Quadrant II – Transcript and Related Materials

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Notes

Database Management System: Definition, Standard and Spatial Database models.

Introduction

A database management system is thus a method of encapsulating the valuable data to make it available to a multitude of users while simultaneously protecting the data. Early in the history of data processing, programmers became aware of the similarity in needs of different applications to store and retrieve data. Instead of rewriting procedures for these functions for each application, an attempt was made to write a generally applicable program to provide these services. The idea of a (generalized) database management system was born (CODASYL, 1962, 1971).

What are databases?

A database is a collection of information stored within a computer. Databases allow computers to store essential information in an organized and easily searchable way. A database is a collection of related data which represents some aspect of the real world. A database system is designed to be built and populated with data for a certain task.

DBMS Definition

A database is a collection of data or records. Database management systems are designed to manage databases. A database management system (DBMS) is a software system that uses a standard method to store and organize data. The data can be added, updated, deleted, or traversed using various standard algorithms and queries.

Database management system

A Database Management System (DBMS) is a set of computer programs that controls the creation, maintenance, and the use of the database of an organization and its end users. It allows organizations to place control of organization-wide database development in the hands of database administrators (DBAs) and other specialists. DBMS allows users and other software to store and retrieve data in a structured way. It helps to specify the logical organization for a database and access and use the information within a database. It provides facilities for controlling data access, enforcing data integrity, managing concurrency controlled, and restoring database.

Characteristics of Database Management System

Here are the characteristics and properties of Database Management System. Provides security and removes redundancy Self-describing nature of a database system Insulation between programs and data abstraction Support of multiple views of the data Sharing of data and multiuser transaction processing.

Database Management Software allows entities and relations among them to form tables. It follows the ACID concept (Atomicity, Consistency, Isolation, and Durability). DBMS supports multi-user environment that allows users to access and manipulate data in parallel.

Types of Database Management Systems

There are several types of database management systems. seven common database management systems are Hierarchical databases, Network databases, Relational databases, Object-oriented databases, Graph databases, ER model databases, Document databases and NoSQL databases.

What is a Spatial Database System?

In various fields there is a need to manage geometric, geographic, or spatial data, which means data related to space. The space of interest can be, for example, the two-dimensional abstraction of (parts of) the surface of the earth that is, geographic space. At least since the advent of relational database systems there have been attempts to manage such data in database systems.

We are not aware of a generally accepted definition. The following reflects the author's personal view:

- A spatial database system is a database system.
- It offers spatial data types (SDTs) in its data model and query language.
- It supports spatial data types in its implementation, providing at least spatial indexing and efficient algorithms for spatial join.

What needs to be represented?

There are two important alternative views of what needs to be represented:

- ❑ Objects in space: We are interested in distinct entities arranged in space each of which has its own geometric description.
- ❑ Space: We wish to describe space itself, that is, say something about every point in space.

The first view allows one to model, for example, cities, forests, or rivers.

The second view is the one of thematic maps describing e.g. land use or the partition of a country into districts. Since raster images say something about every point in space, they are also closely related to the second view.

We can reconcile both views to some extent by offering concepts for modeling

- ❑ single objects , and
- ❑ spatially related collections of objects.

Spatially related collections of objects

Partitions (of the plane)

A partition can be viewed as a set of region objects that are required to be disjoint. The adjacency relationship is of particular interest, that is, there exist often pairs of region objects with a common boundary. Partitions can be used to represent thematic maps

Networks

A network can be viewed as a graph embedded into the plane, consisting of a set of point objects, forming its nodes, and a set of line objects describing the geometry of the edges. Networks are ubiquitous in geography, for example, highways, rivers, public transport, or power supply lines.

A realm

- ❑ An alternative proposal of a discrete geometric basic is the concept of a Realm.
- ❑ A realm conceptually represents the complete underlying geometry of one particular application space (2 dimensions).

- Formally, a realm is a finite set of points and line segments over a discrete grid such that
  - Each point or end point of a line segment is a grid point
  - Each end point of a line segment is also a point of the realm
  - No realm point lies within a line segment (which means on it without being and end point)
  - No two realm segment intersect except as the end node

The role of DBMS

- The role of DBMS in new generation GIS architecture and focuses on the manner spatial data can be managed, i.e., stored and analysed in DBMSs.
- Two important aspects of DBMS functionality are addressed in detail, i.e., spatial models and spatial analysis.
- Special attention is placed on the third dimension (3D) because of the increased demand for 3D modelling, analysis and presentations in many applications.
- Modeling of spatial features in DBMSs, both using geometrical primitives and topological structure.

Components of DBMS

- DBMS Engine accepts logical request from the various other DBMS subsystems, converts them into physical equivalent, and actually accesses the database and data dictionary as they exist on a storage device.
- Data Definition Subsystem helps user to create and maintain the data dictionary and define the structure of the files in a database.

- Data Manipulation Subsystem helps user to add, change, and delete information in a database and query it for valuable information. Software tools within the data manipulation subsystem are most often the primary interface between user and the information contained in a database. It allows user to specify its logical information requirements.
- Application Generation Subsystem contains facilities to help users to develop transactions-intensive applications. It usually requires that user perform a detailed series of tasks to process a transaction. It facilities easy-to-use data entry screens, programming languages, and interfaces.
- Data Administration Subsystem helps users to manage the overall database environment by providing facilities for backup and recovery, security management, query optimization, concurrency control, and change management.
- Storage and retrieval of data
- Standardized access to data and separation of data storage and retrieval functions from the programs using the data
- Interface between database and application programs based on a logical description of the data
- Make access functions in applications independent of the physical storage structure, so adaptations to expanding storage needs do not influence the application programs;

DBMS functionality

- Allow for access to the data by several users at the same time; and
- Provide for the definition of consistency constraints for the data which will then be automatically enforced.

- Consistency constrains are rules which must hold for all data stored, and are an excellent technique to reduce the number of errors in a large data collection.

Spatial Database Management Systems

- A spatial database management system (SDBMS) is an extension, some might say specialization, of a conventional database management system (DBMS).
- Every DBMS (hence SDBMS) uses a data model specification as a formalism for software design, and establishing rigor in data management.

Three components compose a data model

Constructs developed using data types which form data structures that describe data, operations that process data structures that manipulate data, and rules that establish the veracity of the structures and/or operations for validating data.

The term spatial database system

- The term spatial database system is associated with a view of a database as containing sets of objects in space rather than images or pictures of a space that have identity and well-defined extents, locations, and relationships are rather different from those for dealing with raster images.
- A spatial database therefore has the following characteristics:
    - A spatial database system is a database system.
    - It offers spatial data types (SDTs) in its data model and query language.
    - It supports spatial data types in its implementation, providing at least spatial indexing and efficient algorithms for spatial join.

Spatial Database Design

The design of the spatial database is the formal process of analyzing facts about the real world into a structured model. Database design is characterized by the requirement analysis, logical design and physical design. need a plan, layout and process. Simple well organized collection of data that can be utilized in a geographic form.

Categories of spatial modelling

Three main categories of spatial modeling functions that can be applied to geographic features within a GIS are geometric models, such as calculating the Euclidean distance between features, generating buffers, calculating areas and perimeters, and so on; Coincidence models, such as topological overlay; and Adjacency models (path finding, redistricting, and allocation). All three model categories support operations on spatial data such as points, lines, polygons, tins, and grids. Functions are organized in a sequence of steps to derive the desired information for analysis.

Characteristics of a Good Database Design

In order that the GIS database provides the best service it should be Contemporaneous , Flexible and extensible , Positionally accurate, Compatible with other information. Readily updated on a regular schedule and Accessible to whoever needs it.

Two approaches representing the spatial data within GIS

Two approaches or models have been widely adopted for representing the spatial data within GIS are the cartographic map model and the geo-relational model

Each of these approaches is based on a specific spatial data model.

The Composite Map Model is usually based on a tessellated (raster) representation of space and the Geo-relational model is usually associated with a vector representation of space. Raster data model represents phenomena as occupying the cells of a predefined, grid shaped tessellation. Vector data model represents phenomena in terms of the spatial primitives, or components, consisting of point, line, polygon, surfaces and volumes.

Spatial Databases

A database that needs to store and query spatial objects, e.g.

- Point: a house, a monument
- Line: a road segment, a road network
- Polygon: a county, a voting area _ Types of spatial data

Data Structures

The 2 basic data structures in any fully-functional GIS are Vector, e.g., ArcInfo Coverages, ArcGIS Shape Files, CAD (AutoCAD DXF & DWG, or MicroStation DGN files), ASCII coordinate data, Raster, e.g., ArcInfo Grids, Images Digital Elevation Models (DEMs), generic raster datasets.

Spatial Data Types

There are two types of spatial data.

The **geometry** data type supports planar, or Euclidean (flat-earth), data conforms to the *Open Geospatial Consortium (OGC) Simple Features for SQL Specification* version 1.1.0 and is compliant with SQL MM (ISO standard).

SQL Server also supports the **geography** data type, which stores ellipsoidal (round-earth) data, such as GPS latitude and longitude coordinates.There's an additional instantiable type for the geography data type: **FullGlobe**.

Spatial data objects

Simple types are: Point, Line String, Circular String, Compound Curve, Polygon and Curve Polygon

Collection types are Multi Point, Multi Line String, Multi Polygon and Geometry Collection

Relational Databases and Geodatabases

A **relational database management system** (RDMS) utilizing geodatabases - a specific kind of relational database in order to store, organize, edit, and analyze locational data. **Geodatabases** store and relate *both spatial and non-spatial data*, such as **feature classes, feature dataset**, **raster catalog**, **topologies**, **address locators, network datasets**, **geometric networks**, **parcel fabrics**, **spatial and non-spatial data tables**, and **terrains** (like TINs).

The Importance of Spatial Data Standards

In spatial database systems, standards provide for consistency in the interfaces between data, applications and users that ensures the implementation according to accepted architecture, functionality and best practices in the IT industry.

The advantages of standards and standardization in spatial database systems include Quality assurance and control, Accountability in spatial design and implementation and accessibility and interoperability

Best practice in spatial data management

Standards document the principal properties of spatial data sets in a comprehensive and structured manner to help avoid information loss and assist in the transfer of knowledge between data supplier and end users.

Equal opportunity for all spatial data suppliers and users, Technological innovations, Synergy and scale of economies in the use of spatial data.

Standards for Spatial Database Systems

Professional Practice Standards : guidelines that aim to set out the required knowledge and skills of people working on spatial database systems.

Hardware Standards: the selection of computers for desktop and client-side applications, and for data and application servers in a client/server architecture

Software Standards : Operating Systems (OS) and DBMS. Conventionally, Microsoft Windows and UNIX were the dominant OS standards.

Telecommunications Network and Web Services Standards: the transfer of data over global and local computer networks, such as the Transmission Control Protocol/Internet Protocol (TCP/IP) and Hypertext Transfer Protocol (HTTP), as well as API protocols for using spatial data on the Web

Data Standards

Perspectives of functionality, development and implementation

The location and characteristics of and the relationships. An object or feature catalogue that contains lists of tables and lists of terms, names, classification codes and types of permissible values that are used to describe the characteristics of an object / feature or a class of objects / features in the data sets of a particular application domain. Individual encoding specifications as well as the representation of the data in specific raster and vector formats. One or more reference or framework data sets of spatial data are geo-referenced and integrated. Metadata including the content and production information of data sets

Examples of Spatial Data Standards

Data standards are explicitly declared as a cornerstone of the Global Spatial Data Infrastructure (GSDI), the Canadian Geospatial Data Infrastructure (CGDI) and the American National Spatial Data Infrastructure (NSDI). The European Union, ISO and OGC stewarded international spatial data standards.

Advantages of DBMS

DBMS offers a variety of techniques to store & retrieve data DBMS serves as an efficient handler to balance the needs of multiple applications using the same data Uniform administration procedures for data Application programmers never exposed to details of data representation and storage. A DBMS uses various powerful functions to store and retrieve data efficiently. Offers Data Integrity and Security. The DBMS implies integrity constraints to get a high level of protection against prohibited access to data. A DBMS schedules concurrent access to the data in such a manner that only one user can access the same data at a time.

Reduced Application Development Time- In some organizations, all data is integrated into a single database which can be damaged because of electric failure or database is corrupted on the storage media. Use of the same program at a time by many users sometimes lead to the loss of some data. DBMS can't perform sophisticated calculations

Disadvantage of DBMS

DBMS may offer plenty of advantages but, it has certain flaws- Cost of Hardware and Software of a DBMS is quite high which increases the budget of your organization. Most database management systems are often complex systems, so the training for users to use the DBMS is required.

References

1. Shekhar, S., Zhang, P., & Chawla, S. (2005). *Spatial Databases. Encyclopedia of Social Measurement, 599–604.* doi:10.1016/b0-12-369398-5/00337-6
2. Yeung, A. K. W., & Hall, G. B. (n.d.). Spatial Data Standards and Metadata. The GeoJournal Library, 129–173. doi:10.1007/1-4020-5392-4_5
3. https://courses.washington.edu/gis250/lessons/introduction_gis/spatial_data_model.html
4. https://www.safe.com/what-is/spatial-data/
5. https://learngis.org/textbook/section-five-what-are-relational-databases-and-geodatabases