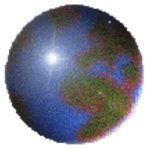

CSEG601 & CSE5601:
Spatial Data Management & Application

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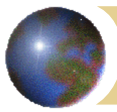


Value of SDBMS

- Traditional (non-spatial) database management systems provide:
  - Persistence across failures
  - Allows concurrent access to data
  - Scalability to search queries on very large datasets which do not fit inside main memories of computers
  - Efficient for non-spatial queries, but not for spatial queries
- Non-spatial queries:
  - List the names of all bookstore with more than ten thousand titles.
  - List the names of ten customers, in terms of sales, in the year 2001
- Spatial Queries:
  - List the names of all bookstores with ten miles of Minneapolis
  - List all customers who live in Tennessee and its adjoining states

Value of SDBMS – Spatial Data Examples

- Examples of non-spatial data
  - Names, phone numbers, email addresses of people
- Examples of Spatial data
  - Census Data
  - NASA satellites imagery - terabytes of data per day
  - Weather and Climate Data
  - Rivers, Farms, ecological impact
  - Medical Imaging
- Exercise: Identify spatial and non-spatial data items in
  - A phone book
  - A cookbook with recipes

Value of SDBMS – Users, Application Domains

- Many important application domains have spatial data and queries. Some Examples follow:
  - **Army Field Commander**: Has there been any significant enemy troop movement since last night?
  - **Insurance Risk Manager**: Which homes are most likely to be affected in the next great flood on the Mississippi?
  - **Medical Doctor**: Based on this patient's MRI, have we treated somebody with a similar condition ?
  - **Molecular Biologist**:Is the topology of the amino acid biosynthesis gene in the genome found in any other sequence feature map in the database ?
  - **Astronomer**:Find all blue galaxies within 2 arcmin of quasars.

What is a SDBMS ?

- A SDBMS is a software module that
  - can work with an underlying DBMS
  - supports spatial data models, spatial abstract data types (ADTs) and a query language from which these ADTs are callable
  - supports spatial indexing, efficient algorithms for processing spatial operations, and domain specific rules for query optimization
- Example: Oracle Spatial data cartridge, ESRI SDE
  - can work with Oracle 8i~11g DBMS
  - Has spatial data types (e.g. polygon), operations (e.g. overlap) callable from SQL3 query language
  - Has spatial indices, e.g. R-trees

SDBMS Example

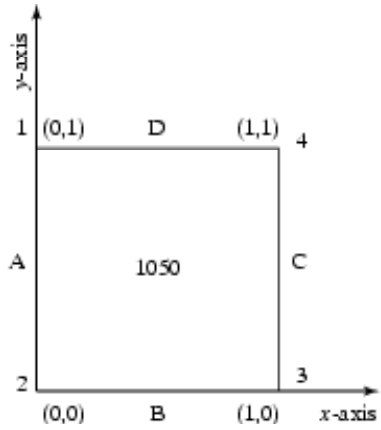
- Consider a spatial dataset with:
  - County boundary (dashed white line)
  - Census block - name, area, population, boundary (dark line)
  - Water bodies (dark polygons)
  - Satellite Imagery (gray scale pixels)
- Storage in a SDBMS table:

```
create table census_blocks (
        name        string,
        area        float,
        population  number,
        boundary    polyline );
```

Figure 1.2. Landsat image of Ramsey Country

Modeling Spatial Data in Traditional DBMS

- A row in the table census_blocks (Figure 1.3)
- Question: Is Polyline datatype supported in DBMS?



Census_blocks

Name	Area	Population	Boundary
1050	1	1839	Polyline((0,0),(0,1),(1,1),(1,0))

Figure 1.3. Census blocks with boundary ID:1050

Spatial Data Types and Traditional Databases

- Traditional relational DBMS
  - Support simple data types, e.g. number, strings, date
  - Modeling Spatial data types is tedious
- Example: Figure 1.4 shows modeling of polygon using numbers
  - Three new tables: polygon, edge, points
    - Note: Polygon is a polyline where last point and first point are same
  - A simple unit sqaure represented as 16 rows across 3 tables
  - Simple spatial operators, e.g. area(), require joining tables
  - Tedious and computationally inefficient
- Question. Name post-relational database management systems which facilitate modeling of spatial data types, e.g. polygon.

Mapping "census_table" into a Relational Database

Census_blocks

Name	Area	Population	boundary-ID
340	1	1839	1050

Polygon

boundary-ID	edge-name
1050	A
1050	B
1050	C
1050	D

Edge

edge-name	endpoint
A	1
A	2
B	2
B	3
C	3
C	4
D	4
D	1

Point

endpoint	*x*-coor	*y*-coor
1	0	1
2	0	0
3	1	0
4	1	1

Figure 1.4. Four tables required in a relational database

Evolution of DBMS technology

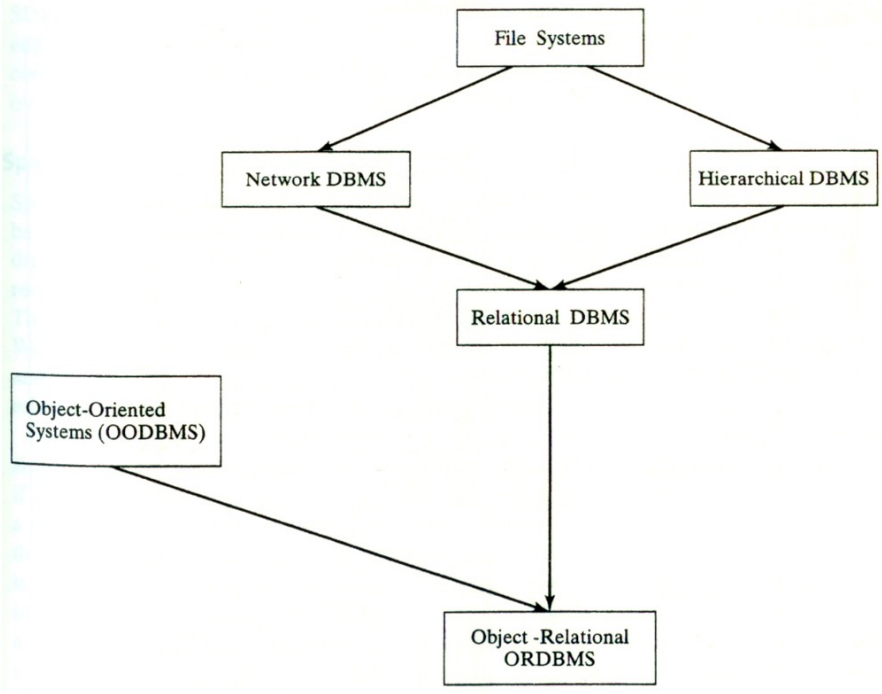


Figure 1.5. Evolution of databases.

Spatial Data Types and Post-relational Databases

- Post-relational DBMS
  - Support user defined abstract data types
  - Spatial data types (e.g. polygon) can be added
- Choice of post-relational DBMS
  - Object oriented (OO) DBMS
  - Object relational (OR) DBMS
- A spatial database is a collection of spatial data types, operators, indices, processing strategies, etc. and can work with many post-relational DBMS as well as programming languages like Java, Visual Basic etc.

How is a SDBMS different from a GIS ?

- GIS is a software to visualize and analyze spatial data using spatial analysis functions such as
  - **Search** Thematic search, search by region, (re-)classification
  - **Location analysis** Buffer, corridor, overlay
  - **Terrain analysis** Slope/aspect, catchment, drainage network
  - **Flow analysis** Connectivity, shortest path
  - **Distribution** Change detection, proximity, nearest neighbor
  - **Spatial analysis/Statistics** Pattern, centrality, autocorrelation, indices of similarity, topology: hole description
  - **Measurements** Distance, perimeter, shape, adjacency, direction
- GIS uses SDBMS
  - to store, search, query, share large spatial data sets

How is a SDBMS different from a GIS ?

- SDBMS focusses on
  - Efficient storage, querying, sharing of large spatial datasets
  - Provides simpler set based query operations
  - Example operations: search by region, overlay, nearest neighbor, distance, adjacency, perimeter etc.
  - Uses spatial indices and query optimization to speedup queries over large spatial datasets.
- SDBMS may be used by applications other than GIS
  - Astronomy, Genomics, Multimedia information systems, ...
- Will one use a GIS or a SDBM to answer the following:
  - How many neighboring countries does USA have?
  - Which country has highest number of neighbors?

Components of a SDBMS

- Recall: a SDBMS is a software module that
  - can work with an underlying DBMS
  - supports spatial data models, spatial ADTs and a query language from which these ADTs are callable
  - supports spatial indexing, algorithms for processing spatial operations, and domain specific rules for query optimization
- Components include
  - spatial data model, query language, query processing, file organization and indices, query optimization, etc.
  - Figure 1.6 shows these components
  - We discuss each component briefly in chapter 1.6 and in more detail in later chapters.

Three Layer Architecture

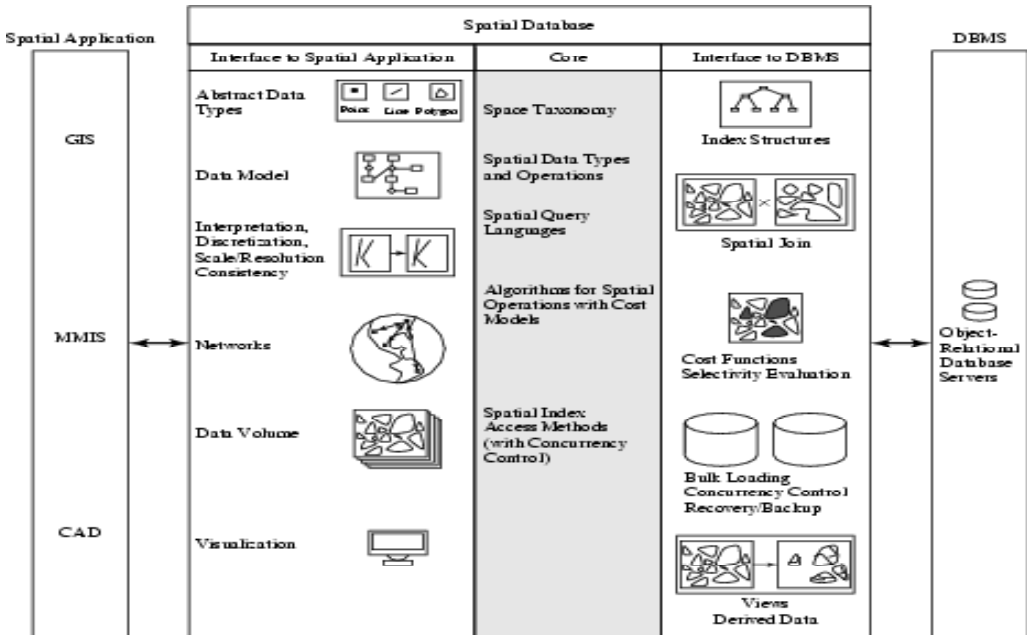


Figure 1.6. Three-layer architecture

1.7 Summary

- SDBMS is valuable to many important applications
- SDBMS is a software module
  - works with an underlying DBMS
  - provides spatial ADTs callable from a query language
  - provides methods for efficient processing of spatial queries
- Components of SDBMS include
  - spatial data model, spatial data types and operators,
  - spatial query language, processing and optimization
  - spatial data mining
- SDBMS is used to store, query and share spatial data for GIS as well as other applications