Realization of data sharing as an approach to disaster with the Digital Japan Web System

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Abstract

The Digital Japan Web System is a web mapping system which realizes the concept of Digital Japan: "Anyone can make a map of any location at any period at any time using anyone's data." Digital Japan requires a set of framework geographic information which is freely and rapidly available with high cartographic quality, and a simple way to provide any type of thematic geographic information. Digital Japan Web System has been implemented to meet such requirements and is available for general use. More than 200 applications of the Digital Japan Web System have recently emerged.

In Japan, where there are a lot of natural disasters, rapid and precise responses to disasters are needed. Systems to meet such needs are implemented with the Digital Japan Web System.

1. Introduction

Map information is useful for almost all human activities. It is especially necessary for land management. The Geographical Survey Institute has traditionally contributed to the restoration and formation of Japanese land use, infrastructure and transport.

Since the Internet appeared on the scene in the 1990s, the Geographical Survey Institute has been pursuing a way to use its geographic information at a higher level using the Internet. The Geographical Survey Institute has proposed the concept of Digital Japan, which shows a concrete ideal of spatial data infrastructure.

"Anyone can make a map of any location at any period at any time using anyone's data" is the slogan of Digital Japan, which is advocated by the Geographical Survey Institute. With Digital Japan, anyone can freely overlay and utilize any kind of geographic information on the Web.

The Geographical Survey Institute has been working to implement the concept of Digital Japan according to the architecture of the Web, in which any resource is identified by a Uniform Resource Identifier (IETF, 2005). The most important goal in order to realize the concept of Digital Japan is to realize the circulation of reusable and system-neutral geographic data on the Web.

In order to achieve this goal, we have developed a web mapping system which minimizes the amount of work required for the users of the system. We assumed the users of our system are any users of the generic Web. We identified three kinds of participants who are involved; they are infrastructure providers, service providers and service consumers. We have also classified the data circulated on the web mapping system into two categories which have completely different natures; framework data and thematic data.

Keeping these participants and categories in mind, we have implemented the web mapping system named the Digital Japan Web System. The system is an efficient reference implementation of the concept of Digital Japan, implementing each task for each participant effectively.

2. Architecture of Digital Japan Web System

The primary goal of the concept of Digital Japan is to enable everyone to publish thematic data easily. Therefore, the first goal of the Digital Japan Web System is to minimize the workload of all participants involved. The second goal is to make the experience from the service as rich as possible so that more users will be interested in the service.

After the advent of web mapping technologies, there are two different fields of computer mapping, i.e., geographic analysis and geographic documentation (Sepsi, 2004). Web mapping technology mainly covers the field of geographic documentation rather than geographic analysis. In the field of geographic documentation, the ease of generation and modification of thematic data is more important than the effectiveness of processing. Therefore, we designed the format of the thematic data to be as simple as possible. Also, we designed the way

of publishing thematic data to be as simple as possible.

In contrast, the processing effectiveness of the framework data is still important even if the data is used for geographic documentation, because the amount of framework data is huge, in contrast to the thematic data.

To make the experience from the system as rich as possible, we have clearly distinguished the framework data and thematic data and designed the system differently for each kind of data.

It is also important to analyze the participants involved in web mapping. We have identified three kinds of participants in web mapping systems. This is different from the traditional web mapping model, which has only two kinds of participants, map servers and map clients. The participants in our model are infrastructure providers, service providers and service consumers.

We separated infrastructure providers and service providers because it is unrealistic to assume that each service provider serves all the data including the huge amount of framework data. As we introduced infrastructure providers, service providers can concentrate their resources into their own value-added services.

We might say that our model is analogous to a transportation network model. The spatial data infrastructure provider will provide framework data in the same way that a transportation infrastructure constructor provides a transportation network. A spatial service provider will provide services in the same way that a transport service provider provides transportation. Spatial service consumers will use services in the same way that people use transportation services.

By clearly separating infrastructure providers and service providers, we have a clear interface between the infrastructure and its use. Therefore, service providers can remix the infrastructure service with other kinds of service.

In the traditional model, as shown in the OGC Web Map Service, the processing which each mapping client does is left completely to the mapping client. This leads to a heavy burden on mapping clients.

According to our model, service consumers must simply be able to use their web browser while enjoying plenty of functionality without explicitly installing any standalone software.

Each participant in our model has both a software task and a data task, as shown in Fig. 1. Detailed analysis of each task as follows leads to determination of the requirements for the Digital Japan Web System.

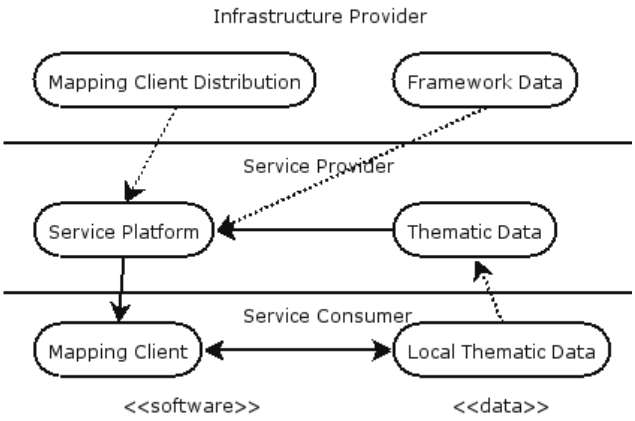

Fig. 1 Architecture of Digital Japan Web System

2.1 Requirements for Mapping Client Distribution

Mapping client software has to be distributed through the Internet. The method of distribution has to be reliable but require no additional platform software other than the operating system and the web browser.

After the installation of the client software, the client software has to start automatically without taking a lot of time. Also, updates of the installed software have to be as few as possible, while updates of the functionality of the software have to be easy for the infrastructure provider.

2.2 Requirements for Framework Data Distribution

The framework data, which work as a background map, have to actually cover all of the area of Japan and be already available with a high cartographic quality. Also, the framework data will be available freely but with good speed. These requirements are fundamental to attract many service providers and service consumers.

It is also desirable for service providers and service consumers to get attribute data from the framework data. To achieve this requirement, and also to achieve high cartographic quality, the framework data must be attributed vector data.

2.3 Requirements for Thematic Data Distribution

According to the primary goal of the concept of Digital Japan, the thematic data should be encoded in a simple, open, system-independent and general-purpose format so that each service provider can publish their data as easily as possible.

Also, the thematic data should be universally accessible as resources via their URIs so that the data will be able to circulate through the Internet for multiple purposes.

Thematic data have to be loosely decoupled from the other part of the Digital Japan Web System so that the thematic data may be used even after the current implementation of the Digital Japan Web System is outmoded.

2.4 Requirements for Service Platform

A service platform of the Digital Japan Web System is a web site which uses the infrastructure of the Digital Japan Web System. Service platforms should be easily implementable by any web site owner.

Anyone should be able to implement the service platform using plain HTML and JavaScript by conforming to a few rules from the Digital Japan Web System.

As a consequence, anyone should be able to remix other kinds of services into a service platform of the Digital Japan Web System, as demonstrated in the recent concept of Web 2.0 (O'Reilly, 2005).

2.5 Requirements for Mapping Client

A mapping client of the Digital Japan Web System is the client software which runs in a web browser to map framework data and thematic data designated by the service platform.

A mapping client should be a 'rich internet application' (Wikipedia, 2005) which can render the data quickly and should render attributes of data on demand. Also, the mapping client should be able to edit, open and save client local data so that new thematic data may be created easily.

Though the most traditional web mapping services have not gone beyond portrayal with simple lines and polygons, it is essential that the mapping client can render framework data like traditional paper maps.

This is because the variety of color or width of lines alone is not enough to convey the variety of information buried in the framework data, which contain topographic map information.

This is also because most users of web mapping seemingly would like to use web maps like paper maps.

Framework data should be conveyed with fewer colors, because a lot of thematic data will be overlaid in the Digital Japan Web System.

The Geographical Survey Institute has traditionally developed a legend for paper topographic maps using only a few colors. The mapping client should make use of this traditional legend so that users can understand the topographic information in the framework data effectively.

This topographic map legend is also very familiar to Japanese people, because this legend is taught in primary education. This is also the reason the mapping client should conform to the topographic map legend.

In contrast, the mapping client should be ready for new map design optimized for the characteristics of the Web (Räber and Jennz,2003). The legend should be able to be reconfigured in the future.

3. Implementation

In accordance with the requirements described in the previous section, we have implemented the Digital Japan Web System as described as follows.

3.1 Implementation of Mapping Client Distribution

The core functionality of the mapping client is implemented as browser plug-ins using ActiveX technology or XPCOM technology. These plug-in components are distributed from the Digital Japan Portal (Secretariat, 2005) with the digital signature of the Geographical Survey Institute.

The functionality of the plug-in software is called through a set of JavaScript APIs whose implementation is automatically loaded when a service consumer opens a service platform. The plug-in software works as library component of the JavaScript API. Seen from the service platform builders, all the concrete functionalities of the

Digital Japan Web System are exposed as just a set of JavaScript APIs.

By implementing the mapping client as above, the frequency of plug-in software updates became very low. Many of the updates are implemented at the JavaScript level so that an update of the installed plug-in software is unnecessary. Also, a plug-in software update is often not necessary when testing the new functionality because much of the new functionality can be implemented at the JavaScript level.

In addition to the insertion of the JavaScript layer, we have implemented in-memory plug-in update functionality. When the installed plug-in software is loaded into the browser, the binary image of the software is modified by the online patch file sent from the mapping client distribution site.

With these methods, the frequency of the updates of the installed plug-in software is minimized. This leads to the stable availability of the infrastructure of the Digital Japan Web System.

3.2 Implementation of Framework Data Distribution

The framework data of the Digital Japan Web System is generated from the national topographic map data. These topographic map data are the source data for the paper topographic maps of Japan and are constantly maintained by the Geographical Survey Institute. An update of the national topographic information database is rapidly reflected in the framework data of the Digital Japan Web System.

As a consequence, very high quality framework data may be distributed without charging for cost recovery. For example, an annexation of local autonomous bodies, which is very frequent in Japan these days, is reflected on the day of the annexation. A mistake in the framework data will typically be fixed a few days after the mistake is identified. This kind of free and high quality framework data is the key to realizing the concept of Digital Japan.

In contrast to other web mapping services provided by the private sector, our topographic framework data has plenty of information about suburban, rural and mountainous areas. It is possible to say that our framework data fill the vacant area of geographic data services. As for the urban areas, much of the information can be implemented as thematic data or additional framework data which might be from the private sector.

Fig. 2 Framework data 1:10,000,000

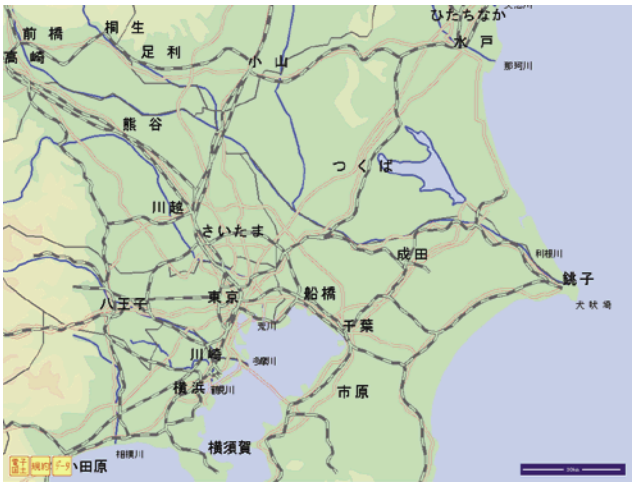

Fig. 3 Framework data 1:3,000,000

Fig. 4 Framework data 1:200,000

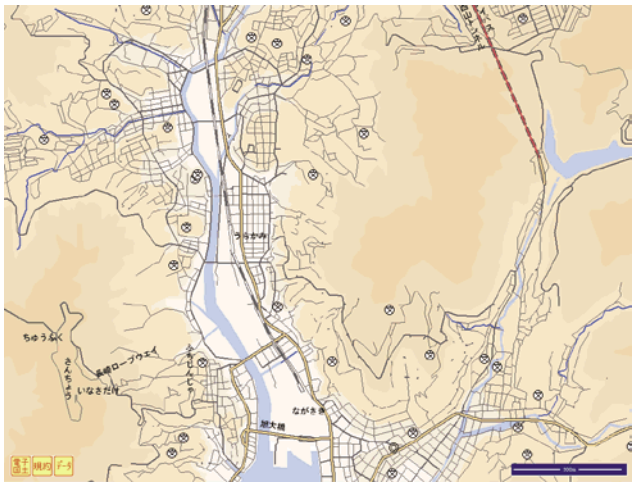

Fig. 5 Framework data 1:50,000

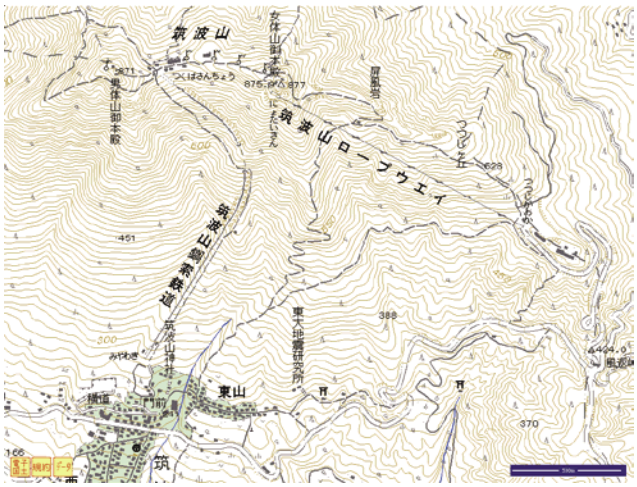

Fig. 6 Framework data 1:25,000

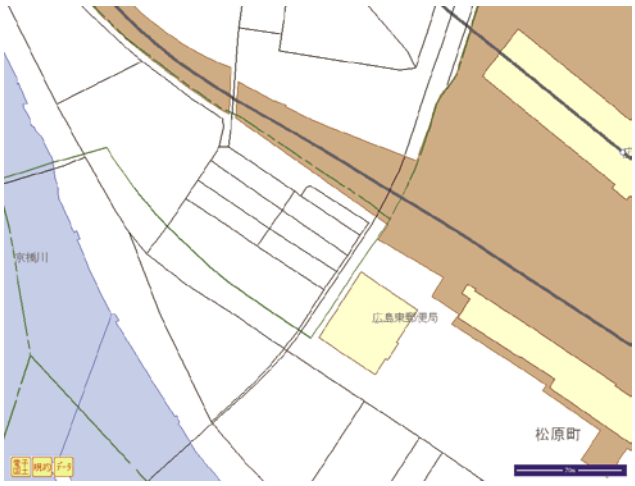

Fig. 7 Framework data 1:500

The format of the framework data is designed for effectiveness of the processing at the mapping client. This is because the volume of framework data is too large to distribute in a system-independent human-readable format. The format is binary, compressed and encrypted. The format is obfuscated because the administrative permission to use the framework data is exclusively for the Digital Japan Web System.

Our framework data includes data for five nominal scales; 1:10,000,000, as shown in Fig. 2, 1:3,000,000, as shown in Fig. 3, 1:200,000, as shown in Fig. 4, 1:50,000, as shown in Fig. 5, 1:25,000, as shown in Fig. 6, and 1:500, as shown in Fig. 7.

The framework data are divided into tiles whose size is a little smaller than the typical map window size on the mapping client. Each piece of tile data is accessible through a unique URI. Because each piece of tile data is a static data file, the data is easily cacheable on the Internet. The mapping client calculates the URIs of the necessary pieces of tile data and requests the data on the fly.

In consequence, the load to the framework data server is very low and distributed to the cache servers throughout the Internet. Therefore, this architecture is very scalable. This architecture can be considered to be based on the representational state transfer (REST) architectural style (Fielding, 2000) while most traditional web mapping services can be considered to be based on the remote procedure call (RPC) model, which means the service scalability is limited.

All spatial attributes in the framework data are in latitude and longitude in the ITRF94 on GRS80. There are also many thematic attributes in the framework data already buried inside. These data have been prepared for use in the future.

3.3 Implementation of Thematic Data Distribution

The format of the thematic data is a very simple XML format harmonized with the ISO 19100 series international standard for geographic information. This format is called Cyberjapan Profile, which is named after the domain name of the Digital Japan Portal (Secretariat, 2005).

The method of distributing the data is to make the XML file accessible via a URI. So, when the XML data is located on a web server, that XML data is published on the Digital Japan Web System.

When a service provider wants to load one thematic dataset into their service platform, it only has to add one JavaScript statement; a JavaScript API function named top.map.openJSGIXML will load the thematic dataset through the URI given as the argument.

Because the thematic data is accessed via URI, the thematic data can be dynamically generated at the server side. This shows the high possibility of remixing other kinds of web service as thematic data of the Digital Japan Web System.

The copyright issues of the thematic data have been considered from the design phase. Firstly, the Cyberjapan Profile includes metadata items to show the copyright holders. Secondly, a service consumer can always check the copyright information about all the thematic data shown on the mapping client by just clicking the 'data' button which is always shown on the lower-left side of the mapping client.

3.4 Implementation of Service Platform

The service platform is implementable without knowing the details of the Digital Japan Web System. When the service platform builders include the map service of the Digital Japan Web System, they only have to embed a few HTML files into their own web sites. These HTML files are readily downloadable from the Digital Japan Portal (Secretariat, 2005).

When the service platform builder includes a file named webtis_map_obj.htm, which is downloadable from the Digital Japan Portal, as a frame named map (Fig. 8), the Digital Japan Web System is available on the service platform.

The Digital Japan Web System is controllable through JavaScript code, as shown in Fig. 10. The first two functions are implemented for the initialization of the mapping client. The third function, named to_tsukuba, is implemented for processing a mouse click event caught in a controller frame. Its code is shown in Fig. 9.

The platform resulting from the code in Fig. 8, Fig. 9, and Fig. 10 is shown in Fig. 11.

```
<?xml version="1.0" encoding="UTF-8"?>
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<title>Simple Sample</title>
<script type="text/javascript" src="./javascript.js"></script>
</head>
<frameset cols="200px, *">
<frame name="control" id="control" src="./control.html"/>
<frame name="map" id="map" src="./webtis_map_obj.htm"/>
<frame name="message" id="message" src=""/>
</frameset>
</html>
```

Fig. 8 digital_japan. html

```
<?xml version="1.0" encoding="UTF-8"?>
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<title>Digital Japan Controller</title>
</head>
<body>
<h1>Simple Sample</h1>
<button onclick="top.to_tsukuba();">
To Tsukuba City</button>
</body>
</html>
```

Fig. 9 control. html

```
function showMapFrame() {
   top.map.tcl("gui update");
}

function app_main() {
   showMapFrame();
   top.map.openMap('http://cyberjapan.jp/japan0.htm');
}

function to_tsukuba() {
   top.map.setMapRect(
      139.998211, 35.947714, 140.169313, 36.236528);
   top.map.openMap();
}
```

Fig. 10 javascript. js

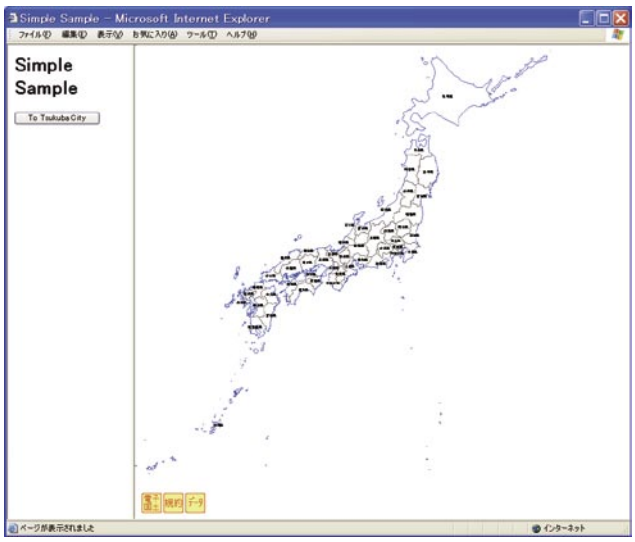

Fig. 11 The service platform implemented by the files shown in Fig. 8, Fig. 9, and Fig. 10

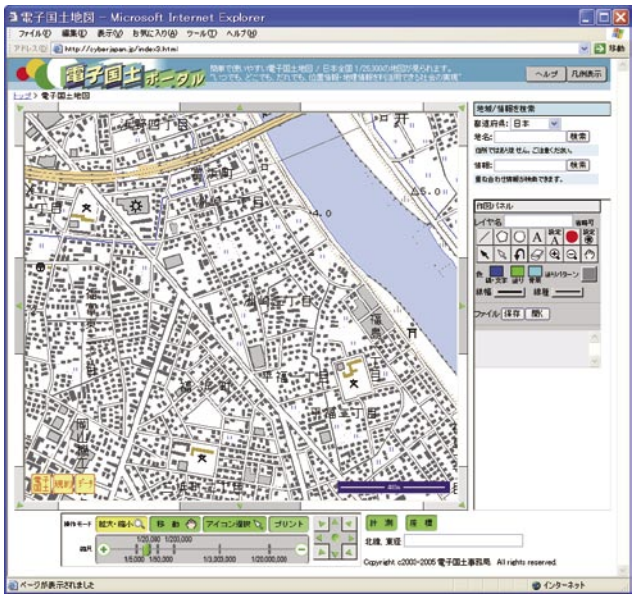

Fig. 12 Example of a service platform

Much functionality is available through the JavaScript API for the service platform. This includes the functionality to move, zoom, print, select, measure, draw, load, save, edit, make tables, make graphs and so on. Additional functionality is under development for future release.

Fig. 12 shows a more complex service platform. This service platform makes use of the zooming, moving, printing, selecting, measuring, and drawing functionality of the Digital Japan Web System. A gazetteer functionality which is independent of the Digital Japan Web System is remixed to the service platform.

3.5 Implementation of Mapping Client

The mapping client implements the functionality of browsing maps like other traditional web mapping systems. However, the speed and the quality of the functionality are quite different. For example, a line width which is designated by the real widths in the real world will change each time the map scale is changed. The map scale or extent will change very quickly by clicking or dragging the mouse. This is because the framework and thematic data are transferred to the mapping client in a vector form and the mapping client will render the image on the web browser.

The mapping client implements the technology for vector data processing. The technology is developed for the New Topographic map Information System (NTIS) by the Geographical Survey Institute (Ohno, 2002). This technology realizes portrayal of the framework data with very high cartographic quality.

In addition, the mapping client can process printing to paper, drawing geometric attributes on the map, or loading/saving local data in Cyberjapan Profile format. This enables wider application of the Digital Japan Web System and also promotes the increase of thematic data for Digital Japan.

4. Services using Digital Japan Web System

The Digital Japan Web System was released to the Internet on July 15th, 2003 (Ohno, 2004). At the first stage, the service providers were limited to public entities. After ensuring there were no major problems with the social impact of the Digital Japan Web System, the programming manual and the API reference guide of the Digital Japan Web System were released to the general public on the Internet on March 29th, 2005.

The number of service providers was 215 on November 30th, 2005. These service providers include national and local governments, educational institutes, NPOs, research institutes, the public sector, and individuals. Technical support for public entities are supplied by the Geographical Survey Institute and technical support for other sectors are supplied by the Secretariat of Digital Japan.

Because the use of the Digital Japan Web

System is loosely constrained, some private companies have started to use the Digital Japan Web System as a part of their enterprise system.

At the government level, the Digital Japan Web System is an effective tool for sharing information. The following are the reasons:

1) Most of the information used in the government is closely related to location.
2) Framework data provided by the Digital Japan Web System are virtually equal to the paper maps currently used by the government.
3) Thematic data can easily be published through the Digital Japan Web System.
4) Thematic data can easily be protected using intranet technology, which is very common and cheap.

Local governments have larger scale framework data for their region. The data are detailed and necessary for the work of local governments. The Geographical Survey Institute provides an effective and easy method to publish their larger scale framework data to the Internet or their intranet. According to this method, the framework data encoded in the common Digital Mapping Format will be automatically converted to the framework data for the Digital Japan Web System. The framework data just have to be located on an appropriate web server. In addition, the Geographical Survey Institute proposes hosting their framework data at the framework data server at the Geographical Survey Institute.

The Digital Japan Portal (Secretariat, 2005) is a directory of the service platforms of the Digital Japan Web System. Public services using the Digital Japan Web System are listed on this portal site.

5. Services for disaster management

Natural disasters, especially large scale earthquakes, are frequent in Japan. Almost all areas of Japan are at risk of a great earthquake disaster.

As a lesson from the Great Hanshin-Awaji Earthquake (Cabinet Office, 2005), a lack of data sharing at the first stage of disaster management is a major problem; many organizations collected data about the disaster, but there is virtually no way to aggregate the data instantly and easily.

The Digital Japan Web System can offer a solution to this problem. The following are the reasons:

1) Thematic data can be remixed freely on request.
2) Updates of thematic data are reflected instantly whenever the mapping client reloads the data.
3) The framework data provided from the Geographical Survey Institute contains plenty of topographic information, which is fundamentally important in disaster management.

We have implemented a few service platforms for disaster management shown in the following sections.

5.1 Early direct link to disaster locations

It is fundamental to get the topological information of the location at which a natural disaster has occurred at the very first stage of disaster management. We have implemented a very simple service platform which opens the map of any location designated as the parameter to the service platform. Using this service platform, the Digital Japan Portal provides early and quick links to the disaster locations, as shown in Fig. 13. These links to the disaster locations are generated after a few hours or at least a few days after the disaster occurs.

Fig. 13 Direct link to disaster locations

5.2 Information Aggregation Map for the Mid-Niigata Prefecture Earthquakes

The Mid-Niigata Prefecture Earthquakes were a major natural disaster which occurred on October 23rd, 2004.

The Geographical Survey Institute released a service platform named the Damage Situation Map for the Mid-Niigata Prefecture Earthquakes on October 29th, 2004 as shown in Fig. 14. This service platform integrates the results of the emergency survey conducted by the Geographical Survey Institute and information from a NPO (Nagaoka Life Information Exchange Network),

which provides the location of the disaster response headquarters.

If this kind of service platform were implemented using traditional web mapping technology, it would be very difficult to prepare the platform in only six days. Even if the platform were implemented, the quality of the service would be greatly degraded because of the burst of accesses.

By using the Digital Japan Web System, the service platform could easily be implemented and was also very scalable with good quality of service.

Fig. 14 Damage Situation Map for the Mid-Niigata Prefecture Earthquakes, served by the Geographical Survey Institute

The Information Aggregation Map for the Mid-Niigata Prefecture Earthquakes, as shown in Fig. 15, is a service platform released on December 7th, 2004. This platform integrates much information from many sections of the Ministry of Land, Infrastructure and Transport. The thematic data includes the location of landslides, natural dams, sections impassable to transportations, photographs, aerial photographs, epicenters, estimated distribution of seismic intensity, progress of temporary housing construction, location of active faults and so on. Thanks to the Digital Japan Web System, each section only has to prepare its own thematic data. The data is overlaid with other thematic data just after uploading the data on the web server.

The thematic data from each section are firstly sent to the Geographical Survey Institute in various formats, and then the data are converted and uploaded to the web server there. In the future, web based data input or data conversion will accelerate the implementation of this kind of service platform.

Fig. 15 Information Aggregation Map for the Mid-Niigata Prefecture Earthquakes, served by Ministry of Land, Infrastructure and Transport

5.3 Inclusion of various devices to the service platform

Because the thematic map distribution function is highly independent of the input device, it is easy for a service platform to get thematic information from various input devices.

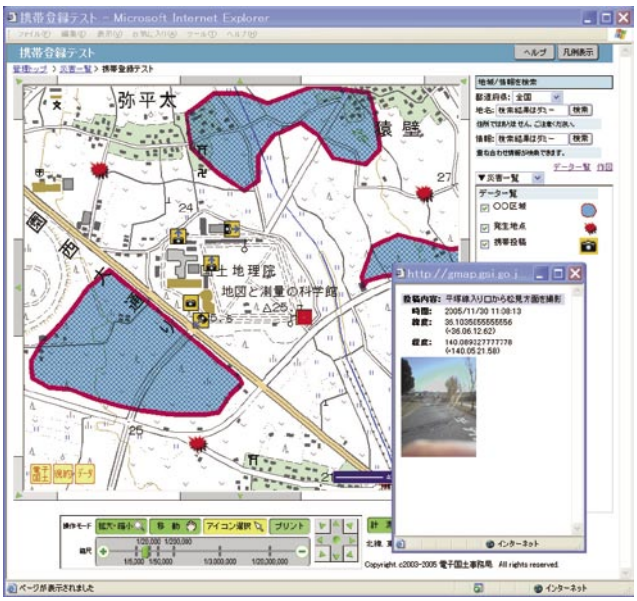

Fig. 16 Service platform with connection to mobile phone

We have implemented some prototype service platforms to get disaster situation information from mobile phones with GPS (optional) and email functionality, as shown in Fig. 16.

The Regional Development Bureaus of the Ministry of Land, Infrastructure and Transport have responsibility for managing damage from natural disasters to infrastructure such as national roads or the banks of major rivers.

A new disaster information management platform is being prototyped as a result of a research project performed by the Ministry of Land, Infrastructure and Transport. The Digital Japan Web System is being used in this platform. In this project, the priority is on conserving the current workflow. So, the first report on the damage by the disaster is sent by fax. A fax-OCR server will convert the content of the fax report to the thematic data for the Digital Japan Web System. This prototype platform is under development and will be tested soon.

6. Conclusion

The Digital Japan Web System is an efficient and practical web mapping system for implementing the concept of Digital Japan, in which various system-neutral thematic geographic data are shared through the Internet.

According to the three participant (infrastructure provider - service provider - service consumer) model, the Digital Japan Web System is implemented efficiently so that the load and the stress of each participant are technically minimized.

The number of providers of Digital Japan Web System services is steadily increasing in Japan. The effectiveness of the Digital Japan Web System is being proved through its application to disaster management.

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