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Active GIS: A Geographic Information System Using Active Database Systems

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ABSTRACT

In recent years, the increasing popularity of mobile hosts and GPS equipments creates a great demand on location-aware geographic information systems (GIS). If information servers transmit geographic information with wireless communication equipments anywhere in the real world, a GIS running on a mobile computer can provide a high level service to users by integrating the information received from servers and the map information stored in the computer. To realize this kind of service, we proposed and implemented the ActiveGIS, a geographic information system based on an active database system. The ActiveGIS is a kernel system of a GIS for mobile computing environments such as integrating and using the data held by mobile host. ActiveGIS enables users to add their own functionalities by describing rules that express the processes for the events such as data arrival and user's approach to a specific real-world situation.

1. INTRODUCTION

In recent years, the increasing popularity of mobile hosts and the evolution of wireless communication technologies enable users to access a variety of information on networks in the open air. If this environment becomes so popular that many people bring their mobile hosts in their daily life, the demand on a geographic information system on the mobile host will become strong. Moreover, the personal digital assistants, which have GPS functionality, are already on sale and several services using user's location are also performed now. Therefore, the environment that a geographic information system can be used on a personal digital assistant in the open air becomes realistic. In such an environment, applications should realize flexible services on a user terminal, for example, to navigate users in amusement park which is based on the user's request and the waiting time of each attraction. However, there are several problems in realizing such flexible application with the conventional system as follows:

- **Difficulty in integrated use of information:**
There is no mutual compatibility of data in different systems and applications.

- **Lack of the capability to provide various location-aware services:**

There is no capability to provide the flexible services, which perform complicated interaction with an information server, such as changing functions of applications dynamically according to the location of a user.

- **Lack of the flexible data management mechanism:**

there is no flexible data management mechanism to use resources of a user terminal effectively.

Therefore, our goal of this research is realization of the fundamental system of the geographic information system that solves these problems. In our proposed system, flexible services and data management mechanisms are provided by using active database mechanisms as a base of the proposed system and it will become easy to integrate data among different applications.

The remainder of this paper is organized as follows. Section 2 outlines the ActiveGIS. Section 3 explains the design of the ActiveGIS and section 4 illustrates examples of ECA rules to realize some location-aware services. Section 5 explains the implementation of the

Active GIS. In section 6, we mention related works. Section 7 presents the conclusion and future works.

2. ACTIVEGIS

The ActiveGIS, which we propose in this paper, is a geographic information system for mobile terminals using an active database system. The mobile terminal has a GPS, wireless communication equipments and electronic maps.

An active database processes prescribed actions in response to the occurrence of an event occurred inside/outside the databases (Lohman, 1991) (Gehani, 1991). Generally, its behavior is prescribed with ECA rules, which consist of three parts: the event, the condition, and the action. In the event part, an event which may occur in the system is specified. In the condition part, the conditions for executing the action are specified. In the action part, operations to be carried out when the event and condition parts are satisfied are specified. Using ECA rules, we can describe system behaviors in an event-driven manner. Therefore, it is suitable for processing emergent events, such as a reception of data and an approach to a geographic object (Murase, 1996) (Murase, 1998).

We enhanced the notation of ECA rules to fulfill various requirements of geographic information systems. In ECA rules on the ActiveGIS, behaviors of mobile host (connection/disconnection to the cell of mobile host server), communications (receiving data packet) and relations to geographic objects (approaching/separation) are associated with an event. Further, as actions of ECA rules in ActiveGIS, we can describe the action such as sending packet, querying the database, management of ECA rules and so on.

By using ActiveGIS, variety of services can be provided as ECA rules. The following functions are utilization examples of ECA rules.

1. Subject-based map construction

Making ECA rules choose necessary data when the system receives the geographic data, it can construct a map a user required such as a map of the restaurants, or a map of the shops.

2. Collection of location-dependent information

Using ECA rules such as getting location-dependent information when a user closes in the specific building structure, the system can provide services that show suggested routes and details of the sight spot on the display for a sightseeing.

```
CREATE RULE Rule name ON Event name
[ Definition of variables ]
[ WHERE Conditions ]
THEN DO Actions
```

Figure1: The Syntax of the ECA Rule

3. Hording the history of a user's behaviors

Using ECA rules such as updating a user's database when he reaches a certain spot, the system can offer the amusement services like an orienteering and a stamp rally.

4. Dynamic replacement of the system function

The ActiveGIS can send ECA rules to other systems by an ECA rule. Therefore the system can update the system function to store new ECA rules received from the information server. In this way, we can realize the location-aware services by changing the applications dynamically according to the user's location.

3. DESIGN OF ACTIVEGIS

In this section, we explain our design of the ActiveGIS. Firstly, we illustrate the language specification of the ECA rule in the ActiveGIS. Then, we explain the system structure of the ActiveGIS.

3.1 Syntax of ECA Rule

The behavior of the ActiveGIS is defined by ECA rules similarly to the conventional active databases. In general, an active database has the capability to detect the events occurring inside the database. Further, active database can carry out actions only concerning database operations. In this study, we enhance the description capability of ECA rules to fulfill various requirements of location-aware services. Figure 1 shows the syntax of ECA rules of the ActiveGIS.

In the Figure 1, '*Event name*' represents the name of the event which triggers this rule. '*Definition of variables*' defines the local variables used in this rule. '*Conditions*' specifies the condition for executing the following actions. In '*Action*', the operations to be carried out when this rule is activated are described. We show the list of the events and the actions that can be used on the ActiveGIS in Table1, 2.

Table1: The Events of the ActiveGIS

Name	Content
SELECT	Data retrieve
INSERT	Data insert
DELETE	Data delete
UPDATE	Data update
RECEIVE	Receiving a data packet
CONNECT	Connecting to cell
DISCONNECT	Disconnecting from cell
TIMER	Firing a timer
CLOSE	Approaching a object
AWAY	Coming away from a object

Table2: The Actions of the ActiveGIS

Name	Content
QUERY([expression])	Database operation
SEND([opponent],[expression])	Send a data packet
INSERT_ECA([description])	Store an ECA rule
DELETE_ECA([identification])	Delete ECA rules
ENABLE_ECA([identification])	Activate ECA rules
DISABLE_ECA([identification])	Deactivate ECA rules
SET_TIMER([description])	Set a new timer
KILL_TIMER([identification])	Remove a timer
DISPLAY([description])	Display information
XML_PARSE([expression])	Process XML Data

Table3: The Contents of NEW data and OLD data

Event	NEW	OLD
SELECT	Retrieved Data	--
INSERT	Inserted Data	--
DELETE	--	Deleted Data
UPDATE	Updated Data	Data before Update
RECEIVE	Received Data	--
CONNECT	Host Info	--
DISCONNECT	--	Host Info
TIMER	Timer ID	--
CLOSE	Target object	--
AWAY	--	Target object

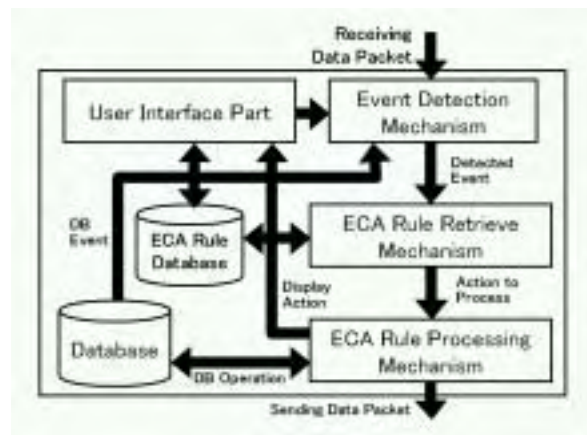


Figure 2: The System Structure of the ActiveGIS

Moreover, the ActiveGIS provides two system parameters, *NEW data* and *OLD data* for each event. The system sets the information shown in Table 3 to both of parameters when the event occurs. These parameters can be used in the condition part or the action part of an ECA rule.

3.2 System Structure

The system structure of the ActiveGIS is illustrated in Figure 2. The *Event Detection Mechanism* detects a change of inside/outside status of the system. The *ECA Rule Retrieve Mechanism* retrieves the ECA rules which fits the detected event from the *ECA Rule Database*. If such rule are found, The *ECA Rule Processing Mechanism* executes them. The *User Interface Part* provides graphical user interfaces for the user to handle the system.

4. EXAMPLES OF ECA RULES

Since the ECA rule has high description capability, it is possible for mobile applications to provide complicated

services by using this facility. Moreover, we can easily customize the system functions by adding ECA rules to the system or by deleting some of them from the system. The following functions are examples of services which can be realized by ECA rules:

1. When there is a bookstore within a certain distance from the user, the system automatically queries the information of price to the database of the bookstore concerning the books that the user is looking for. When the bookstore finds any of them, it displays the result to notify the user "there is one of the books that you are looking for in this store".
2. When a user passes along a restaurant, the system automatically queries to the restaurant and stores menu items whose prices are less than 1,000 yen. Such data will be collected automatically when the user walks around a town.

Figure 3 and Figure 4 show examples of ECA rules to realize these functions. Rule1-3 in Figure1 retrieves the book title from a user's local database and sends it to the bookstore server when the system receives a data packet

```

CREATE RULE Rule1 on RECEIVE
STRING DATA;
WHERE NEW.DATATYPE = `ObjectData'
      NEW.TYPE = `BookStore'
THEN DO
  DATA = QUERY("SELECT BookName
                FROM RequestBookTBL");
  SEND( NEW.FROM, "BookRequest",
        "NAME", DATA );

CREATE RULE Rule2 on RECEIVE
STRING DATA;
WHERE NEW.DATATYPE = `BookRequest'
THEN DO
  DATA = QUERY("SELECT Price FROM
                BookTbl WHERE BookName = `%s'",
                NEW.NAME );
  SEND( NEW.FROM, "Result",
        "PRICE", DATA );

CREATE RULE Rule3 on RECEIVE
WHERE NEW.DATATYPE = `Result'
THEN DO
  DISPLAY( "BookPrice", NEW.PRICE );

```

Figure 3: An example of ECA rules set (1)

concerning bookstore (Rule1). Then it sends back the price information retrieved from a database in the bookstore (Rule2) and displays the result of the received data (Rule3). Rule4-6 in Figure2 queries the menu item to a restaurant when a user approaches in the restaurant (Rule4). Then it sends back the result of query (Rule5) and stores the result into 'collectedData' table on the user's terminal.

In this way, many kinds of functions of are realized by ECA rules. Consequently, the variety of services can be provided for users only to store the ECA rules.

5. IMPLEMENTATION

We implemented a prototype system of ActiveGIS by Microsoft Visual Basic 6.0 and Visual C++ 6.0 with Windows 98 on Toshiba DynabookSS (Mobile PentiumIII 800Mhz, 128Mbyte memory). We also used the wireless LAN system as a wireless communication equipment. As regarding the format of the geographical objects, we use the G-XML that is the geographic information description language using XML regulation (GXML). Figure 5 shows a snapshot of the prototype system.

```

CREATE RULE Rule4 ON CLOSE(30m)
WHERE
  NEW.TYPE = "restaurant"
THEN DO
  SEND( MAPSERVER, "RequestMenu",
        "SQL", "SELECT * FROM Menutable
              WHERE Price < 1000" );

CREATE RULE Rule5 on RECEIVE
RECORDSET DATA;
WHERE NEW.DATATYPE = `RequestMenu'
THEN DO
  DATA = QUERY( NEW.SQL );
  SEND( NEW.FROM, "MenuData", DATA );

CREATE RULE Rule6 ON RECEIVE
WHERE
  NEW.TYPE = "MenuData"
THEN DO
  QUERY( "INSERT INTO collectedData
        VALUES( %s, %s, %s)", NEW.Shopname,
        NEW.productname, NEW.price );

```

Figure 4: An example of ECA rules set (2)



Figure 5: The Snapshot of the Prototype System

6. RELATED WORKS

Similar to our approach, Oliveira uses the ECA rules in GIS systems (Oliveira, 1997). Oliveira uses ECA rules for active customizations of the GIS user interfaces by applying the mechanisms of dynamic construction of user interface using ECA rules (Diaz, 1994) (Oliveira, 1995) to the GIS systems. Oliveira uses ECA rules for only customizing the user interfaces of GIS system. In this study, users can handle the system easily by changing the user interface corresponding to the generated event and the user status. However, it is not possible for this system to build the functions of the

application. On the other hand, the ActiveGIS can build and customize the application by adding/deleting the ECA rules since all functions are constructed with ECA rules in the ActiveGIS.

7. CONCLUSIONS

In this paper, we describe the ActiveGIS, a geographic information system using an active database system. Using the ActiveGIS, we can provide various location-aware services. In the future, we will enhance the functions of this system to enhance the description capability of ECA rules. For example, we plan to support XSLT as the one of the actions of the ECA rule for the flexible transformation of the G-XML contents.

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