Using Temporal Versioning and Integrity Constraints for Updating Geographic Databases and Maintaining Their Consistency

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ABSTRACT

The use of geographic data has become a widespread concern, mainly within applications related to spatial planning and spatial decision-making. Therefore, changing environments require databases adaptable to changes that occur over time. Thus, supporting geographic information evolution is essential and extremely important within changing environments. The evolution is expressed in the geographic database by series of update operations that should maintain its consistency. This paper proposes an approach for updating geographic databases, based on update operators and algorithms of constraints integrity checking. Temporal versioning is used to keep the track of changes. Every version presents the state of the geographic database at a given time. Algorithms of constraints integrity checking allow maintaining the database consistency upon its update. To implement our approach and assist users in the evolution process, the GeoVersioning tool is developed and tested on a sample geographic database.

Keywords: *Consistency, Geographic Database, GeoVersioning, Integrity Constraints, Versioning*

INTRODUCTION

Today, an increasing huge amount of geographic data issued from various producers and data collection techniques is being stored and shared between providers and users of Geographic Information Systems (GIS). A full range of spatial analysis and modeling components are supplied by various software vendors and private individuals, based on geographic data. In addition, GIS software is increasingly used in large multiuser environments where spatial data is gathered from multiple sources and in different formats and should be accessed using a variety

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of platforms and devices. A GIS must produce useful information products that can be shared among multiple users, while at the same time provide a consistent infrastructure to ensure data integrity. As a result, users increasingly require interoperable and flexible GIS with the potential to update, maintain and integrate geographic information (An & Zhao, 2007; Jaziri, Chaabane & Gargouri, 2010). Interoperability enables the integration of data between organizations and across applications and industries, resulting in the generation and sharing of useful information (Jaziri & Mainguenaud, 2013).

In recent years, there has been an explosion of interest in using geographic information provided voluntarily by individuals. This phenomenon is known as Volunteered Geographic Information (Goodchild, 2007, 2008). Sites such as WikiMapia, OpenStreetMap, and Google Map Maker are encouraging volunteers to create, disseminate and share a global patchwork of geographic information using their own data. The accuracy, quality and reliability of the input information are therefore very variable.

Because it is gathered by individuals with no formal training, the quality and reliability of Volunteered Geographic Information is a topic of debate. Quality assurance of Volunteered Geographic Information is important for people who want to use it.

The constant evolution of the real world must be represented in the Geographic Databases (GDB) in order to reflect the actual state of the studied space at a given time. According to (Pierkot, 2008), a GDB is a consistent set of descriptive data and geometry representing a spatial region. The data stored in the database (DB) may be represented in raster or vector mode. The raster mode is based on a pixels grid representation. The vector mode manipulates geographical features (Jaziri, 2007). In the following, we will focus on the vector mode representation where each feature corresponds to an object. Each object is represented according to two components: spatial and semantic components. Spatial components express geometric information such as shape (Point, Line, Polygon, etc.), position (coordinates in space), and spatial relationship descriptions between objects (e.g. intersects, overlaps, equals, etc.). Semantic components describe the nature and the characteristics of the object (e.g. name, address, description).

GDBs contain data captured and/or copied from another source, and are often designed with a specific application in mind. The constant evolution of the real world should be represented in the GDB, to be in conformity with the reality it models. This induces the need to regularly update the database, every time a change occurs.

Procedures for detecting changes and updating dependent objects should be developed, based on change operations which should in addition maintain the database consistency. The change operations may be an operation of adding, modifying or deleting an entity (Sassi, Brahmia, Jaziri & Bouaziz, 2010). After an update operation, the resulting geographical data sets must be consistent in order to keep conformity of the database objects with the real world objects.

The technique of versioning allows managing database evolution while keeping the track of changes. Every version presents the state of the geographic database at a given time and should be consistent with the reality it models at a given time.

Consistency is a desirable and usually mandatory property of databases. Consistency in database systems is defined as the satisfaction by a database instance of a set of integrity constraints that restricts the admissible database states (Rodríguez, Bertossi & Caniupan, 2013). The problem of database consistency is here studied in the context of geographic information. Several characteristics of geographic information complicate the process of keeping objects consistent after update, such as the semantics of changes, the spatial extent (which depends on the level of abstraction), the database structure etc.

Many GIS available on the market provide various features, but highly dependent on the needs of the application and the users' requirements. Thus, there are no complete GIS but there is

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