DEVELOPMENT OF OPEN GIS COMPONENT SOFTWARE

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ABSTRACT

Technology of GIS evolved as a means of assembling and analyzing diverse spatial data. Many systems have been developed, and almost of systems are proprietary. There is a lots of lack of interoperability and reusability between them.
This paper describes the development of Open GIS component software. The developing system have an end in view of GIS tool software which is interoperable and reusable. To increase the interoperability and reusability, the system is based on the OGC(Open GIS Consortium)'s Open GIS Simple Features Specification for OLE/COM. The OGC's specification is announced to increasing the full interoperability of various geospatial data and geoprocessing resources. With the Open specification, component based software ensures the reusability. We implement three kinds of component: Geometry component, Spatial Reference System Component, and MapBase Component. The first two components are compatible to the OGC's specification and the third one is designed to GIS tool software for variant GIS applications. The Open GIS component software system is developed on object-oriented computing environment, ATL/COM and Visual C++. As we made application programs using Visual Basic, the advantages of component based Open GIS software was proved.

I. INTRODUCTION

Recently, GIS technology is rapidly improved and stabilized. With the such improvements, the needs for the interoperability and reusability is appeared. This kind of needs is well known in the domain not only GIS but also the whole information systems. The GIS is, in essence, the automation of map-based information. Until now, GIS systems are proprietary system, which is opposite to open system. An open system is one whose characteristics are publicly described and available everyone. Well-known example of open systems are Internet, WWW, TCP/IP, and HTML. This open system guarantees interoperability, and the interoperability result the explosive growth of the Internet and the WWW. In spatial systems, a key roadblock was the fact that each vendor kept the specification of its own data private. It was very difficult to use data from other systems. The OGC(Open GIS Consortium) is an attempt to create open standards for geospatial data and systems that further the cause of interoperability(Limp and Harmon, 1998). For the sake of the reusability, a new approach to software development is the use of software components, also termed component-ware or distributed objects. Components are software pieces that can be assembled into applications. Microsoft's OLE/COM and the Object Management Group's CORBA model are currently the two dominant models for software components(Hartman, 1997).

To satisfy the such trends of the information system, we develop the component based Open GIS software system. The system has been designed with the UML, reflect upon the OGC's Open GIS Simple Features specification for OLE/COM. The developed Open GIS system, as a GIS application development environment, consist of several components which provides the GIS technologies such as geodata modeling, spatial operations, various renderers, and user interface.

II. OpenGIS Simple Features Specification

2.1 The OpenGIS Consortium

The OGC(Open GIS Consortium) was formed in 1994 to fulfill the role of a standard-setting consortium within the GIS industry. The OGC recognizes that the infrastructure for main stream computing is evolving into an interoperable, distributed computing, component-based model defined by technology industry standards such as COM and CORBA(Open GIS Consortium Technical committes, 1998).

2.2 The OpenGIS Specification

The OGC has developed a specification for a software framework that will support its goals for distributed and open access to geographics software and data. This specification formerly called the OGIS(Open Geodata Interoperability Specification) is an abstract specification(Open GIS Consortium, Inc., 1998). The implement specifications are developed to define how the OGIS abstract specification can best be implemented within a given component architecture such as OLE/COM and CORBA(Open GIS Consortium, Inc. 1999).

The OGC's specification consists of three main elements : open geodata model, OpenGIS service model, and information communities model. Figure 2-1 shows the relations of the abstract and implementation specifications. This paper concerns the development of Open GIS component software on Windows platform, so we briefly examine the

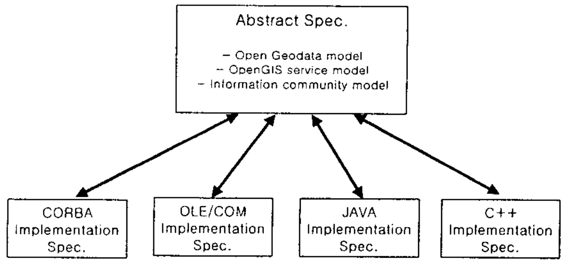


Figure 2-1 The OpenGIS specification is a DC-independent specification

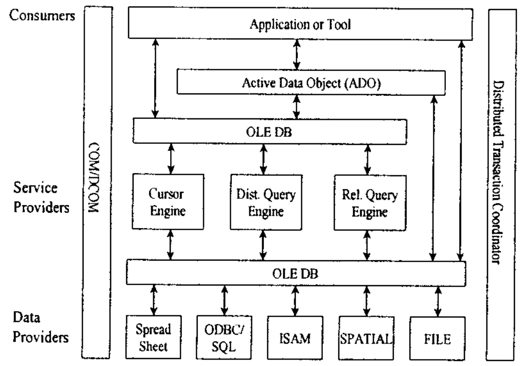


Figure 2-2 Microsoft OLE/DB data access architecture

implementation specification for OLE/COM.

2.3 Data Access Architecture

The data access architecture have three categories shown in figure 2-2 such as Data Provider, Service Provider and Consumer, in acordance with OLE/DB interface of Microsoft.

2.4 Geometry Object Model

The object model for geometry is shown in figure 2-3. Each geometry class have an attributes and method functions. The specification states the detailed attributes, method functions and geometric assertions.

2.5 Spatial Reference System Object Model

The spatial reference system object model is shown in figure 2-4. This object model is uses the geodetic model for spatial reference systems of the European Petroleum Survey Group(EPSG) and the Petrotechnical Open Software Corp.(POSC).

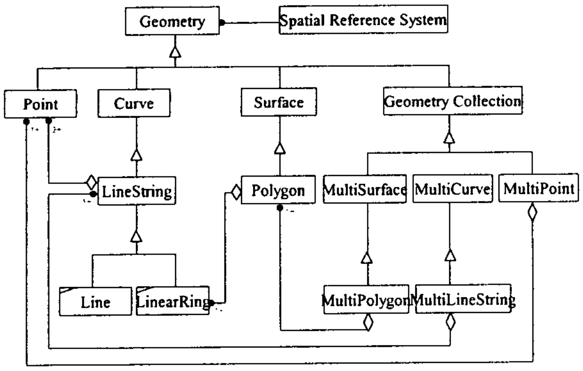


Figure 2-3 Geometry Class Hierarchy

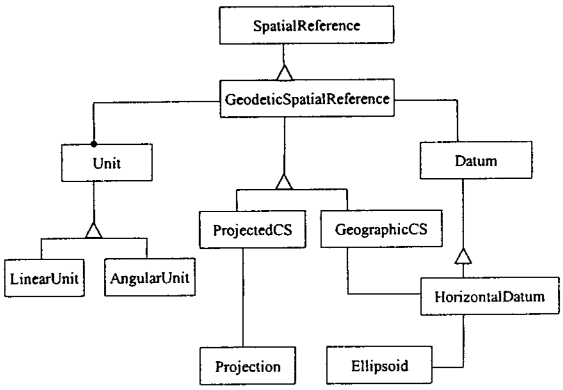


Figure 2-4 The Spatial Reference System Object Model

III. The Open GIS Component Software System

3.1 Overall Architecture

The architecture of the Open GIS component software is shown in figure 3-1. The main focus of this paper is the Base component. Base component as a consumer of the Data Provider component connects the various data source and process upon spatial data. As a GIS tool system, this system provide a funtional interfaces about spatial analysis and mapping.

Base component implement the Geometry component and the Spatial Reference System component proposed by OGC's simple features specification and Mapbase component which operates upon with former two components.

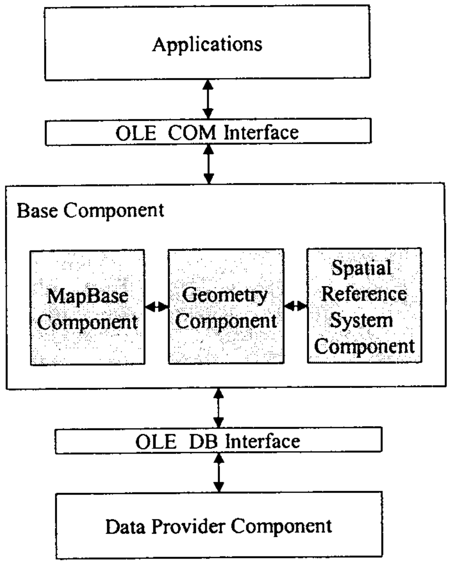


Figure 3-1. The Open GIS Component Software System Architecture

3.2 Data Provider Component

Data provider component is implemented by database vendor or GIS industry which provide spatial data. Data provider component is based on the extended OLE/DB interface for GIS which is described in the OGC's specification. In this system, five data provider components are implemented : SDE, Shape file, Geus, GeoMania, and MGE data provider component.

3.3 Base Component

3.3.1 Base Component Architecture

Base component is the core of the Open GIS component software system. According to the figure 3-2, Base component consist of three components, Geometry component, Spatial reference system component and MapBase component. As mentioned above, Geometry component and Spatial Reference System component abide by the OGC's specification. Mapbase component is designed to support GIS technologies such as spatial operations, various renderings and event handlings. We referenced the MapObject which is GIS and mapping component used world wide(ESRI, 1996).

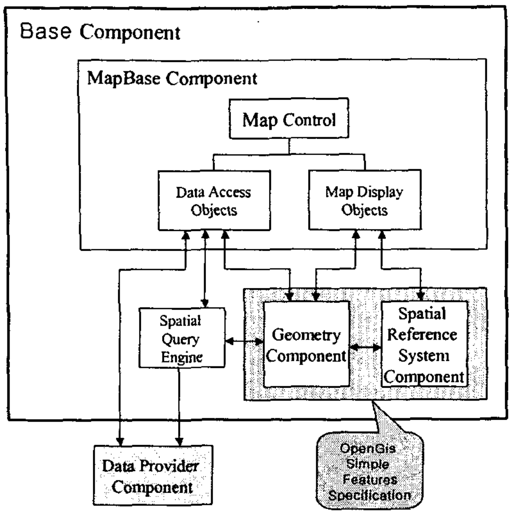


Figure 3-2 The Base Component Architecture

3.3.2 Geometry Component

Geometry component contains the functional interfaces about the geodata modeling and spatial operations. From the geometry object model shown in Figure 2-3, the Geometry is the super class, hence the attributes and the methods are inherited to the all of subclasses. Geometry component support the methods to testing spatial relations between two geometric objects about Equals, Touches, Contains, Within, Disjoint, Crosses, Overlaps, and Intersections. The relation testing algorithm is based on the Egenhofer's DE9IM technique(Egenhofer et al., 1991/1994). In addition to the relation testing, the methods that support spatial analysis are included such as Boundary, Buffer, ConvexHull, Difference, Distance, Intersection, SymmetricDifference, and Union. To create the geometry objects from data stream formatted WKB, import/export functions for WKB are implemented.

3.3.3 Spatial Reference System Component

Spatial Reference System component contain the functional interfaces to define and describe the spatial reference system for geographic features. The Spatial Reference System interfaces allow the transformations between two different spatial reference systems and various projection techniques. In this system, the Standard Molodensky and the 7-parameter technique are implemented for transformation and more than twenties projection techniques are implemented.

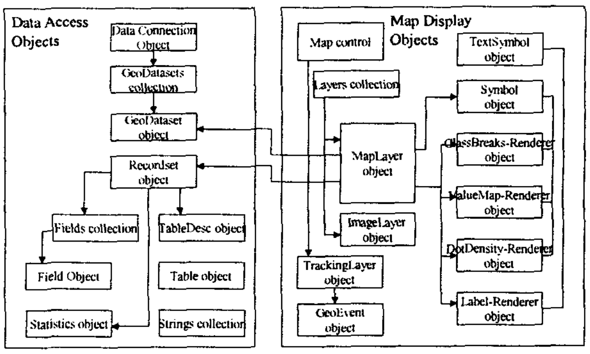


Figure 3-3 Object model of Mapbase Component

3.3.4 MapBase Component

For the purpose of the GIS tool software, the MapBase component take charge of the GIS functional capabilities. MapBase component which including the Geometry component and the Spatial Reference System component, supplement the geographics processing functional interfaces for various GIS applications. MapBase component consist of two functional objects : DAO(Data Access Object) and MDO(Map Display Object). Figure 3-3 shows the object mdel of MapBase component.

Data access object establish the connection to the data source which is provided by the data provider component, return information about attributes from features on map, and update data values.

Map display object draw maps with symbols and thematic renderers. Multiple layers are overlaid in map, and the image map could added as backdrops of map. For the dynamic features on map, tracking layer is implemented to display the real time events. MapBase control is an ActiveX control which is appeared as working area to application system. The MapBase control contain the interfaces about set attributes such as coloring, area extents etc., user interfaces and event handling such as mouse event, keyboard event, and before/after map drawing events.

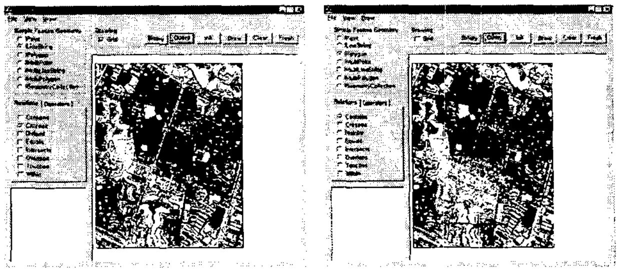
3.4 Applications

With the Open GIS component software system, diverse GIS applications could be developed. The application area is not limited. Currently, four kind of GIS application systems are on the developing, such as city planning using geocoding, water supply and drainage, land registration, and road management. Application system itself could be developed to the component which contains application dedicated functional interfaces.

IV. Implementations and Results

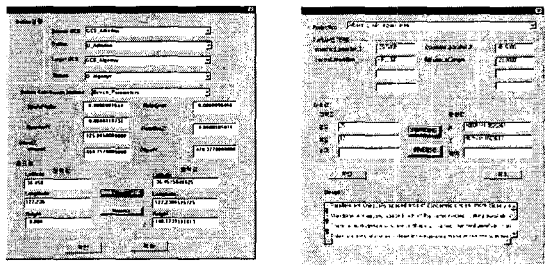
The Open GIS component software system is developed on Windows OLE COM environment using ATL and Visual C++. Each of these components implement IDispatch, therefore accessible to rapid development language such as Visual Basic, Java, and Power Builder. All COM interfaces are accessible from lower level languages such as C++ for optimal performance.

We experiment the implemented system with three kinds of program. With the Visual C++, spatial operations of Geometry component are tested. Figure 4-1 show the experimental results as, (a) is for query geometries in the map to crossing given LineString object, (b) is for query geometries containing given Polygon object. Figure 4-2 show the results of Spatial Reference System component, (a) is the result of transformation, (b) is the projection function's result. Using the Visual Basic, whole integrated components are tested and the results are showed in figure 4-3: (a) is display map with image, (b) is enlarged map, (c) (d) (e) and (f) are show the map with different renderers.



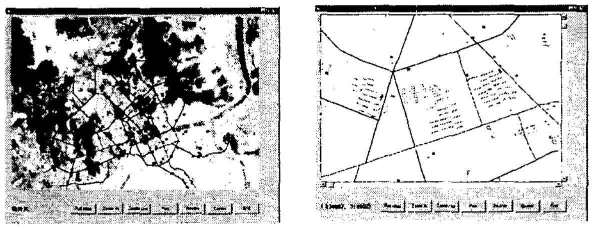
(a) Crossing geometries with LineString object (b) Contained geometries with Polygon object

Figure 4-1. Experimental Results of Geometry Component

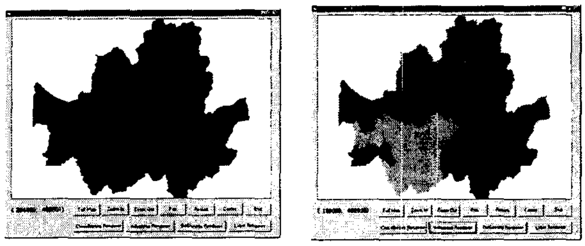


(a) Transformation between two geodetic datums (b) Projection of specified datum

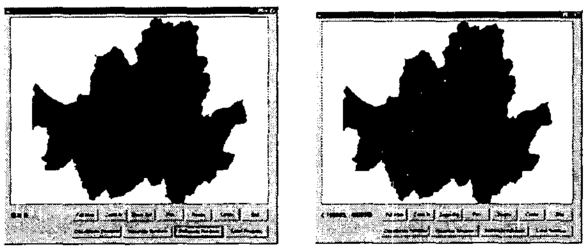
Figure 4-2. Experimental Results of Spatial Reference System Component



(a) Displayed map with geometry and image (b) Enlarged map by changing map extents



(c) ClassBreaks Renderer (d) ValueMap Renderer



(e) DotDensity Renderer (f) Label Renderer

Figure 4-3. Experimental Results of MapBase Component

V. CONCLUSION

In this paper, we describes the development of component-based Open GIS software system which proffer the interoperability and reusability. The system has been designed to adapting OGC's specification and provide the GIS technology functions as GIS tool software. We experiments the developed system using Visual C++ and Visual Basic, and the result make sure of the advantages of the open systems.

The system would be expanded to support more powerful GIS technology such as communication server for map data service on the Internet, network analysis for ITS, linking to MIS, more graceful mapping, and user interfaces.

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