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A Study on GIS Component Classification considering Functional/Non-Functional Elements

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기능적/비기능적 요소를 고려한 GIS 컴포넌트 분류에 관한 연구

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ABSTRACT

Recently software industry in GIS(geographic information system) becomes an interesting issue by performing a large scale of national GIS application development as well as even small unit of FMS(facility management system). Also, there exist many cases to combine GIS with various business domains such as MIS(marketing information system), CNS(car navigation system) and ITS(intelligent transportation system). In this situation, in order to develop an efficient and useful GIS application for a short term, there must be a deep consideration of not only developing GIS component but also managing GIS component. In fact, even though there exist many certain components having high reusability, excellent interoperability and good quality, their reusability may be reduced because of their difficulty to access in a certain repository. Therefore, it is important to classify components having common characteristic based on their particular rule with reflecting their functionality and non-functionality before cataloging them. Here, there are two non-functional classification categories discussed such as GIS content-dependent metadata and GIS content-independent metadata. This cataloged components will help application developers to select easily their desired components. Moreover, new components may be easily producted by modifying and combining previous components. Finally, the original goal of all this effort can be defined through obtaining high reusability and interoperability of GIS component.

KEYWORDS: GIS(Geographic Information System), Component, Classification, Metadata, Reusability, Interoperability

요 약

최근 지리정보시스템은 국가단위의 대규모 응용 애플리케이션 개발 뿐만 아니라 시설물관리시스템과 같은 소규모 시스템에 이르기까지 그 규모가 다양하다. 또한 그 활용 분야도 경영정보시스

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템에서부터 카네비게이션시스템에 이르기까지 우리의 일상 생활에 다양한 모습으로 다가오고 있다. 이런 시점에서 짧은 시간 내에 효과적이고 유용하게 지리정보시스템을 개발하기 위해서는 GIS 컴포넌트의 개발방법론 뿐만 아니라, 이미 개발되어 사용되어지고 있는 GIS 컴포넌트의 관리측면에 대한 고려가 매우 절실한 실정이다. 현재 많은 GIS 컴포넌트가 그 상호운용성 및 질적면에서 탁월한 결과를 가지고 있지만, 저장소 내에서 검색의 비효율성으로 인해 재사용성의 많은 문제점을 가지고 있다. 본 논문에서는 각 GIS 컴포넌트가 저장소 내에 위치하기 전에 이들의 기능적 및 비기능적 요소를 반영하여 컴포넌트를 분류하고자 하였다. 특히 비기능적 요소를 정의함에 있어서 컴포넌트의 메타데이터를 이용하여 'GIS content-dependent metadata'와 'GIS content-independent metadata'를 식별하였다. 그리고 이들 정보를 바탕으로 웹기반 GIS 컴포넌트의 등록 및 검색시스템을 설계하였다. 향후 GIS 애플리케이션 개발자는 웹기반 GIS 컴포넌트 저장소 내에 등록된 컴포넌트와 그 정보를 바탕으로 자신의 목적에 부합하는 새로운 컴포넌트를 쉽게 재구성하고 수정할 수 있으리라 사료된다. 결국 GIS 컴포넌트의 재사용성과 상호운용성을 높여 새로운 지리정보시스템 개발에 소요되는 인력 및 시간, 예산 절감의 효과를 얻을 수 있을 것으로 기대된다.

주요어: 지리정보시스템, 컴포넌트, 분류, 메타데이터, 재사용성, 상호운영성

INTRODUCTION

Recently many software engineers have focused on component research to increase its reusability and interoperability. Especially, the research of common repository system for architecture technology, management and development has been regarded as a hot issue because it can save time and manpower by accessing to exactly what system developers are looking for(Han, 2002).

Usually system developers tend to spend much of their time and effort to find out certain functionality for the implementation of their preferred style. Also, they want to obtain guaranteed component to improve their system productivity and quality at the same time(Kim, 2000).

However, as you may know, it is very difficult to identify certain components in a repository because of the lack of quality of software components and the inability of developers to efficiently find them. Here, in order to solve this problem, establishing fully repository architecture on the web for component sharing and circulation should be encouraged in a proper way.

In addition, to implement GIS more efficiently in the view of cost and time, GIS developers started to consider the concept of GIS component. It is mainly focused on reusability and interoperability because most GIS projects have its certain application such as MIS(marketing information system), ITS(intelligent information system), LIS(land information system), DCS(disaster control system) and FMS(facility management system) and each application needs its common functionalities such as mapping and query or its certain functionality such as 3D viewer and GPS data processing. Therefore, if there exists a universal repository storing GIS components and system designers or developers know where desired component are located in real time, they can easily select their desired component then modify or composite to their system by using them(Han, 2002).

In this paper, the GIS metadata, which describe GIS component, are the key to the repository. Therefore, metadata, especially describe GIS components the most, should be first defined then the architecture of a component repository can be constructed soon. This GIS component architecture can identify the functionality and non-functionality based on GIS domain and will be possibly used for registering component, searching, cataloging, deploying GIS components in a repository system.

RELATED WORKS

What is the first thing that system developers consider when they are developing the application system? It must be to maintain the interoperability and reusability by using components. Because of this, the technology of component tends to be widely used in all kinds of application development, especially GIS.

1. The Tendency of Component Development in GIS(Joo, 2001; Presto, 2001)

Generally different GIS users have their own requirements and preferences, a number of models depending on what they are focusing on. Recently, while a number of standardization bodies are currently working on different aspects of GIS, OpenGIS Consortium and ISO Technical Committee 211 are mostly noticeably. As you may know, the OGC is concerned with software specifications while ISO/TC 211 concentrates more on data standards.

In this paper, the OGC(OpenGIS Consortium) is more focused as related work because it has dedicated much time and effort towards to solve the interoperability issues outlined previously. The OGC is the full integration of geo-spatial data and geo-processing resources into mainstream computing and the widespread use of interpretable geo-processing software and geo-data products throughout the information infrastructure. In order to facilitate this, its working groups have developed abstract specifications and implementation specifications for its two central technology themes of sharing geo-spatial and providing geo-spatial services.

1) Open GIS Consortium (OpenGIS Consortium. 1998)

- The Abstract Specifications

The abstract specification documents provide the theoretical background for the Implementation Specifications. The Open GIS abstract specification documents are composed of two models: 1) the Essential model that describes a conceptual link between the software system and the real world, and 2) the Abstract Model that describes how the eventual software system should work in an implementation neutral manner. Table 1 provides a very brief description of each of the topics described in the Open GIS Abstract Specification.

- The Implementation Specifications

The Implementation Specifications documents are a set of specifications that contain guidelines for implementing Open GIS applications or components. Table 2 provides a very brief description of each of the Implementation Specifications.

TABLE 1. The abstract specifications

Specification	Purpose
Overview	Provides on overview of the OpenGIS® abstract specifications
Feature Geometry	Describes on abstract model for the geometric representation of GIS-objects(i.e. fuatures)
Spatial Reference System	Contains definitions of classes for reference systems, data types, units and operations
Locational Geometry	Functions for mapping features from one locational system to another
Stored Functions and Interpolation	Calculating functions, interpolation, and extrapolation
The OpenGIS® Feature	Modeling real world and abstract entities
The Coverage Type	The formulation and calculus of the coverage type and its subtypes
Earth Imagery	Image geometry models, and models for computing the real world-model
Relationships Between Features	How to model relationships between Features
Quality	Defines various positions accuracy terms and concepts
Feature Collection	Models for handling feature collection
Metadata	Models for handling feature and feature collection metadata
The OpenGIS® Service Architecture	A framework of services required for the development and execution of geometrically oriented applications
Catalog Service	OpenGIS® service for data dictionary and data access
Semantics and Information	Communications sharing data between communication
Image Exploitation Service	Functions for image exploitation, such as feature extraction
Image Coordinate Transformation Service	Service for transforming image position coordinates to and from ground position coordinates

TABLE 2. The implementation specifications

Specification	Purpose
Simple Features Specification	Specification for the handling of simple geometric representations of GIS-objects, such as polygons(excludes 3D), and reference systems
Catalog Services Interface Implementation Specification	Specifies how geo-spatial handing over networks should be implemented
Grid Coverage Implementation Specification	Specification for all types of raster based images. Interfaces for analysis and calculation, such as histogram, covariance etc
Coordinate Transformation Service Implementation Specification	Strategies for coordinate systems and transformation between them
Web Map Server Interface Implementation Specification	Defines services necessary for Web-based access to geo-data and processing
Geography Makeup Language(GML) Implementation Specification	XML encoding of the Simple Feature Specification

GIS COMPONENT CLASSIFICATION

As mentioned in related works, the number of component technology based on OpenGIS specification, which is a global standard for the interoperability of GIS, has rapidly developed. Also, these researches are mainly focused on developing components.

In this paper, to obtain the higher reusability and interoperability of existing components, which was already developed based on standard, the way to classify these components and store them in a repository properly should be considered. Here are two views of classification; 1) The functional component classification, 2) The non-functional component classification.

1. The Functional GIS Component Classification

As you may know, actually there are some consideration about functional component classification as show in related works. In this paper, the functional component classification in GIS is proposed considering 3 layers in Figure 1. First of all, GIS data source component, which has purpose to acquire interoperability among spatial data format constructed under heterogeneous environment. Secondly, GIS functionality component, which can be used as the kernel of GIS by developing certain GIS application software. There exist general GIS functions such as map display, and attribute display also exist certain GIS functions such network analysis, 3D analysis, and authority. Third, GIS application component, which shows several GIS domain such as MIS(marketing information system), FMS(facility management system), DCS(disaster control system), ITS(intelligent transformation system), UIS(urban information system) and LIS(land information system). In Figure 1, the functional GIS component classification architecture indicates the view of vertical GIS component and it will help to catalog them in a repository.

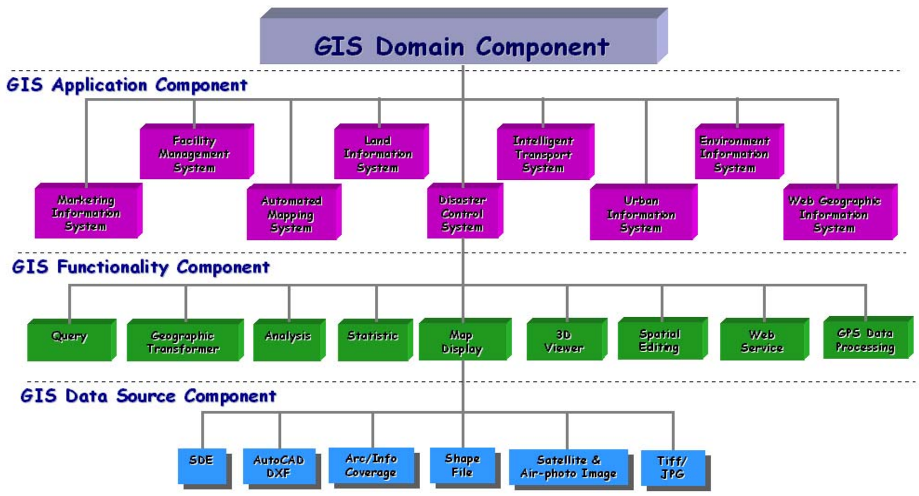


FIGURE 1. The functional GIS component classification

2. The Non-Functional GIS Component Classification

It is important to classify components having common characteristic based on their particular rule. It shows the view of horizontal GIS component. Even though there are certain components having reusability and good quality, the rate of their reusability may be low because they have difficulty to access in a repository. It is essential to express the non-functional element to identify components(Jo, 2002).

Here, two big non-functional classification categories are discussed such as GIS content-dependent metadata and GIS content-independent metadata. As you see in

TABLE 3. The definition of each metadata

GIS content-dependent metadata	
Identifier attribute	Metadata to identify each component is unique in a repository
Service attribute	Metadata to explain each component s certain GIS production
Support data attribute	Metadata to define GIS feature type that each component supports
GIS content-independent metadata	
Description attribute	Metadata to define the configuration of each component
Environment attribute	Metadata to show system operation environment for component
Development attribute	Metadata to show system development environment for component
Restriction attribute	Metadata to explain restriction rule or state of each component
Supplier attribute	Metadata to show component supplier's information
Quality attribute	Metadata to show each component s authentication state
Special mention attribute	Metadata to show each component s preference & manual language

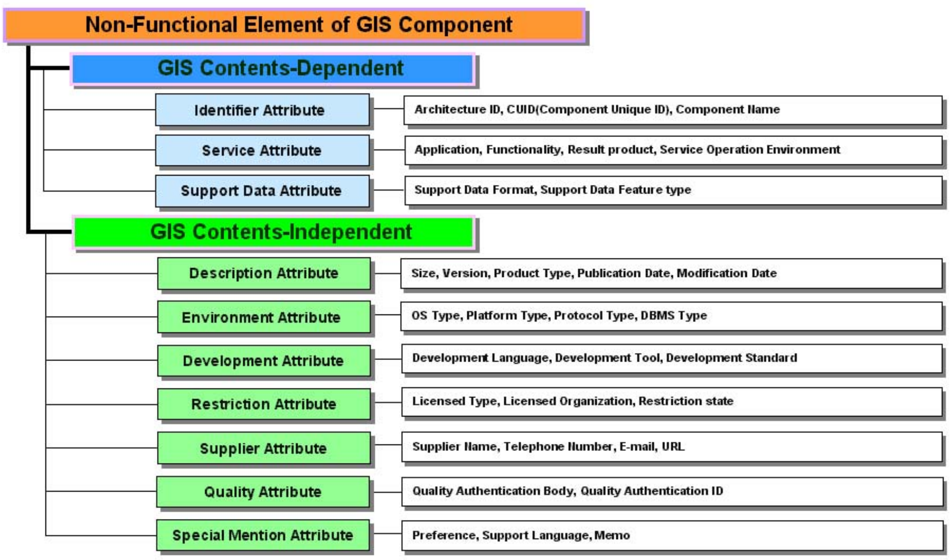


FIGURE 2. The non-functional GIS component classification

the item name, when metadata is associated with the original GIS domain itself, we call it GIS Content-dependent metadata. Especially, considering GIS content-dependent metadata, there are three small categories related to it; 1) Identifier Attribute 2) Service Attribute, 3) Support Data Attribute.

On the other hand, GIS content-independent metadata, it does not depend on the GIS domain, itself. These kinds of metadata can be derived independently from the content of the GIS. It includes seven small categories; 1) Description Attribute, 2) Environment Attribute, 3) Development Attribute, 4) Restriction Attribute, 5) Supplier Attribute, 6) Quality Attribute, 7) Special Mention Attribute.

Table 3 shows the definition of each metadata and while Figure 2 presents the example of each meta data, respectively.

In Figure 3, the needs of individual GIS system developers tend to limit to what kinds of component they are accessing to on Web. System developers can obtain certain functionality presented to them in a way suiting their preferred style for its implementation. As the result, they can save their time, effort, and cost through on-line adaptation of GIS component in a repository.

At this time, metadata query broker is working as a brokerage mechanism supplied in the repository for the retrieval of various types components. As stated before the original purpose of these metadata query broker is to search the component that is usually associated with implementation of GIS application. Especially, to avoid storing multiple copies in a repository, each component should be registered through UID(Unique ID).

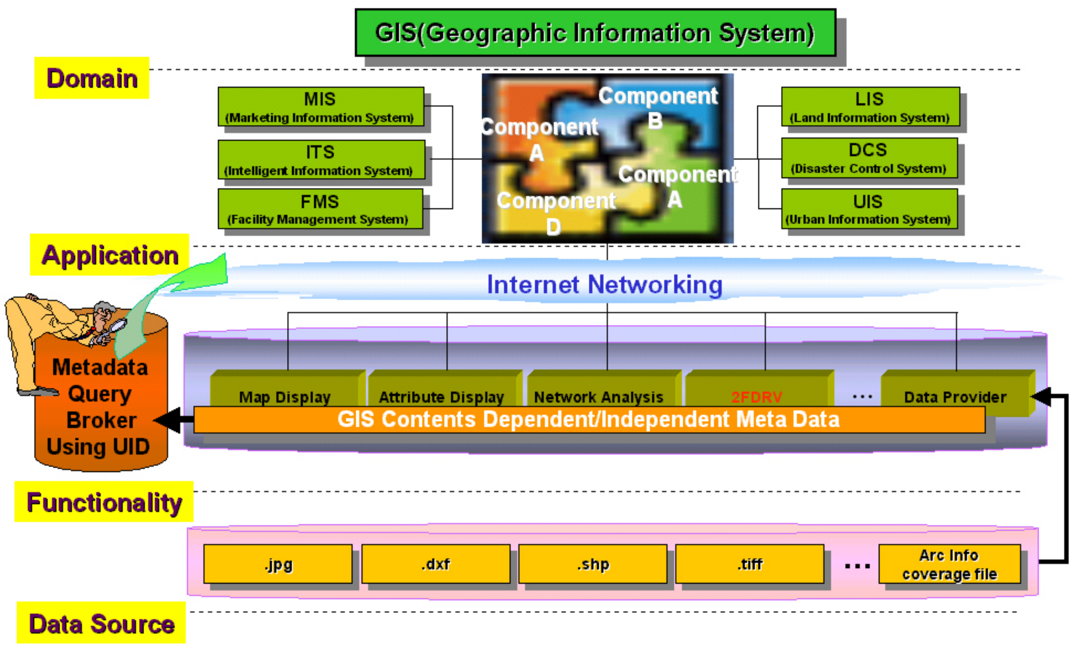
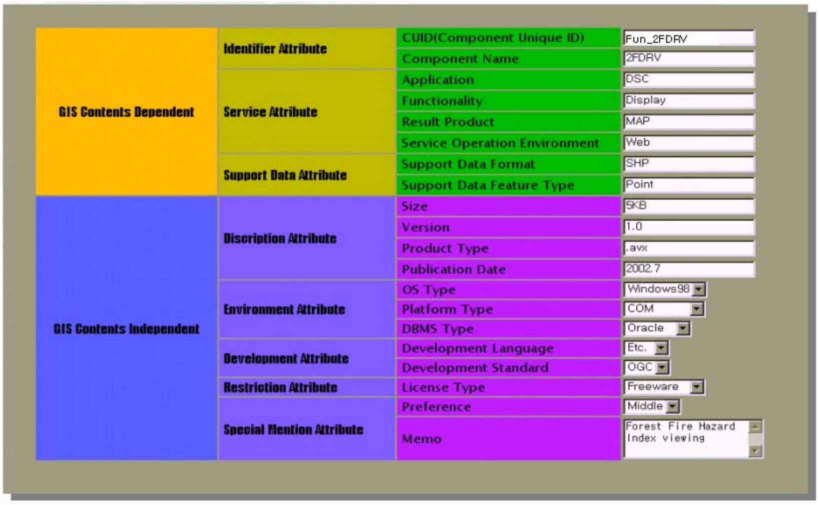


FIGURE 3. On-line adaptation of GIS component

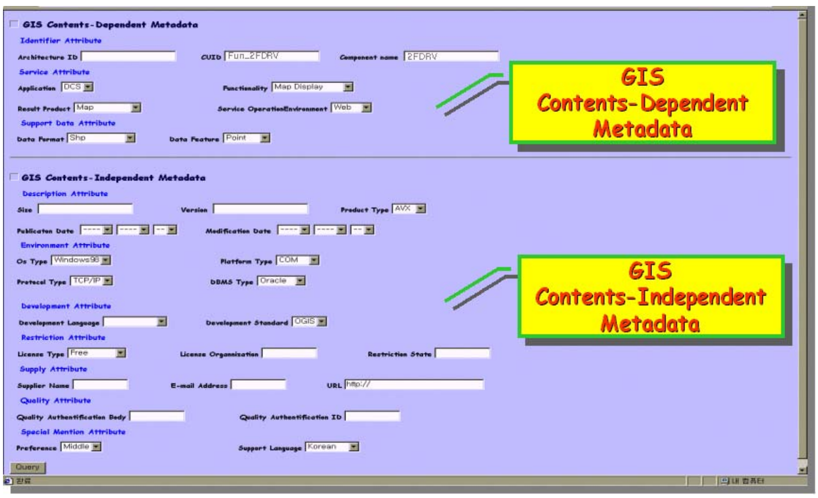
PROTOTYPE OF GIS COMPONENT REGISTRATION & RETRIEVAL SYSTEM On-LINE

In this paper, the prototype of GIS component registration & retrieval system is shown considering one certain component, whose UID is Fun_2FDRV(GIS Functionality_Forest Fire Danger Rating Viewing component). The main goal of this component is to service web based forest fire danger rating on map(Jo and Jo, 2002).

For this, the architecture in the view of both functionality and non-functionality is considered to search desired component in a repository. First of all, in the view of functional GIS



(a)



(b)

FIGURE 4. The prototype of GIS component registration system

component classification, this component is identified as DCS in GIS application component level, map display component in GIS functionality component level. Also, it supports shape file format using GIS data source component level.

Figure 4 shows the prototype of web based GIS component registration & retrieval system. To operate this system, the non-functional GIS component classification, metadata of each component, is mainly used.

In order to implement this prototype of web based GIS component registration and retrieval system, Oracle 8i is used as DBMS and Java and HTML are used as development language, respectively. When GIS component is registrated, the GIS contents dependent metadata are required mandatorily. Also, component UID should be considered not to be repeated in a repository after certain GIS component authenticator inspects.

Figure 5 tells the prototype of result after operating GIS component registration and retrieval system, which is shown above. Here, the detail metadata of 2FDRV is described in the terms of non-functional GIS component classification defined already.

CONCLUSION AND FUTURE WORKS

Recent paradigm of software engineering tends to focus on developing component, which considers reusability and interoperability. In addition, it considers storing them in a repository, managing, and deploying in various business domains such as financial system and manufacture system.

In this paper, GIS component classification in the view of functional and non-functional metadata is described by developing GIS application in efficiently and manage GIS components generated for high reusability.

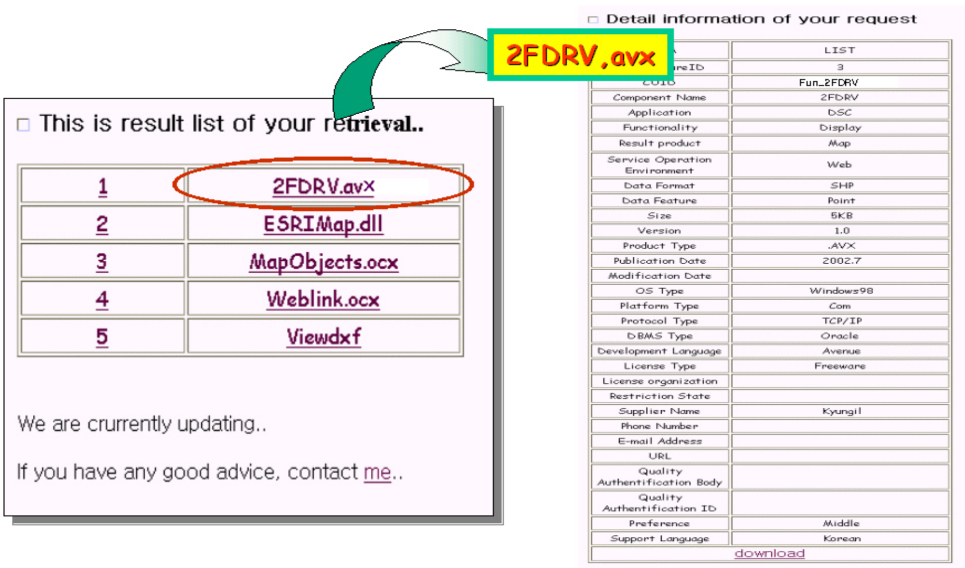


FIGURE 5. The prototype result of GIS component registration and retrieval system

Also, as the case study, the prototype of web based GIS component registration and retrieval system is implemented by using GIS component metadata.

In the future, in order to increase component reusability and interoperability in GIS domain, these should be consideration for GIS component repository management system using not only metadata described here but also further extended metadata. KAGIS

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