An Oracle-based Data Management Method for Large Database in CyberCity GIS

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1 Introduction

The term CyberCity is used to represent the virtual representation of a city. It facilitates the processes of urban planning, telecom system design, control and decision making, tourism, etc. The CyberCity represents three-dimensional data and photorealistic surface description. Therefore, the description of surface character and material parameters, including geometry, photo texture and additional information, are the contents of a CyberCity database. Traditional GIS involving spatial and thematic attributes employs a so-called hybrid solution, in which the thematic attributes are represented in the relation model whereas the spatial attributes are stored in a file-based model. The hybrid solution has various disadvantages. It is difficult to maintain and usually has different approaches in data security, backup and concurrence access for different data type. However, the technology and software achievement in object-relational database system in recent years offers an opportunity to solve this problem. The object-relation database system is a relational database which can be extended with the and of application-specific data types. In various commercial DBMS Oracle8i provides a completely standard architecture for the management of spatial data within a database management system. Users of spatial data gain access to standard Oracle8i feature, such as client/server architecture, object capabilities, data management utilities, data integrity, recovery and security feature.
So the implementation of CyberCity application is based on Oracle 8i (8.1.6) commercial database.

2 Architecture of CCGIS

The construction of CyberCity requires 3D city models with realistic material or texture description and related attributes. There are usually three basic data models involved in the CCGIS: digital elevation model (DEM), digital orthoimage map (DOM) and 3D object models. Unlike the true 3D GIS needed in geological or oceanic applications, the main objective of current CyberCity GIS is to deal with the 3D objects as surface models (sometimes they are considered as 2.5D models). As shown in Fig. 1, the architecture of CCGIS consists of three layers. The top layer is the 3D real time applications such as 3D dynamic interactive visualization. Its data access depends on the middle layer, i.e. the CCGIS-SDE, which is responsible for the data communication with the database management system (DBMS) that manages all data of CCGIS in database. This database is an object relational database, e.g. Oracle 8.1.6. The SDE extends the data retrieval functionality and provides various efficient data management approaches, such as special R + -tree index, data compression schemes and fast access strategy.

3 R + -tree index for fast data retrieve

The authors propose to use R + -tree as the basis for CyberCity GIS to develop a data structure to spatially organize large amount of 3D data. Why this index method is called R + -tree index is because among the bounding boxes of local regions there is no intersection, and among all the leaf nodes of the R + -tree (geometry records) there is no repetition. In order to keep the data consistence in the database, one geometry in one city is exclusive. As shown in Fig. 2, the spatial index of CyberCity includes three different types of indexes: 3D object index, DEM index and image index. The whole city is divided into rectangular regions at first, and geometries are then classified into different regions based on the center of the rectangular bounding box of each geometry. A global table that manages all the rectangular regions of a city is established to locate the local regions with the bounding box information. Simultaneously several management tables are set up according to the number of local region and each local region has a management table to manage all the geometry tables in this rectangular region. To insert geometries into geometry table, the proper local region and proper geometry table based on the center of the rectangular bounding box of each geometry is fixed.

3.1 Management of large DEM

To manage large DEM which is processed as typical raster data, a so-called gridded manner algorithm is designed. In this method tile is the logical subdivision of the whole region. The tile is composed of blocks which are the basic data storage and access units and servers as the foundation of data index. For 3D real time visualization applications, block is also the basic rendering and LODs (levels of details) process unit. When blocks are stored, each block in tile is aligned with its neighbour blocks in four directions. The cell, minimum subdivision of DEM data, consists of four original elevation points. All blocks of a specific grid interval constitute a layer, the DEM dataset at a certain scale or resolution. For large region the terrain visualization LODs are important, it relates to various grid intervals DEM data (DEM pyramid) layers on this occasion. When DEM database is created, the