"GIS ON THE FLY"
TO REALIZE WIRELESS GIS NETWORK BY JAVA MOBILE PHONE
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ABSTRACT

Java cellular phone has arrived in the marketplace as the latest device of a mobile gear. The gear is very compact, allowing 10KB for Java program size and 5KB for data size.

Although small in size, it features innovative computer system architecture. Java program can be sent dynamically to the gear in a streaming manner over wireless network. In addition, compared to conventional mobile computers, Java cell phone is very cheap both in hardware price and in communication cost.

Java cell phone has an enormous potential as a mobile gear. In this paper, we discuss our trial of constructing a extensive wireless GIS network by utilizing Java cell phone as a GIS terminal.

1. Introduction

In January 2001, a new service for allowing Java applications to be used on mobile phone started in Japan. This new capability to utilize mobile phone as GIS terminal proposes the following benefits.

- Inexpensive mobile terminal cost will allow larger number of people to use GIS on their business and improved return of investments.
- With mobile terminals, GIS data will be referred to and updated in real time basis compared to current circumstances. Such GIS terminals will be used mainly in the fields out of office amid the real geospatial world.
- Since basic telecommunication method is already standardized, it is not required to newly construct network infrastructure. In addition, it is expected that high-speed telecommunication becomes available under IMT2000 (pilot testing will start in July 2001). The network speed will be 384Kbps for inbound and 64Kbps for outbound.
- Mobile telephone will include location service function in the near future. Thus, GIS application will expand to include dynamic location management, emergency disaster notification and others.

However, we have the following problems to be solved first.

- Capacity of mobile telephone is extremely weak to be regarded as a computer. The size of Java application program is allowed from 10 to 30 KB, and the data size is allowed only 5KB.
- No application compatibility exists between career providers and types of mobile phone hardware.
- A mechanism is required to effectively manage huge backend GIS data stored on server side.

Above problems cannot be solved only by providing special interface for mobile phone terminals onto conventional GIS system.

To cover low computer power of mobile terminals, more GIS processes have to be taken away from terminal to server machine. Moreover, it is expected that busy transaction will occur as a result of frequent request from enormous number of users. A mechanism to resist heavy transaction load is required on server. In applying to practical use, operation management GIS run on workstation will be required.

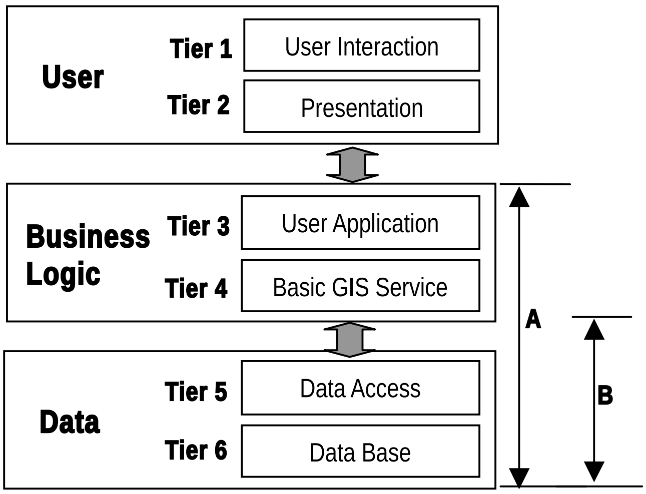
In summary, when realizing mobile GIS, supportive GIS management system based on backend server machine is more required than GIS application itself that is active on mobile terminal.

We focus the objectives of this paper on the following two.

- Development of GIS architecture that will resist heavy transaction workload and support constructing huge network
- Development of mobile terminal GIS architecture that are independent from career provider and terminal hardware.

2. Basic Concept of Network GIS

The following figure shows 6 Tier model that includes Basic GIS Service Tier in addition to Web GIS 5 Tier architecture model advocated by OpenGIS Consortium.



A: Server process when terminal is a mobile phone
B: Server process when terminal is a Internet workstation

Figure 1. Six Tier Model

This paper pursues the development of network GIS architecture that allows access to single database from Internet workstation and also from mobile phone terminals in the same way.

Internet workstation uses personal computer as a hardware device. This will allow heavy load process to be performed on client side. In other words, Internet workstation will execute user application on client machine based on distributed architecture, and will lower the workload on server machine.

On the other hand, mobile phone terminal only supports input/output process on the terminal, while application programs are stored on server side.

Above whole system has been implemented with Java.

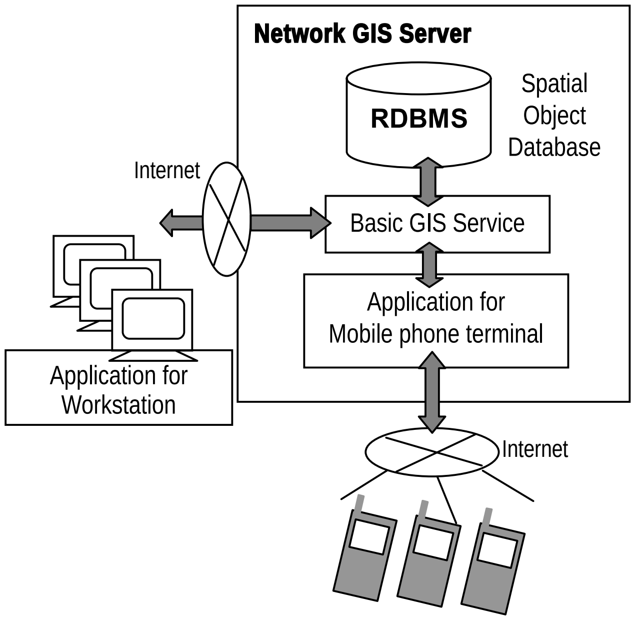


Figure 2. Outline of Network GIS

3. Spatial Object Database

In recent years, standardization activities have been in vigorous progress to define geospatial data standard. The active bodies include international organizations such as ISO/TC211 and OpenGIS Consortium and Japan domestic activity of G-XML.

In these groups, discussions are underway on how to exchange GIS data between heterogeneous systems and how to define service interfaces for GIS data operation.

The common discussion between these activities is to define GIS data feature as spatial object in real world such as road, river, house and so on. GIS data is a collection of varieties of feature data and is described in XML or XML Schema.

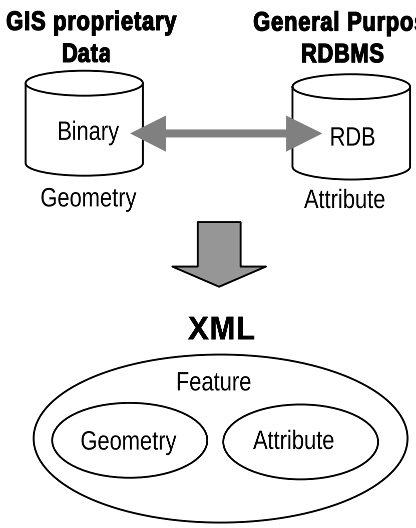


Figure 3. GIS Data Model

In conventional GIS system, geometry and attribute data are managed separately and linked to each other with unique ID.
Although handling vast amount of GIS data, this mechanism enables effective enormous data process, because geometry data processing and text data processing are separately executed on optimized system for special purpose use.
On the other hand, in this mechanism, system design and data design are tightly related. It is difficult to acknowledge the data definition easily outside of the system and to retrieve specific data for data exchange. In addition, it is difficult to synchronize data update between geometry data and attribute text data and to maintain data consistency, especially in the case of frequent transaction management system.

In this paper, we manage GIS data retained from two different systems, one from Internet workstation and one from mobile phone terminal, in a single database on feature data basis.
In describing feature data, XML encoding is flexible and comprehensible as an advantage point, but XML is weak from the aspect of data process and data transfer efficiency. Thus, we apply general purpose RDBMS as data storage.

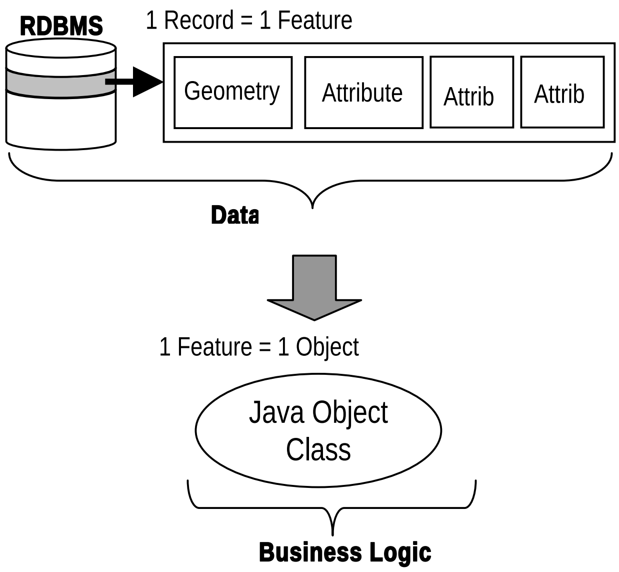


Figure 4. Feature Base Data

One record of RDB is composed of geometry data and attribute data. When GIS read in this record, it can be managed in a class as a Java object inside of the system.

4. Basic GIS Services

Figure 5 depicts the whole system framework. Each rectangle indicates Java Class Libraries that provide Basic GIS services. The libraries are allotted to client terminal or server.

(1) Spatial Indexing (Server)
In general, RDBMS is weak in spatial query against spatial object data.
The most basic spatial query is to define display area with coordinates and then to acquire spatial object data that are contained in the area.
With Spatial Indexing Control, spatial object data in the target area that is specified by clients can be acquired effectively by referring to Spatial Indexing Table.

(2) Data Update Transaction (Server)
Large number of clients concurrently update spatial object data. Data Update Transaction Control maintains exclusive access control to avoid data update confliction.

(3) Display Cache (Server)
When data request from many clients occurs at the same

time, data process workload on server increases. Display Cache Control retains data cache that is relevant only to display within the whole spatial object data that are accessed.

(4) Data I/O (Server/Client)
Data I/O execute data type convert from SQL record data in RDBMS to Feature Object Class data on client. It also controls data input/output between server and clients.

(5) Space (Client)
Space is the memory storage area for spatial object data in client. It plays the role of client cache.

(6) View (Client)
View displays arbitrary area of spatial object data that are stored on Space. When View displays data, it draws portrayal expressions such as colors and symbols as defined to features by referring to portrayal class. In addition, View passes input operation performed by users via View onto User Event Control.

(7) Terminal Page Control (Server)
In this paper, all mobile phone terminal control is executed on server (refer to section 6). Terminal control is performed by switching terminal display picture that is called Page.

(8) Mobile Phone GIS browser
Synchronizing the above Terminal Page Control, Mobile Phone GIS Browser performs map display and input control for users (refer to section 6).

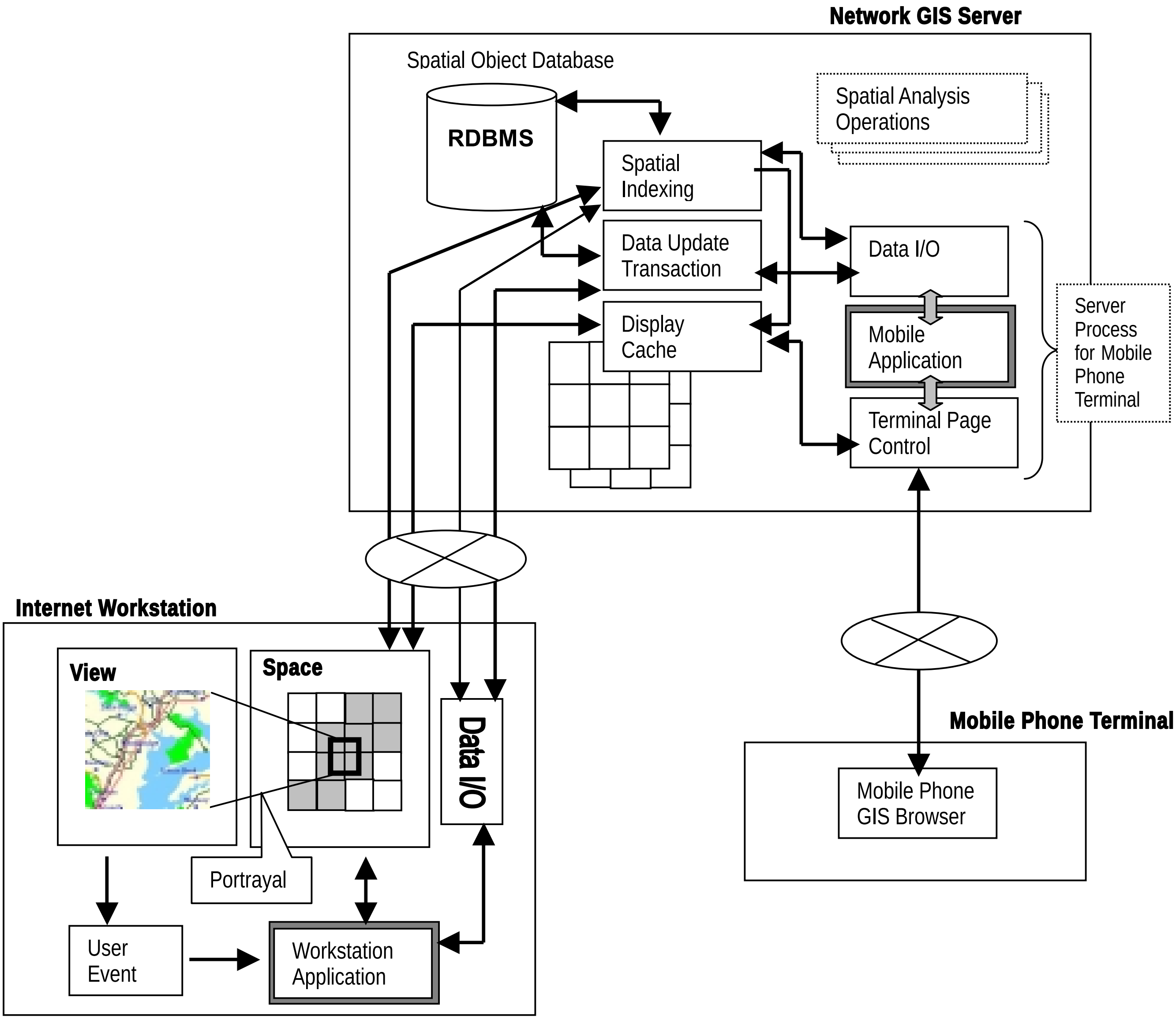


Figure 5. Network GIS Framework

5. GIS Architecture for Mobile Phone Terminal

When utilizing mobile phones and hand-held computers as GIS terminals, the following three types of architecture can be applied.

(1) Application Logic Type
Application is executed on terminal computer. This provides the best operability, since it demands the least data exchange between terminal and server and terminal itself can execute local data manipulation.
However, it requires hardware capability (especially memory size) as a terminal computer to some extent, and specialized programming is required to support each terminal hardware type.

(2) HTML Browser Type
CGI program on server and HTML browser on terminal communicate each other.
All process must be executed on server, and it produces the greatest data exchange. This is the same type of architecture that i-mode applies.
The advantage of this architecture is that it requires programming only on server side and that it is independent from terminal hardware type.

(3) GIS Browser Type
Application logic on server and GIS browser on terminal communicate each other. Basically, this type is similar to type (2). GIS browser function is optimized in the following three points – map manipulation, input sequence control and easy graphic symbol input.
This architecture is useful in its easy system development same as type (2) and also in its map operability same as type (1). However, data traffic is greater than type (1).

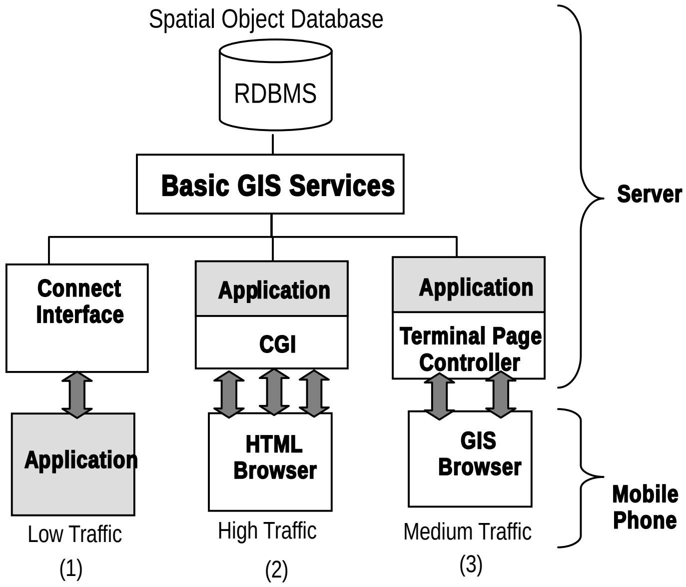


Figure 6. 3 Types of GIS Architecture

We apply type 3) of GIS browser type to this research. When the computing power of mobile phone terminal will be enhanced in the future, we will be migrating current architecture to type 1).

6. Communication of Server and Terminal

Mobile phone terminals are controlled by Java programs on server. All applications are implemented on server, and terminal applications handle remote I/O of user operation and map local operation.
Java programs on server control terminals with Terminal Page Control Class.

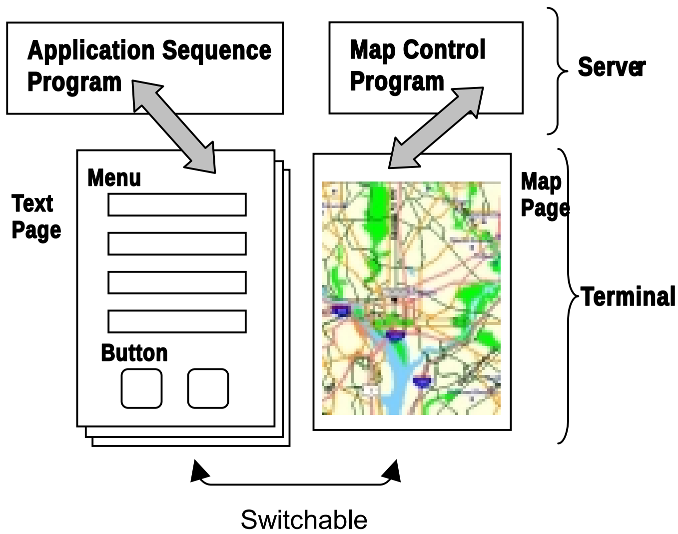


Figure 7. Page Control

On terminal side, the sequence is controlled by page unit. Page has two categories – Text page and Map page.
Text page is composed of menus and buttons. User I/O is mainly performed with text.
Map page performs map display and graphic symbol input such as point and line.
The following shows page configuration control.
(1) Label
Label performs caption display.
(2) Image
Image performs image display such as photographs.
(3) Button
When button is pushed, Button indicates server Java programs that will be called, with argument attached.
(4) List
List indicates caption and key that will be returned when the list is selected. Mainly, List is used as menu.
(5) TextBox
TextBox returns numeric characters and text that are input by users.
(6) Map
Map indicates map type and initial display area. At the same time, contents data type such as restaurants and hospitals that will be overlaid on map are indicated.
When client receives Map control from server, the client requests server map control program for map data. Subsequently, client performs Zoom In/Out and Pan according to user button operation.

In addition, Map can indicate action that user should input, such as graphic symbol input operation. Input coordinate data is returned to server as argument to Java program that is related to Button control.

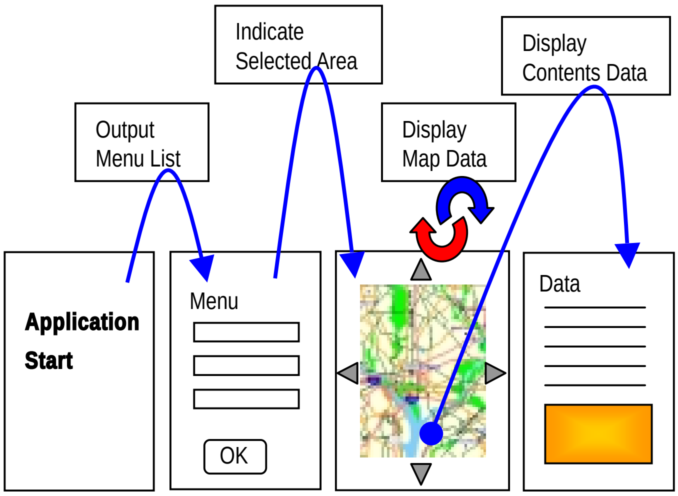


Figure 8. Client Sequence Control

7. Conclusion

We demonstrate in this paper that even Java mobile phone whose computer power is poor and limited can perform GIS operation. It is difficult to implement rich and complicated functions on those mobile terminals as implemented on workstations, but Java mobile GIS is effective within restricted functions. It is expected that high operability of Java mobile phone especially in fields operations can be applied to wide varieties of practical use combined with location service that will be supplied in the near future.
In addition, more important outcome discussed in this paper is that integrated GIS service can be supplied to different types of clients and users in real time basis.
We would like to advance server centered Network GIS concept and to develop more powerful architecture.

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