GIS or documents converted by MapML from GIS D/B and sends to client. (3) MAP client displays graphic data such as vector format or WKS format and XML or HTML document.



**Fig. 1** The structure overview of MAP.

In first stage, MAP client sends a request to server, the response of server is different along to mime-type. In case of a general request except text/xml, it is the same with a general HTTP connection. If it is text/xml and client gets MAP dataset written by MapML, this changes layout for vector plotting. This document sets the client and it requests vector data to server.

```
MIME type Extension
text/xml          map mapml
application/x-mapd-wkb  wkb

Request Example case
GET /index.map MAP/1.1
From: scyun@www-kr.org
Referer: map://my.gisdata.com/index.map
User-Agent: Mozilla-Map 1.2
. . .

Response Example
MAP/1.1 200 OK
Server: MDMA/0.1
Content-type: text/xml
Last-Modified: Thu Jul 7 00:25:33 1994
Content-Length: 2003
. . .
```

The MAP server connects GIS D/B with internal database functions made by the SQL spec. of OGC. Both server and database are able to share their components, so its performance can be elevated. The data format of both is WKS(Well-Known Structure) and MapML for scalable vector graphics. Some features in the OLE/COM spec. of OGC play important role in client functions, because it offers standard to display and plot vector data.

Some vendors joining W3C, Adobe, Microsoft and Autodesk suggest Vector Markup Language(VML) to display a line, polygon and flowchart on the web browser. This includes layer, zoom in/out and pan, important features in GIS. The activity of Scalable Vector Graphics, W3C will improve plotting vector data, so we would offer GIS services on the web without another standard or application. It's essential that various GIS features and geographic elements must be included in this markup language. The MapML is part of this markup language, which defines and implements custom tags by XML (Extensible Markup Language).

### 3.2 MAP Server

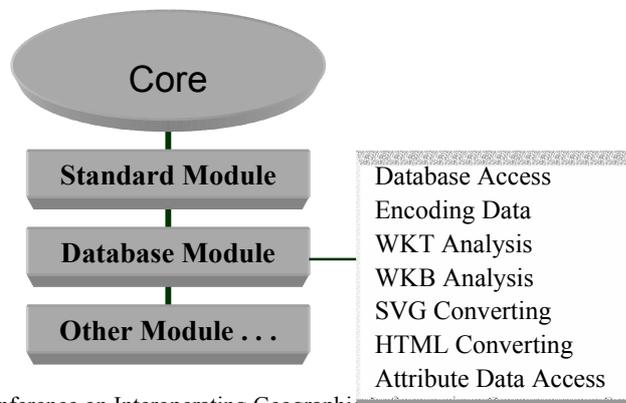
The HTTP is an application-level protocol for distributed hypermedia information systems, the Internet. It is a generic, stateless, object-oriented protocol which can be used for many tasks, such as name servers and distributed object management systems, through extension of its request methods. A feature of HTTP is the typing and negotiation of data representation called mime-type, allowing systems to be built independently of the data being transferred. In version of HTTP1.1, proxy server and caching, commercial usage and authentication

In the Apache web server that supports HTTP 1.1, it is possible to add server APIs and extend functions as these modules, so it's very easy to extend functions of HTTP. A following code expresses `wkb_handler` to process a request of client in map modules of Apache server. The `wkb_handler` makes a WKB file requested by client from database.

```
int wkb_handler (request_rec *);

    handler_rec wkb_handlers[] = {
    { "application/x-mapd-wkb", wkb_handler },
    { NULL }
    };
```

Various modules were designed to process requests of client in Map server. The database module follows the OpenGIS SQL specification and reads and converts spatial data to another format, WKS, SVG and HTML.



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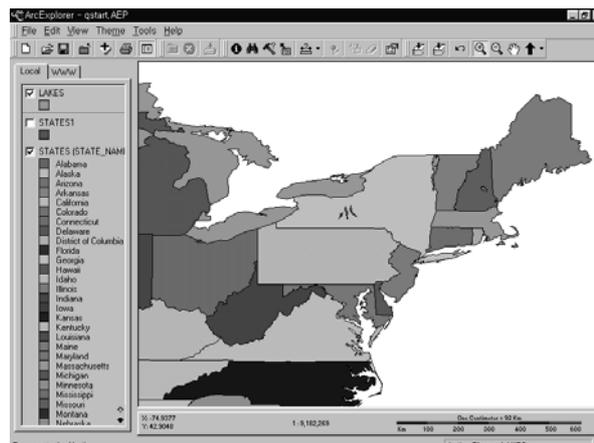
**Fig. 2** MAP modules in the Apache Server structure.

The MAP is able to integrate to web service, adding mapping information in packet message and database access and data format-analysis modules to Apache web server. Also, it would be applied to electronic commerce of spatial data through authentication and certificate authority of users and clients, data security by SSL. The MAP is designed allowing compatible functions with HTTP, it can process web requests too as like other web servers. Especially, attributing data of database would be converted to HTML-type in server by hyper-linking of vector data from MAP client.

### 3.3 MAP Client

The MAP client must have extensible functions in web browser and requirements are as followings. (1) Program components and library for dynamic mapping and vector graphics. (2) Linkage between vector and attributing data based on HTML. (3) Function of zoom in/out, panning, query, layering and thematic mapping. (4) Cryptographic communication using SSL.

The MAP client supports MapML and SVG(XML/VML) to show web documents and display vector data together through easy GUI-environment. To implement this, it's possible to add vector graphic library to open browsers such as Mozilla (Open Netscape Source) and Amiya (W3C Open Browser). The ArcExplorer and Mapobjects of ESRI is good example to this model.



**Fig. 3** The client interface of ArcExplorer, GIS data viewer of ESRI. This has various functions and menus for display vector data and

In this research, the MapML DTD was defined and we are implementing graphic components and XML viewer to show XML documents by MapML DTD. An example of polyline is as following.

```
<!ELEMENT polyline EMPTY>
<!ATTLIST polyline
    points          CDATA          #REQUIRED
    with            CDATA          #IMPLIED
    gname           CDATA          " "
    arrowhead       (none|start|end|both) "none"
    align           (left|center|right) #IMPLIED
    valign          (top|middle|bottom) #IMPLIED
    curve-type      (dotted|dashed|solid) #IMPLIED
    linewidth       CDATA          #IMPLIED
    width           CDATA          #IMPLIED
    curve-colour    CDATA          #IMPLIED
    height          CDATA          #IMPLIED
    position        CDATA          #IMPLIED
    style           CDATA          #IMPLIED
>
```

### 3.4 MapML

The MapML is an application of XML which defines a format for the encoding of vector information together with additional markup to describe how that information may be displayed and edited. This works is processing in part of Scalable Vector Graphics Working Group in W3C. They prepare enhanced vector graphics model in web browser. This will support many data format and simple chart. This is followed by detailed technical definition of the behavior of every SVG element and the permitted and recommended behaviors for all applications.

Vector graphics: line segments, closed filled shapes, Curved elements, Text, ISO 10646 repertoire, font selection supporting CSS/XSL, Truecolor mode, Layering, stencilling/masking, Include raster data, controlling of symbols etc.

Interaction and Dynamic Behaviors :Zoom and pan, Pick single elements, Switching layers, Element grouping into semantic structures, Active menus on pick, linking to other views / other pictures in same file and external media (URL embedding) and etc.

~ Metadata: Desirable that the metadata be readily extractable by search and indexing engines, also by browsers (on the fly html generation), Author, title, copyright (Dublin core), Aspect ratio, physical size for stand-alone print, mapping scale, geographic coordinates, scale factor and GIS format etc.

~ Authoring tools: There should be wide cross-platform support in existing content creation tools which should be able to export the format; preferably re-import it for additional editing. Additional tools for metadata and link editing are desirable from spatial database and vector data.

Simple code of MapML sets browser interface. As following codes show to display the map of Korea.

```
<mapml>
  <map name="Pusan, Korea" coord="38 127, 43 134"
    scale="2" bgcolor="blue">
    <layer name="coastline" color="Red"
      src="map://x.x.com/coast.wkb">
    <layer name="river" color="Blue"
      src="map://x.x.com/river.mapml">
    <basemap name="topology" alt="Basemap"
      src="map://x.x.com/krbase.tif">
  </map>
</mapml>
```

Complex codes for vector graphics were submitted to W3C, such as VML, PGML and Webschemics (See the references).

## 5. Summary

The MAP model optimizes a performance of client and server and includes recent trends of web, also systems are composed of open API followed implement specifications of OGC and W3C. Because this is compatible with HTTP, it is possible to display web page and attributing data converted from GIS database and to pass secure data through authentication and cryptography. The basic protocol of this model is HTTP1.1. The server includes database access modules and analysis modules converting various vector formats to MapML format. The client is possible to implement XML with the vector graphic library. This infrastructure is programmed in Apache web server, Amiya browser and Grass D/B based on MapML which is expressed by Open GIS elements through the scalable vector graphic draft of W3C. The suggested web-based Internet GIS model by

this paper will be good example for effective sharing of spatial data between offers and users, because this is focused on the Internet technologies and environment.

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