Improving Interoperability of 3D Geographic Features via Geographic Managed Objects

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ABSTRACT

This paper presents a method to improve the interoperability of 3D geospatial features from the perspective of data representation, with an emphasis on the interoperability of advanced functions associated with 3D models, such as thematic functions, interaction capabilities, and dynamics. The central concept of the proposed method is to express geospatial features in the form of managed objects, which carry both functions and data of 3D geospatial features in an object oriented and platform-independent manner with the support from virtual machine mechanism. Unlike any conventional data representation method that maintains the data and functionality separately; this method allows the features to carry their own executable functions by themselves in order to achieve the interoperability on a feature’s level. A use case is also provided in this paper to demonstrate the presented method. In this use case, different applications can simply fetch the 3D features and run their functions without the need to know what they can do beforehand.

Keywords: 3D, Behaviors, Data Representation, Geographic, Interoperability, Managed Object

INTRODUCTION

A geographic feature refers to an existing entity that is on or near the surface of the Earth (i.e., the geographic domain). Goodchild (2001) defines geographic as “a subset or specialization of spatial, which by extension refers to any spatiotemporal frame, and any spatial resolution, and also includes non-Cartesian spaces”. Thus, geographic features are also called geospatial features, which are specialized spatial features that carry the specific nature of geographic information (Goodchild, 2001).

Representation of Geospatial Features

The scope of geographic features is extensive; it encompasses any disciplines in the geographic space: geography, meteorology, transportation, energy, criminology, sociology, archaeology, and many more (Goodchild et al., 2007). This diversity actually brings difficulties in the digital representation of geographic features. The same geographic entity is usually differently defined...
in different paradigms for the purpose of depicting different spatial and temporal scenarios, and there is no uniform set of identities that reflect heterogeneous representational models.

Therefore, some researchers suggest that the representation of features is application-dependent. Lehan (1986) defines a feature as a “physical entity that is recognized in the user’s definition of reality’ and reality as ‘the characteristics of a region that are significant to the user of a specific classification of spatial information.” By this definition, “what makes a feature a feature is a system’s users and usages” (Langrana, 1992, p. 49).

In such context, we can say that the number of representation forms is as large as the number of ways that humans perceive the world (Yuan et al., 2004). However, in order to enable the interoperability, it is also required to let the representation forms be understandable by other systems (Fisher, 2005; Bishr, 1998). This requirement is then conventionally fulfilled by standardization, which extracts representation templates that covers most of the needs in a common field of application.

In the field of 3D GIS, the geometry of a feature is normally taken as a basic part of the feature representation. Therefore, we can parameterize a standardized representation of a geographic feature as the following tuple:

\[ F = \{ G, T, V \} \] (a)

Where:

- \( G \) is the geometry (if any) defining the shape and the spatial occupation of the feature,
- \( T \) is the attribute schema of a specific feature type according to a predefined standard,
- \( V \) is the set of values (which are not necessarily numeric) assigned to the attributes.

Since the feature is depicted with strict respect to the \( T \), \( T \) in turn also defines the range of values valid for \( V \). Different systems must fully understand the data representation before they can run any functions regarding the \( F \), and this requirement can be really hard when diverse applications are involved.

The Concept of Managed Objects

In contrast to the conventional data representation methods as shown in Eq. (a), we propose to use managed objects (MOs) to represent geographic features. A managed object (MO) is defined as a pure Object-Oriented (OO) and a platform-independent binary representation of a real world entity.

A MO carries both the executable behaviors and data. It is said to be managed because it is defined within the paradigm of managed code (MC) concept, which uses the virtual machine (VM) (Smith et al., 2005) to manage the code that defines it. Since the code is loaded, executed and unloaded by a VM, it becomes independent from any hardware, operating system or external data sources. The only mandatory requirement is that there is a virtual machine (VM) running on top of the host computer. It is therefore reasonable to think of the term ‘managed’ as a way to achieve interoperability under the ‘management’ of a VM. The idea of MC has been studied and applied in many technologies, such as Smallworld MAGIK, Java, .NET, Apple’s universal binary and more. However it has not effectively been explored for the representation and implementation of geographic features. At the Centre for 3D GeoInformation (3DGI), Aalborg University, an active research aiming at introducing MC to the digital earth domain has been carried out since 2006. It worth to mention this paper is largely built up on top of all the previous research at 3DGI.

A Real Life Use Case

The introduction to our approach begins with a real life use case. The city of Drammen, Norway, is involved in an ambitious project whose main goal is to promote zero-emission electricity consumption. This consists of promoting the use of renewable energy and the optimization of energy consumed by heating. In this project, we were asked to simulate the consumption of electricity for each building. The electricity
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