RESEARCG ON THE MDA-BASED GIS INTEROPERABILITY

Qi,LI[*], Lingling,GUO[*], Yuqi,BAI[**]

[*] Digital Earth Studio, Peking University, Beijing, 100871
liqi@pku.edu.cn, guolingling@cybergis.org.cn
[**] Network Department, Institute of Remote Sensing Applications, Chinese Academy of Sciences, Beijing, 100101, yuqibai@yahoo.com

ABSTRACT

Currently, Geographic Information System (GIS) has become a significant area of application of computing technology. It is now playing an important role in the construction of Digital City. But the GIS software industry that exists today is fragmented. Different GIS applications may have different terminologies and approaches, which greatly hampers the cooperation among them. Also it brings great difficulties when updating the legacy systems.

This paper describes our research on the spatial information sharing and the GIS's interoperability from an MDA-point of view. First we analyse the GIS interoperability difficulties, and then we argue that a common model is needed for the cooperative GIS applications to follow from the design. Based on the careful analysis of MDA, we give a conclusion that MDA will help to promote the GIS interoperability. Next we discuss how to establish and provide the common-models, methods, tools and frameworks for different GIS applications and present some principles and general procedures. Finally a case study, a sub-project of National Project "Digital Beijing", is introduced to demonstrate and validate the usability and viability of this proposed concept.

KEY WORDS:
Digital City, Geographic Information System, Interoperability, Model Driven Architecture, Platform Independent Model, Platform Specific Model

Currently, the Geographic Information Systems (GISs) are playing an important role in the construction of Digital City. But the GIS software industry that exists today is fragmented. Different GIS applications may have different terminology, different data format, semantic meaning and system development approach, which greatly hampers the cooperation and integration among them. Also it brings great difficulties when updating the legacy systems. These problems are lagging the application industry represented typically as Digital City.

1. Digital City Service General Architecture

As the information centers of Digital Earth, the Digital Cities organize the cities' information based on the information highway. The Digital City manages and integrates the mass information effectively. It uses the technologies such as data mining, knowledge discover, and virtual reality to support the decision-makings of the government, the enterprises and the public. A Digital City means a totally connected City. People, Organizations and Businesses are connected with each other in it. In broad terms The

Digital Society will be characterized by networks and joined-up services. In practice it should mean that technology would play a bigger part of everyone's lives - as a tool to make things easier, so that people can save more time. The construction of digital city will show the importance of information consumption to the citizens and will promote the information requirements. Hence it will become a new economic increasing point.

The general architecture of the City's Information Resource Central Engineering has four tiers(1) : the Data Tiers, the Management Tiers, the Server Tiers and the Application Tiers. The data tiers are in charge of the spatial information retrieval, database building and updating; the management tiers manage and integrate the city's multi-source information; the Server tiers are responsible for the city information application services, while the application tiers realize the government, the enterprises and the public's applications based on the three tiers above. To each tier, there are some according specifications and protocols to ensure its functions.

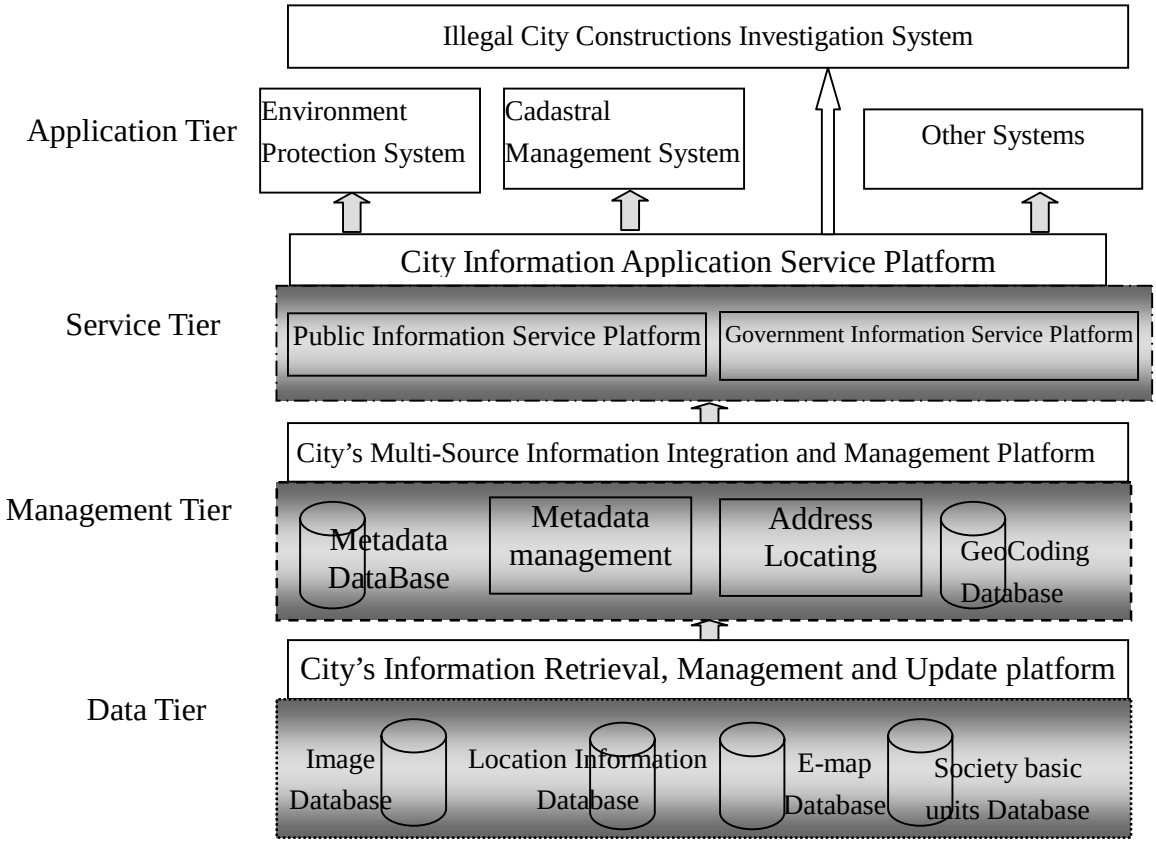

Fig 1 Digital City Service System General Architecture

2. Geographical Information Standards and Specifications

The main geographic information organizations include Technical Committee of Geographic Information/Geomatics of International Organization for Standardization (ISO/TC211), Open GIS Consortium Inc. and so on. Besides, Federal Geographic Data Committee (FGDC) is developing the National Spatial Data Infrastructure (NSDI) in cooperation with organizations from State, local and tribal governments, the academic community, and the private sector in the USA. There are some other organizations such as

which make great efforts to the standardization, such as World Wide Web Consortium (W3C), Object Management Group (OMG).

ISO/TC211 aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth(2) . These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. The work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

OGC is an international industry consortium of 258 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications(3) . Open interfaces and protocols defined by OpenGIS Specifications support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT, and empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications. The OGC Interoperability Program is a series of hands-on engineering initiatives to ccelerate the development and acceptance of OpenGIS Specifications. Learn about the different initiatives currently under way, how they are organized, and how you can participate.

OpenGIS gives a system interoperation solution from the final product view, rather than to instruct the software design and construct from a software engineer view. This is because the OpenGIS is essentially a set of statistic specifications. It cannot adapt to the dynamic requests of software systems. Therefore OpenGIS is not enough to instruct the engineering practice.

3. Model driven architecture, MDA(4) (5)

The Object Management Group (OMG) is an open membership, not-for-profit consortium that produces and maintains computer industry specifications for interoperable enterprise applications. Its mission is to help computer users solve integration problems by supplying open, vendor-neutral interoperability specifications.

The OMG’s MDA(Model Driven Architecture) provides an open vendor-neutral approach to the challenge of interoperability building upon and leveraging the value of OMG’s established modeling standards: Unified Modeling Language (UML); Meta-Object Facility (MOF); and Common Warehouse meta-Model (CWM). During its lifetime, application software requires maintenance to extend its functionality or improve system quality. These changes occur at all stages of the software development process. It is important for developers to rely on efficient and effective tools to facilitate and improve flexibility and productivity during all stages of the development life cycle. The idea of MDA is to separate the system architecture from the implementation and extend the shelf life of distributed applications is to minimize the influence caused by the change of

implementation technologies.

The key idea driving MDA is that one can create abstract models of processes, application development. The key idea driving MDA is that one can create abstract models of processes, applications or middleware systems that are independent of any delivery platform. Once one has created a platform independent model, one can refine it to generate code for any specific platform. As important, one can use the same abstract model to generate multiple implementations for a variety of different platforms. As important as this idea is, there is a lot more to MDA. Behind MDA is an abstract modeling framework MOF that supports a repository that can store any MDA artifact and related diagrams, and XMI, an XMI, an XML language that can move an models to and from the repository, or from one tool to another. In essence, companies and developers that embrace MDA are moving toward creating abstract, or meta-model descriptions that are independent of specific middleware, languages or platforms(6) .

These dynamic models make up the shortcomings of the specifications of ISO/TC211 and OpenGIS. They give a great push to the spatial information applications.

The Model Driven Architecture is illustrated in Figure 2. This model is a series of concentric circles with the core or center circle focused on a domain application's architecture. The core of this architecture is based on OMG's UML, MOF and CWM. The core comprises a number of UML profiles. Each profile represents the common features of all of the middleware platforms appropriate for its category of computing, but will be independent of any specific platform. This Platform Independent Models(PIMs) captures the conceptual design of the standards, untainted by the special features or limitations of a particular software technology. The Platform Specific Models(PSMs) represent a realization of the PIM within the context of a particular software technology wherein the choices among many possible ways of implementing different aspects of the conceptual design have been made.

The Pervasive Services are shown as a ring around the outside of the diagram to emphasize that they are available to all applications, in all environments. True integration requires a common model for directory services, events and signals, and securities. By extending them to a generalized model, implementable in the different environments and easily integrated, the MDA becomes the basis of digital city geographical information share and applications integration. The application systems developed from the same suit of models have no semantic or terminology conflicts, thus they may understand and cooperate with each other. This kind of development methodology will apparently benefit the across-domains information and applications integration.

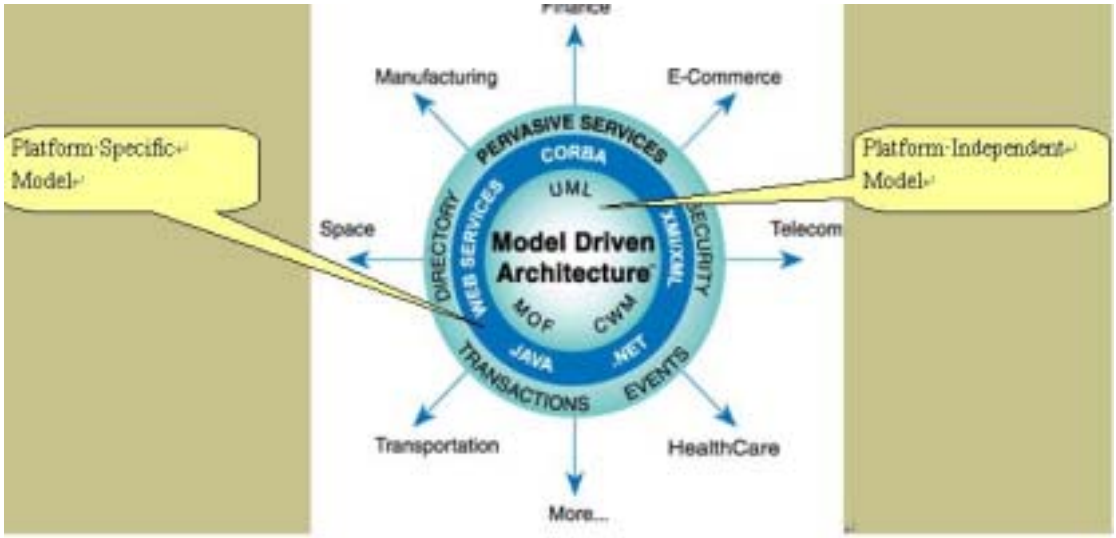

Fig2 The Model Driven Architecture

4. Digital City Models Based on MDA

Based on the work mentioned above, the geographic information share and application interoperability of digital city research begins at Conceptual Modeling. The process is Conceptual Modeling-> Modeling Implementation-> Platform Implementation->Public Service-> Domain Applications(Fig 3).

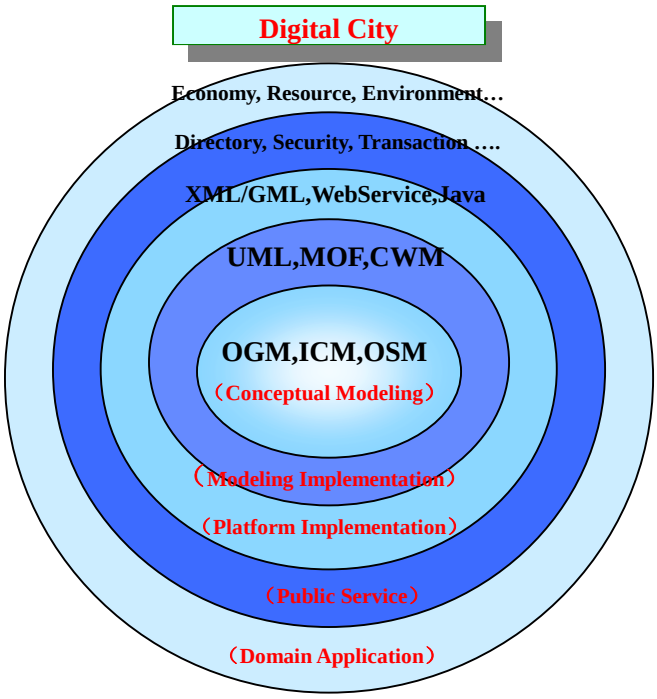

Fig 3 Digital City Models Based on MDA

The technical construction process based on MDA is as the following: System Modeling -> Formalized Expression-> Codes Generation-> System Debugging and Optimization. It is feasible to extend the spatial information systems from the three following logic parts:

（1） Backend Spatial Data Tier

The research of this tier focuses on the spatial data model and spatial data organization. The technical procedure is:

① Analyze the OGM model; Designs and realize the open spatial data models on the base of the existing spatial data models and organizations.

② Research the spatial data storage and the management; Analyze and realize the spatial database storage models and implementation.

（2） Information Service Management Tier

This tier researches the spatial information service management. It mainly includes the following four parts.

① The spatial data expression and spatial information service description specification.

② Development platform selection, such as advanced Microsoft's .NET, IBM's WebSphere, BEA's WebLogic and so on.

③ The design and realization of spatial information service description, organization and retrieval.

④ The integrated platform of spatial information service management and share research design and realization.

（3） Frontend Information Display Tier

① Research the frontend spatial information display standards and technical standards in a certain application systems, such as JavaApplet, ActiveX Control, SVG…

② Research the spatial information service dynamic retrieval mechanism.

③ Realize the frontend spatial information services transparent search and seamless integration.

Based on the above three research results, it can be anticipated to get the spatial information share and application systems interoperation public model standards, specifications and according logic systems and tested technical approach.

5. An Example

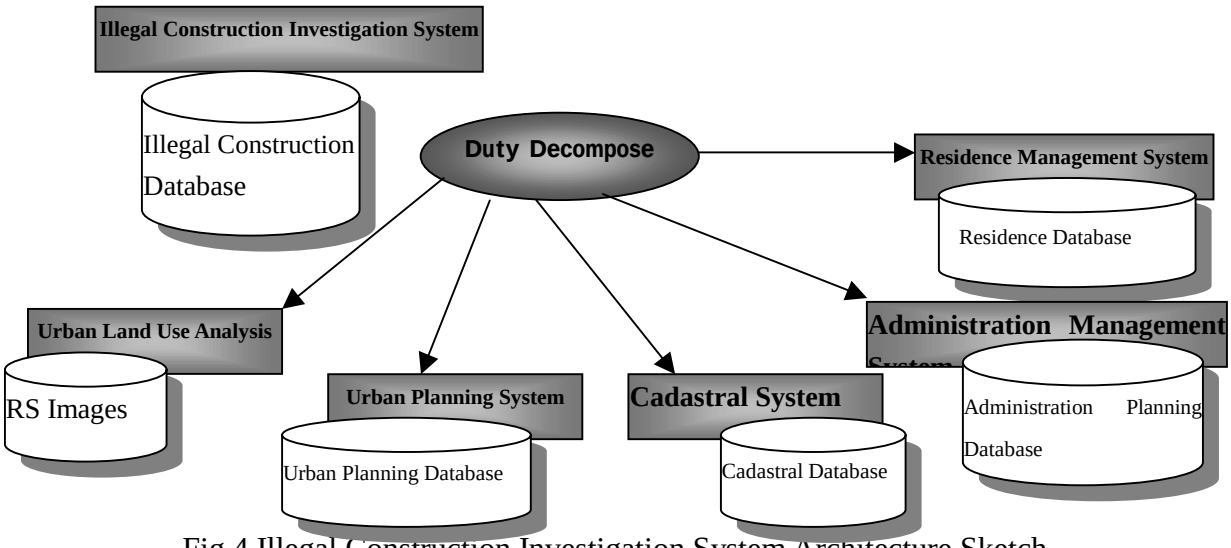

Fig 4 Illegal Construction Investigation System Architecture Sketch

The figure 4 shows a typical digital city application system: Illegal Construction Investigation System.

The workflow of this system is as the following:

1) Use high-resolution remote sensing images to get the urban land-using and urban construction information;
2) Investigate the urban construction change information based on the remote sensing images in different time;
3) Validating the illegal constructions and register in the illegal constructions database;
4) Check the administration planning data and residence data; Submit the disposal and punishment request to the according department;
5) Supervise the disposal situation using the new remote sensing images;

From the digital city service system view, the Illegal Construction Investigation System and other related application systems are all at the application tier. They are of interoperation relationship horizontally and spatial information share relationship vertically. From the workflow above, we can see, the Illegal Construction Investigation System need interact with other systems in other fields. The model driven approach using in the systems will ensure the application models and semantics consistence in these systems and shun the semantic terminology and other kinds of conflicts. This makes these systems interoperate smoothly.

6. Conclusion

This paper researches the spatial information application service interoperations in digital city. With the current spatial information standards and specifications, we give a conclusion that the applications of MDA in GIS application system Models will help to push the GIS data share and applications interoperation forward.

7. Reference

（1） Beijing Information Resource Management Center, 2002, Beijing Information Resource Network Design

（2） http://www.isotc211.org/ 2003-7-30

（3） http://www.ogc.org. 2002-12-28

（4） Joaquin Miller, Jishnu Mukerji, Model Driven Architecture (MDA) Document number ormsc/2001-07-01, www.omg.org/mda

（5） Richard Soley and OMG Staff Strategy Group, Model Driven Architecture White Paper Draft 3.2-Nov 27,2000, www.omg.org/mda

（6） Paul Harmon,2002-10, MDA And Ecilipse, www.ltt.de