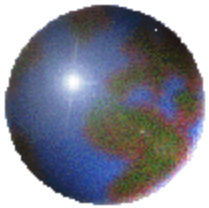
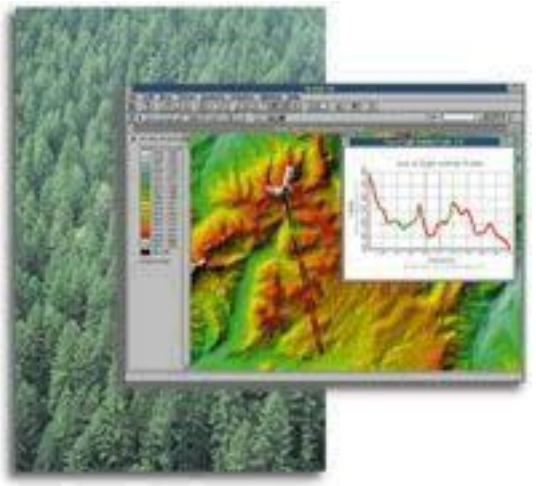
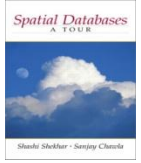


Applications: GIS

What is GIS?

- Computer-based tool for mapping and analyzing things that exist and events that happen on earth
- GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps:
- A multibillion-dollar industry employing hundreds of thousands of people worldwide





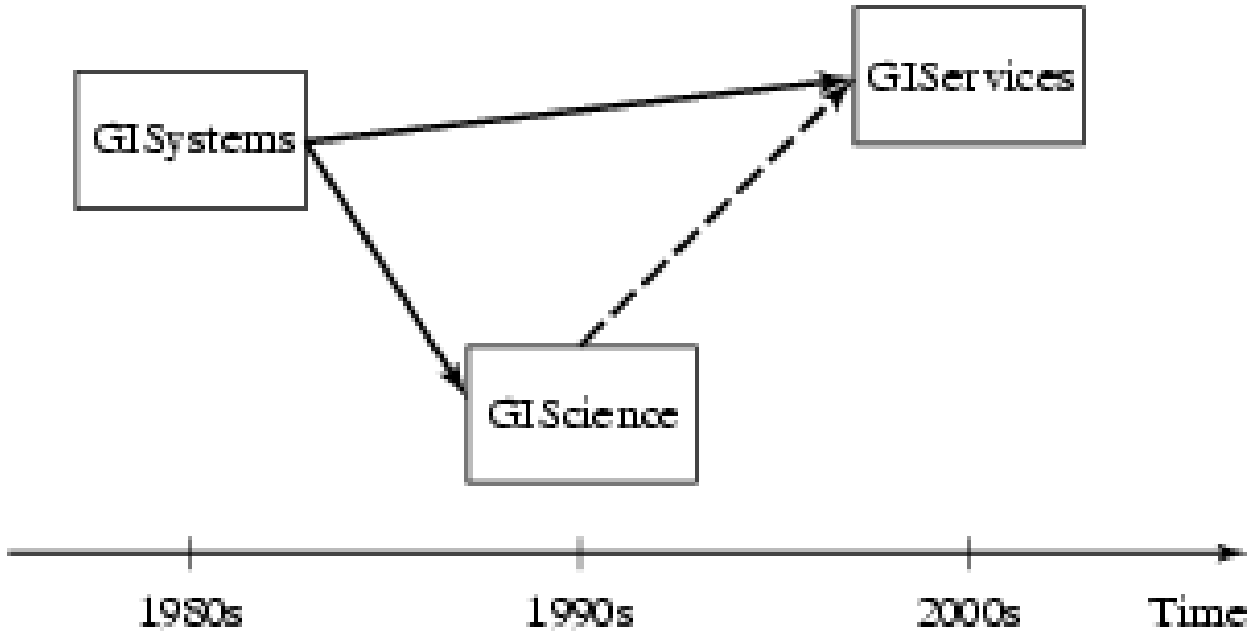
GIS: a formal definition

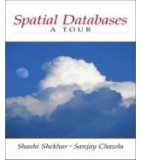
- *"A system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth. This is normally considered to involve a spatially referenced computer database and appropriate applications software"*

Chorley Report "Handling Geographic Information"
HMSO, 1987

Evolution of acronym "GIS"

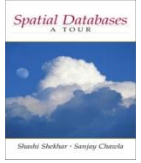
- Geographic Information Systems (1980s)
- Geographic Information Science (1990s)
- Geographic Information Services (2000s)





Three meanings of the acronym GIS

- Geographic Information Services
  - Web-sites and service centers for casual users, e.g. travelers
  - Example: Service (e.g. AAA, mapquest) for route planning
- Geographic Information Systems
  - Software for professional users, e.g. cartographers
  - Example: ESRI Arc/View software
- Geographic Information Science
  - Concepts, frameworks, theories to formalize use and development of geographic information systems and services
  - Example: design spatial data types and operations for querying

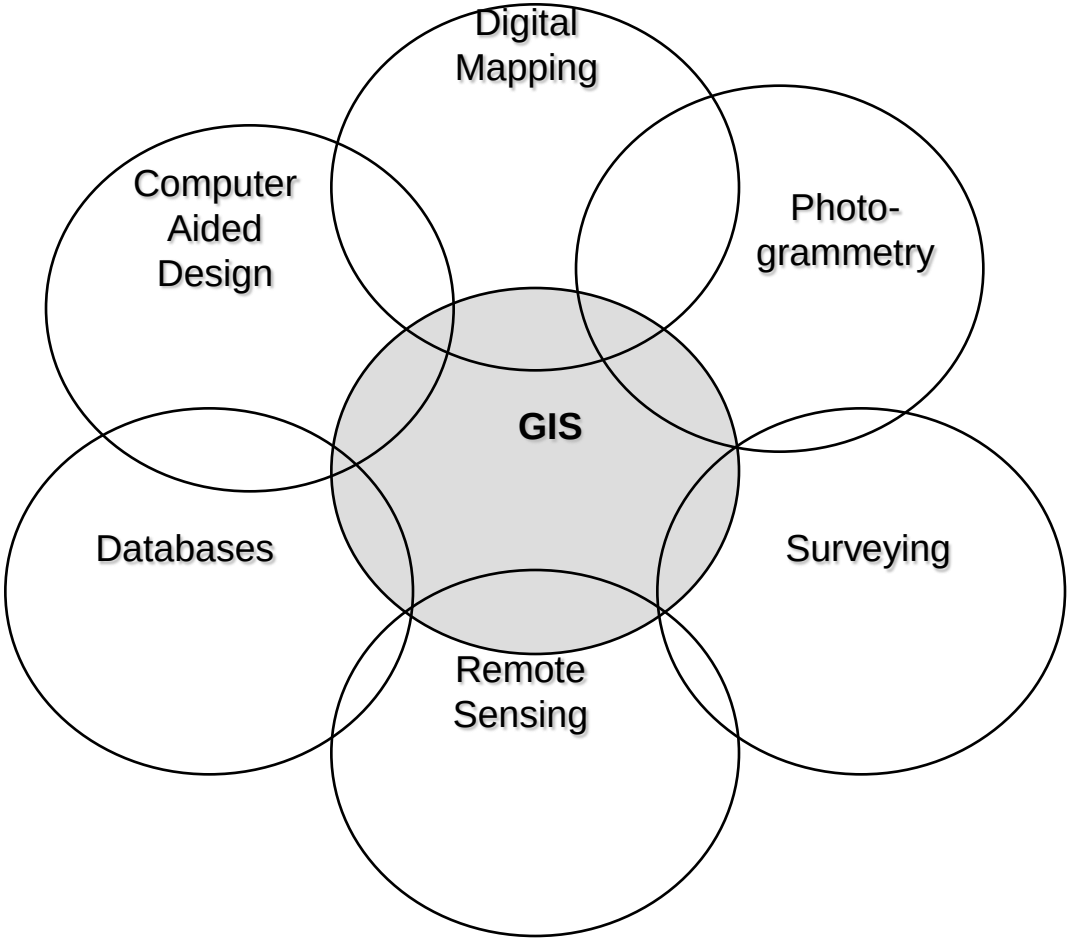


GIS Applications

• **Business**	***Site Location, Delivery Systems, Marketing***
• **Government**	***Local, State, Federal, Military***
• **Economic Development**	***Population Studies, Incomes, Census and Demographic Studies***
• **Emergency Services**	***Fire & Police***
• **Environmental**	***Monitoring & Modeling***
• **Industry**	***Transportation, Communication, Mining, Pipelines, Healthcare***
• **Public Health**	***Epidemiology Studies***
• **Urban Planning**	***Land Use, Historic studies, Environmental and Conservation Studies, Housing Studies, Crime Analysis***
• **Politics**	***Elections and Reappointment***
• **Education**	***Research, Teaching Tool, Administration***

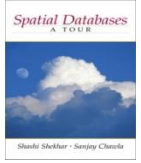
Wherever Spatial Data Analysis is Needed

Cross-disciplinary nature of GIS



Components of a GIS

- A working GIS integrates five key components:
  - hardware,
  - software,
  - data,
  - people, and
  - methods

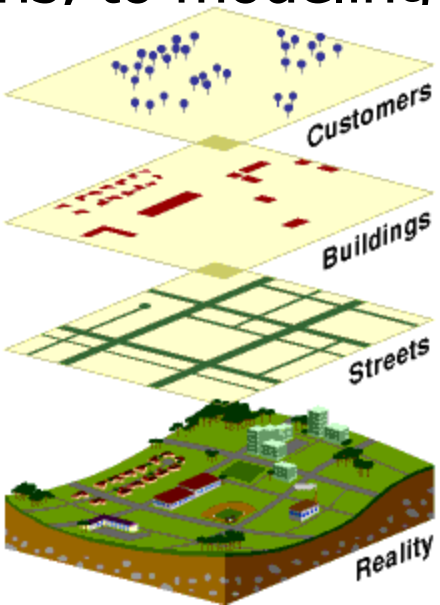


Components of a GIS: Software

- GIS software provides the functions and tools needed to store, analyze, and display geographic information.
- Key software components are:
  - Tools for the input and manipulation of geographic information
  - A database management system (DBMS)
  - Tools that support geographic query, analysis, and visualization
  - A graphical user interface (GUI) for easy access to tools

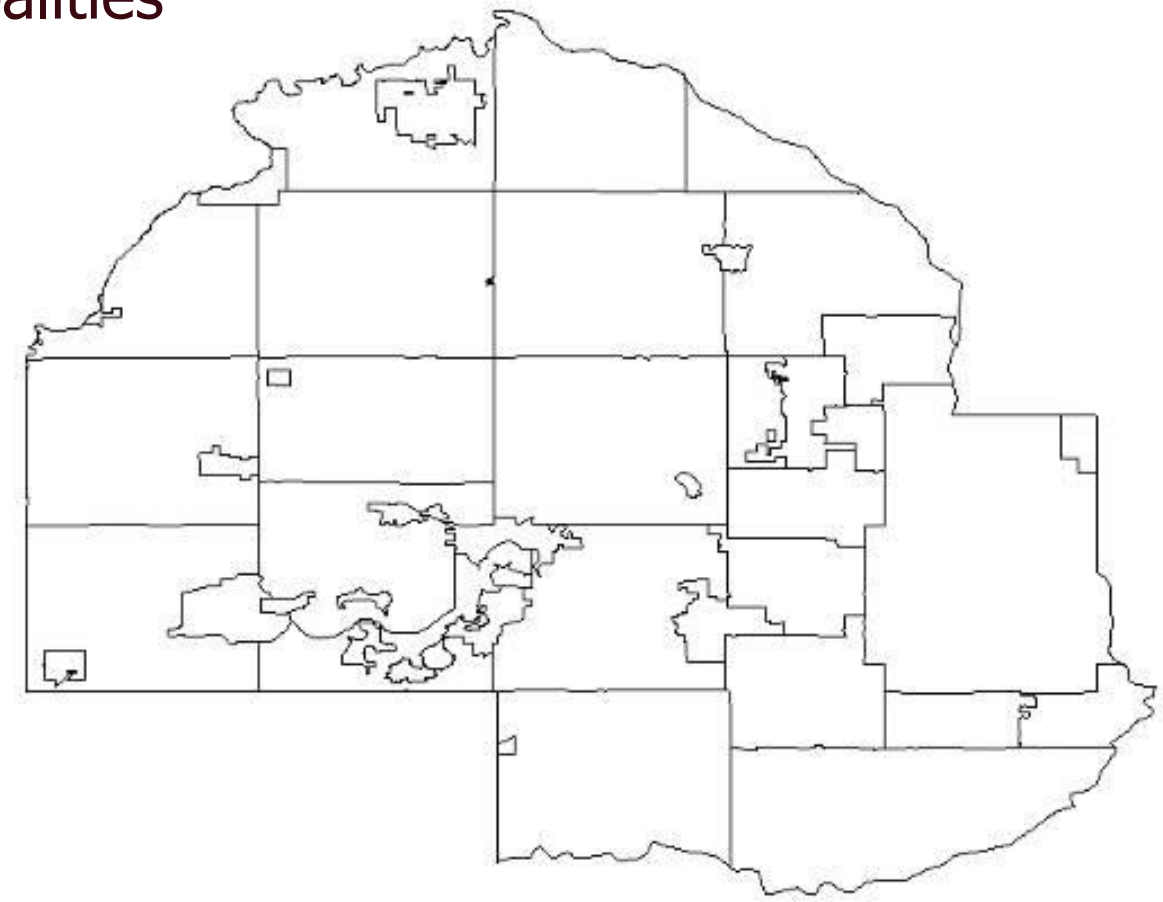
How GIS Works

- A GIS stores information about the world as a collection of **thematic layers** that can be linked together by geography
- This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems: tracking delivery vehicles, to recording details of planning applications, to modeling global atmospheric circulation



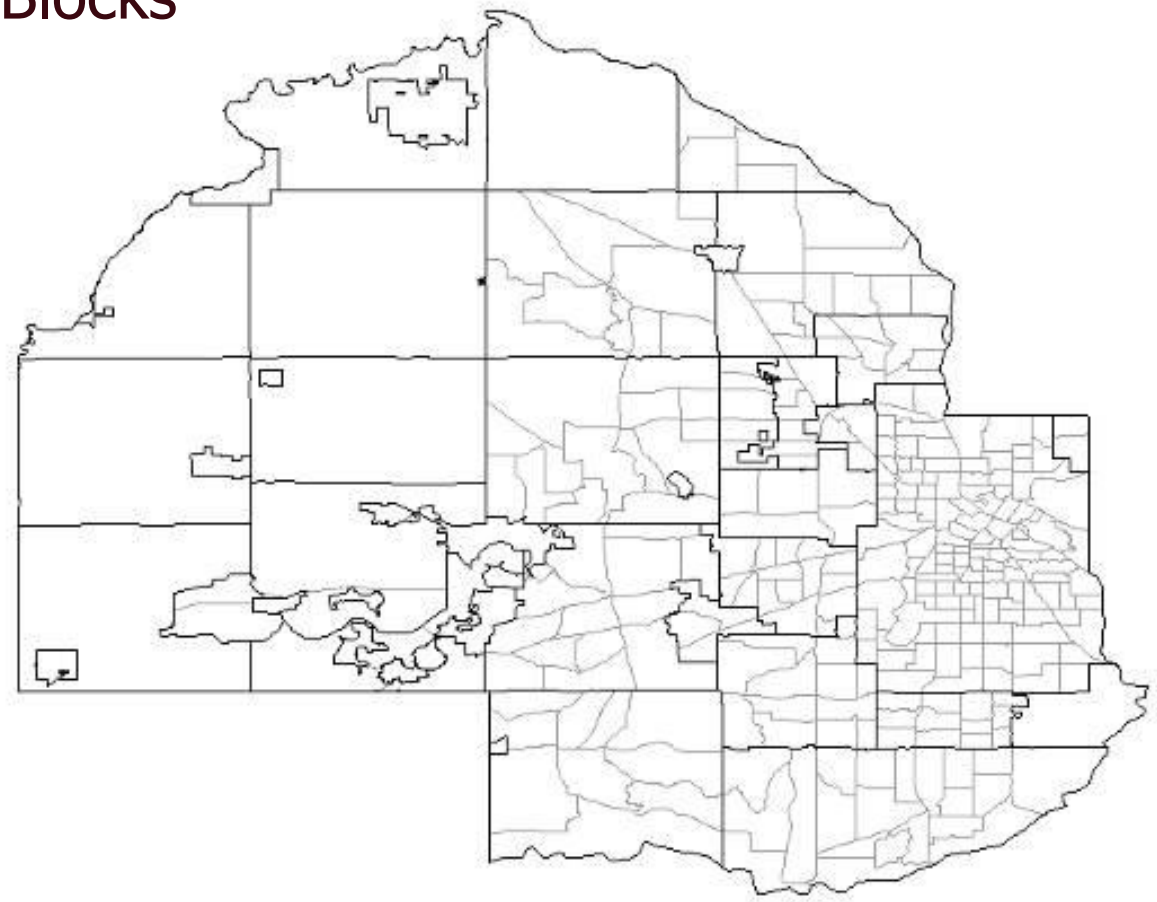
"Layers" of GIS Information

Municipalities



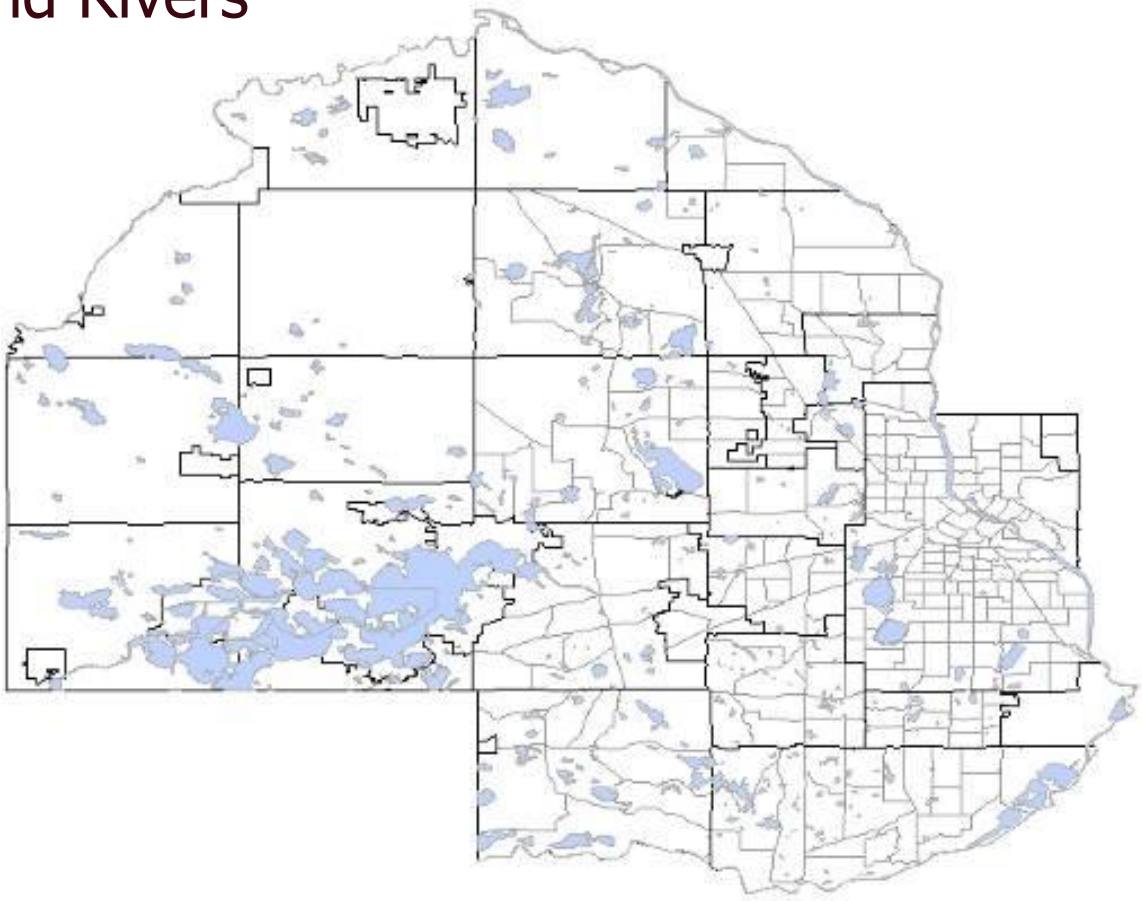
"Layers" of GIS Information

Census Blocks



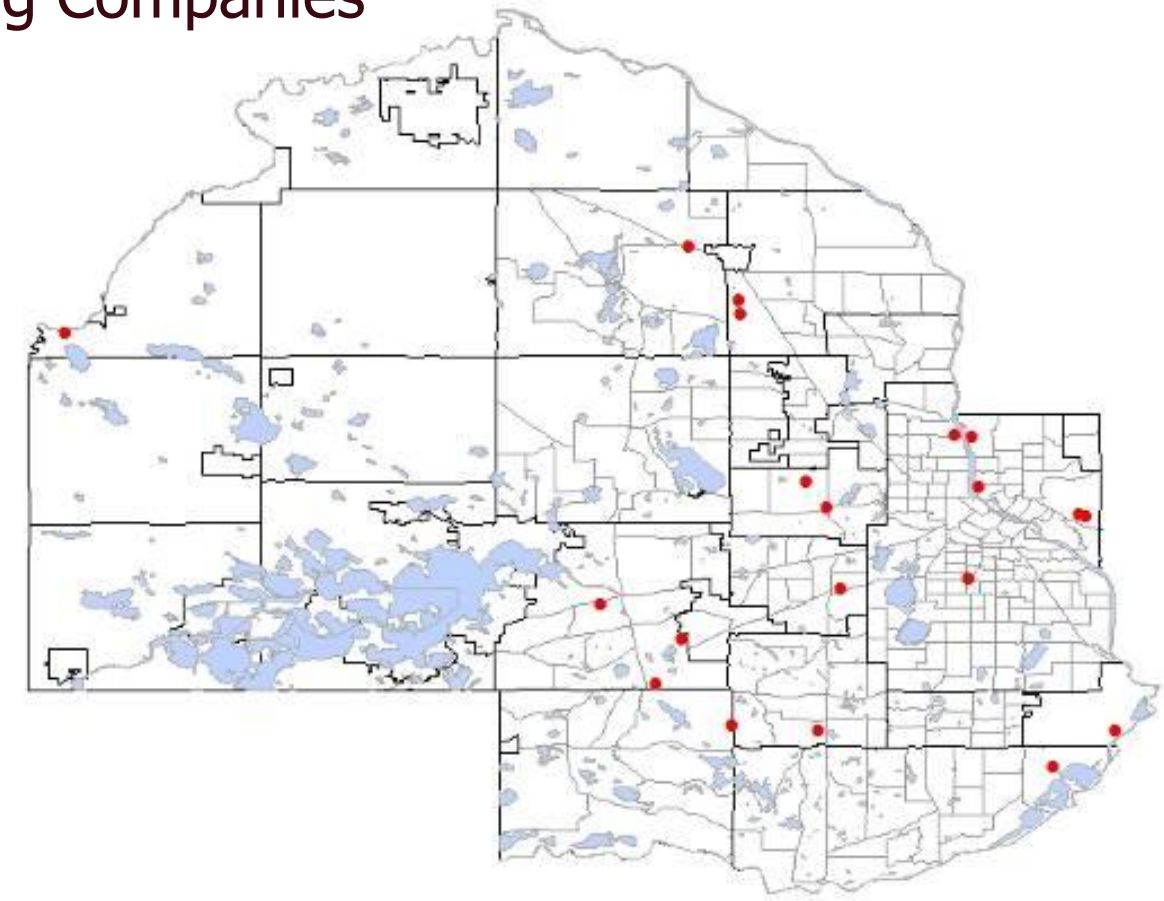
"Layers" of GIS Information

Lakes and Rivers



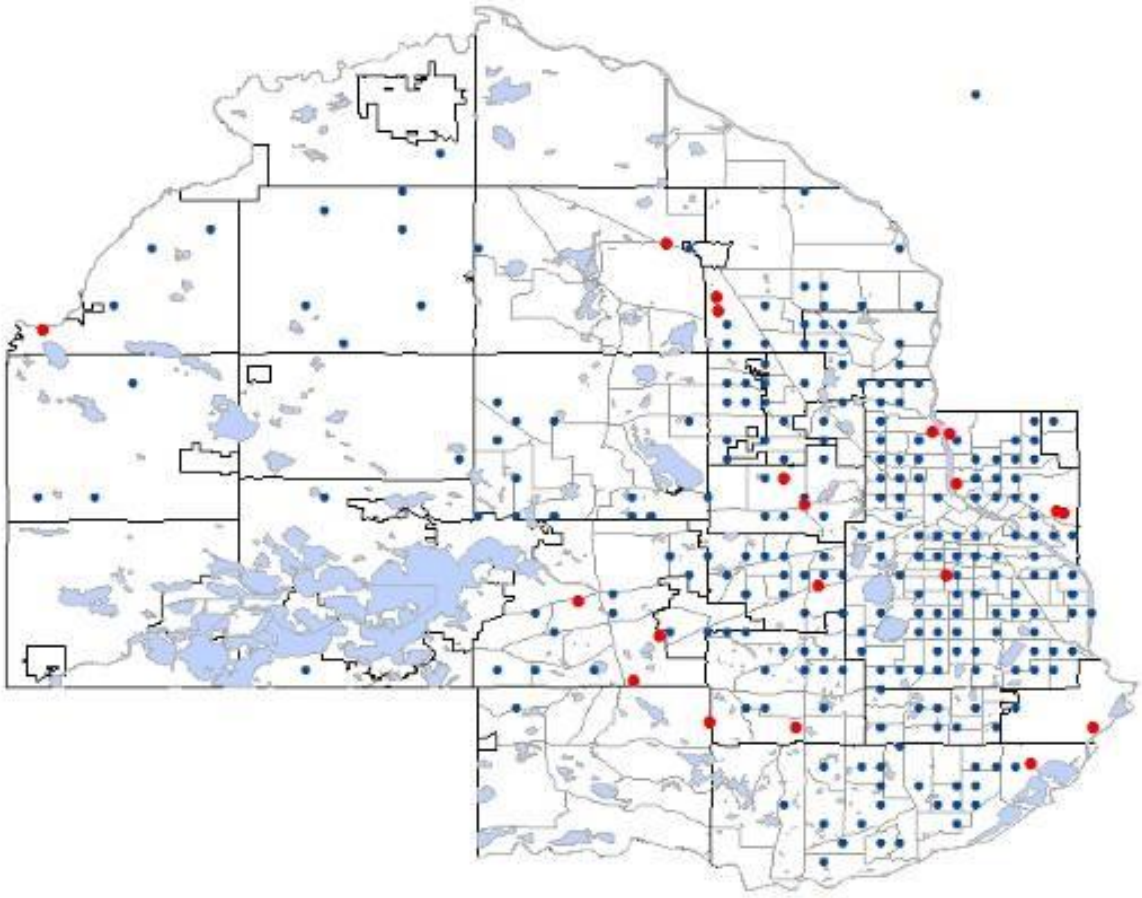
"Layers" of GIS Information

Polluting Companies

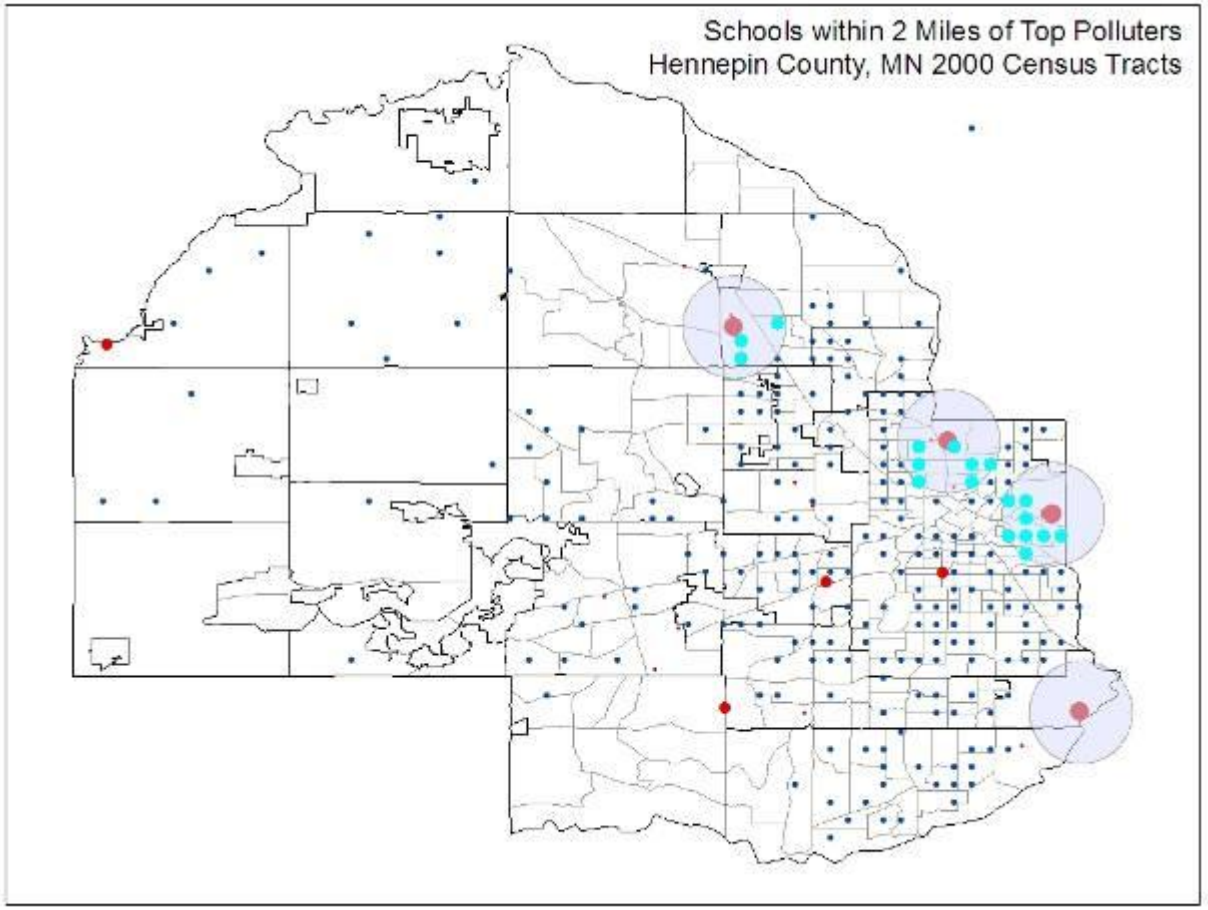


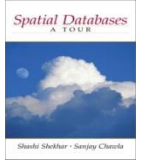
"Layers" of GIS Information

Schools



GIS Turns Data Into Information



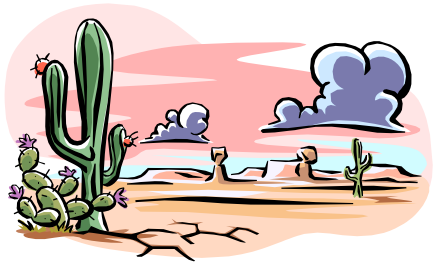


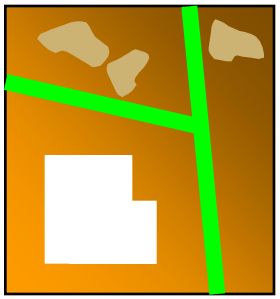
Geographic References

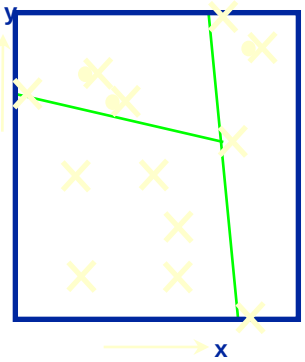
- Geographic information contains either:
  - an explicit geographic reference
    - latitude and longitude or national grid coordinate,
  - or an implicit reference
    - address, postal code, census block name, forest stand identifier, or road name
  - An automated process called **geocoding** is used to create explicit geographic references from implicit references
    - http://en.wikipedia.org/wiki/Geocoding

- **Description:** Kingston University,PenrhynRoad Centre
- **Post Code:** KT1 2EE
- **Grid Reference:** 518106.72 168530.37
- **Latitude/Longitude:** 0° 21’ 55.38”W, 49° 36’ 17.62”N

Modelling the real world







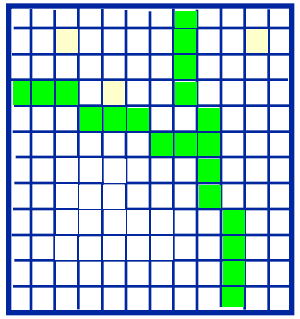
1 1 20 50

1 2 24 45

1 3 52 55

2 1 0 45 46 40

...



0 0 0 0 0 0 0 2 0

0 0 0 0 0 1 0 0 0

0 2 0 0 1 0 0 0 0

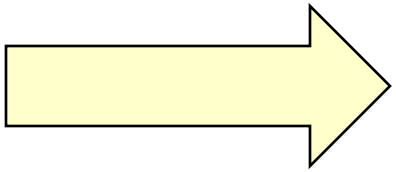
0 0 0 0 2 0 0 0 0

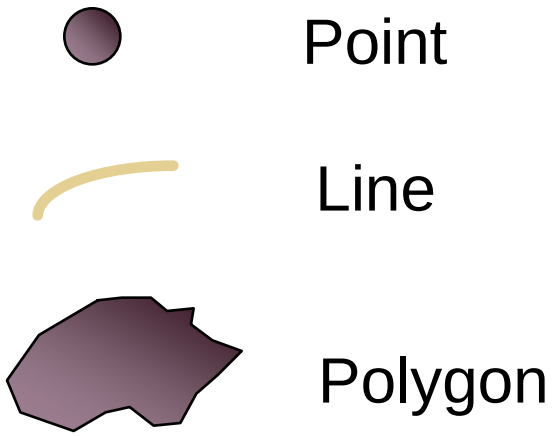
2 2 2 0 1 ...

Data Modelling - step 1

- Features
  - Buildings
  - Road centrelines
  - Lamp columns
  - Gas pipes
  - CTV Access covers
  - Road surfaces

Data Modelling - step 2



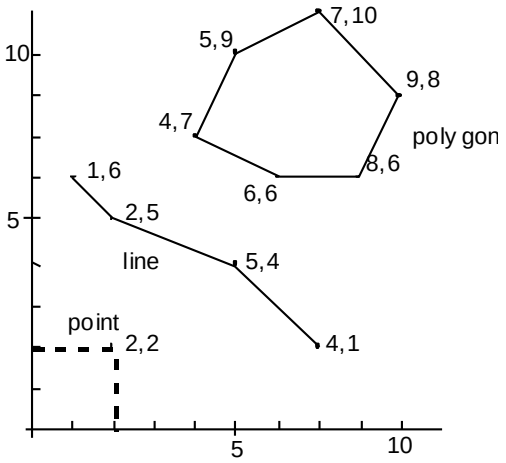


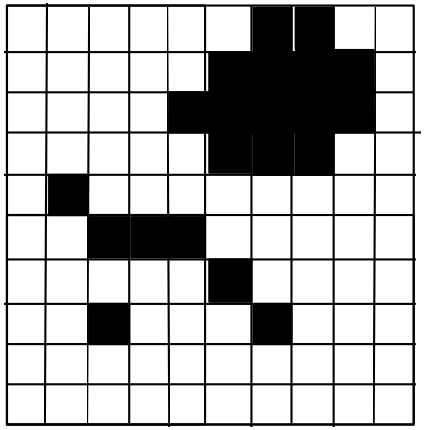
Data Modelling - step 3

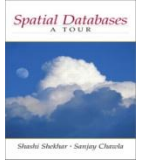
Feature : Building
Object: Polygon
Entity: Tourist Information Bureau

Vector and Raster Models

- GIS work with two fundamentally different types of geographic models
  - the "vector" model: information about points, lines, and polygons is encoded and stored as a collection of *x,y* coordinates
    - useful for describing discrete features
  - the "raster" model: a collection of grid cells rather like a scanned map or picture
    - useful for continuous features such as soil type or accessibility costs for hospitals
- Both have unique advantages and disadvantages and modern GIS are able to handle both models





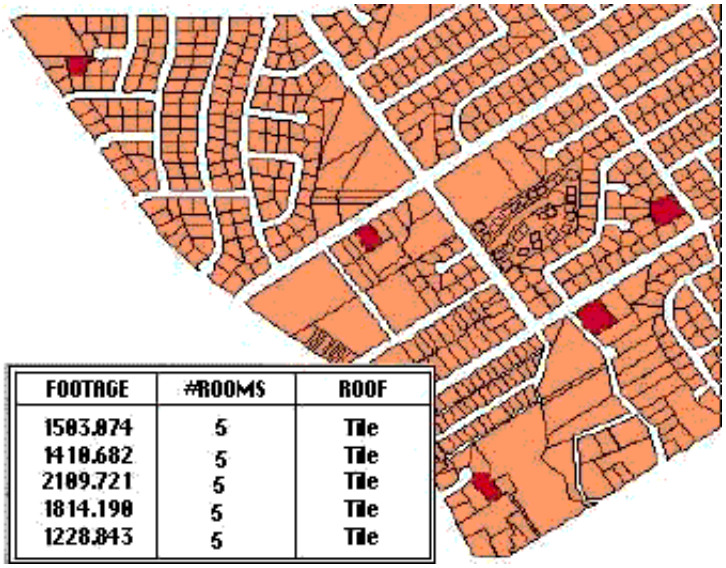


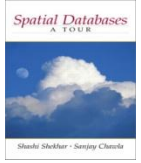
GIS Tasks

- **Input**: *digitizing* (convert paper maps, etc.), obtained from data suppliers and loaded directly into a GIS
- **Manipulation**: integration (e.g., transform to the same scale/accuracy) with tools for manipulating spatial data
- **Management**: use a database management system (DBMS) to help store, organize, and manage data
  - Using an RDBMS and not a SDBMS has **problems**
- **Query and Analysis**: simple point-and-click query capabilities and sophisticated analysis tools, look for patterns and trends and to undertake "what if" scenarios
- **Visualization**: maps or graphs for efficient communicating with reports, three-dimensional views, photographic images, or multimedia.

Query and Analysis

- **Geographic Queries**
- The ability of GISs to search databases and perform geographic queries has saved many companies literally millions of dollars:
  - Streamlining customer service
  - Reducing land acquisition costs through better analysis
  - Reducing fleet maintenance costs through better logistics



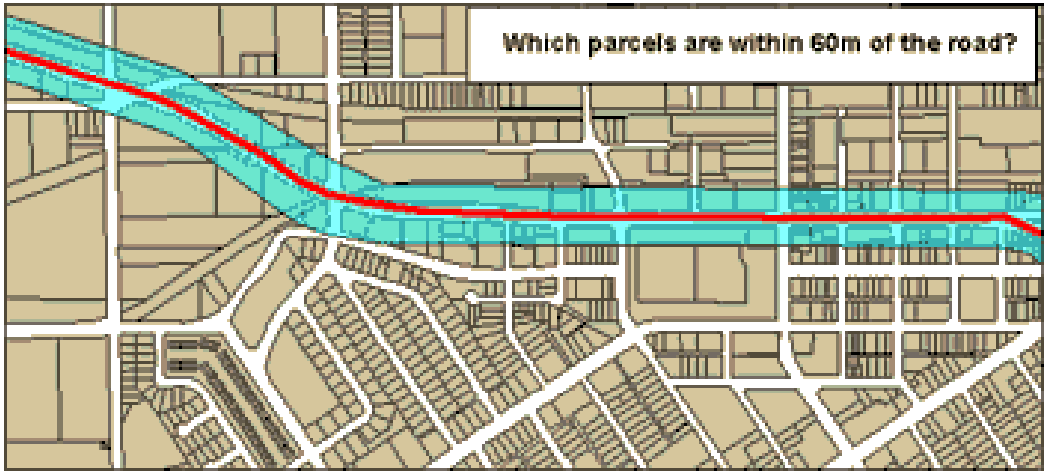


Query and Analysis

- **Example**:
  - A realtor could use a GIS to find all houses within a certain area that have tiled roofs and five bedrooms, then list their characteristics
  - The query could be further refined by adding criteria - the house must cost less than $100 per square foot
  - Could also list houses within a certain distance of a school

Query and Analysis

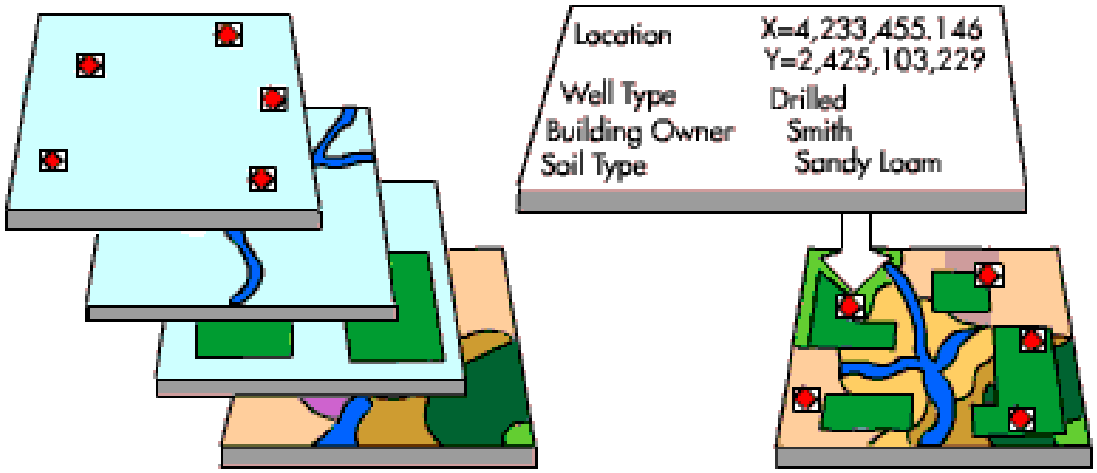
- **Proximity Analysis**
  - How many houses lie within 100 m of this water main?
  - What is the total number of customers within 10 km of this store?
  - What proportion of the alfalfa crop is within 500 m of the well?



- To answer such questions, GIS technology uses a process called **buffering** to determine the proximity relationship between features

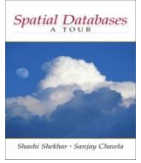
Query and Analysis

- **Overlay Analysis**
  - Integration of different data layers
    - integrate data on soils, slope, and vegetation, or land ownership with tax assessment



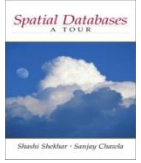
Query and Analysis

- **Improve Organizational Integration**
  - GIS link data sets together by geography and facilitate interdepartmental information sharing and communication
  - Redundancy is reduced, productivity is enhanced, and overall organizational efficiency is improved



Query and Analysis

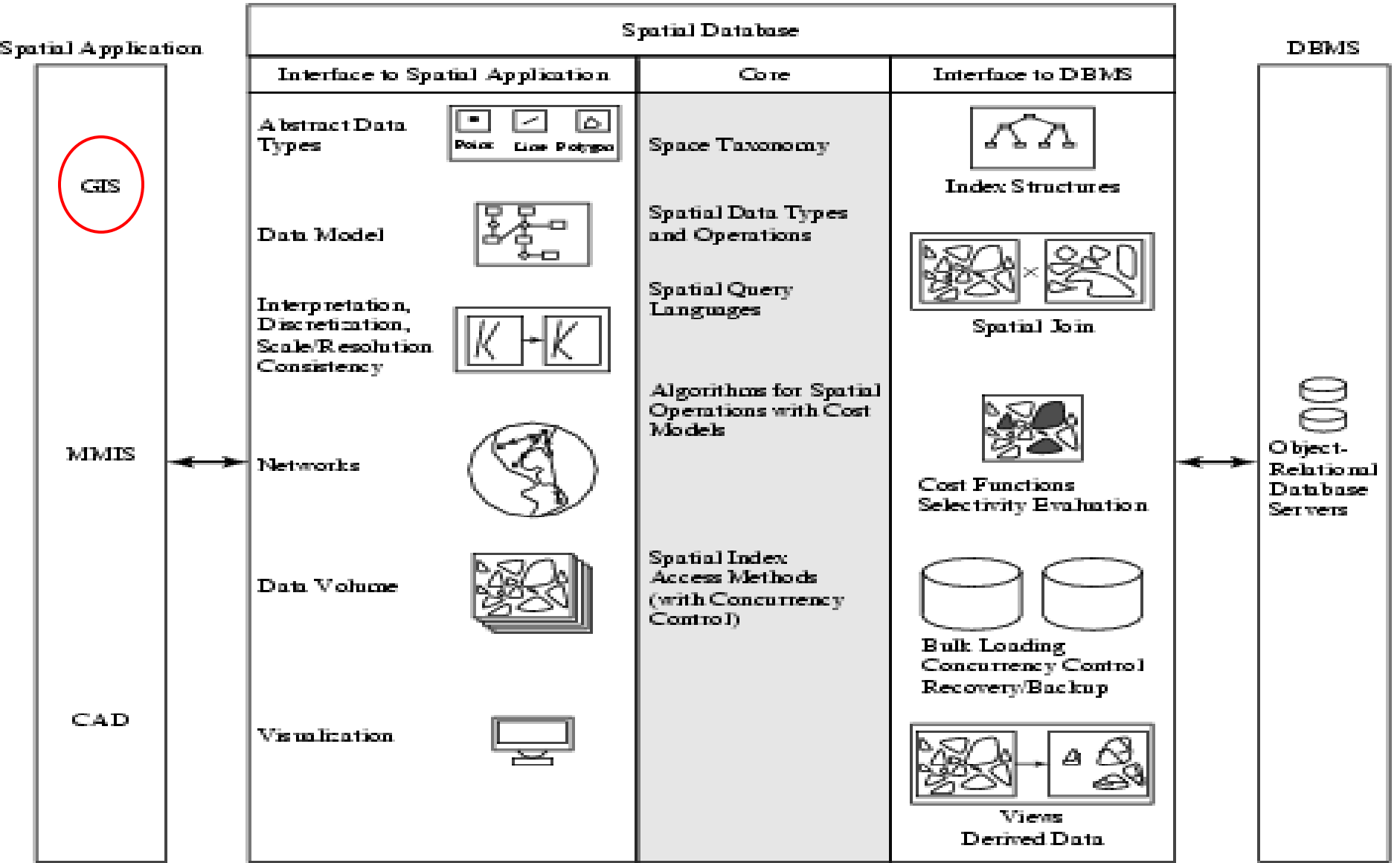
- **Make Better Decisions**
  - GIS is **not an automated** (see spatial data mining) decision making system but a tool to query, analyze, and map data in support of the decision making process
  - GIS can help reach a decision about the location of a new housing development that has minimal environmental impact, is located in a low-risk area, and is close to a population center
  - The information can be presented succinctly and clearly in the form of a map and accompanying report, allowing decision makers to focus on the real issues rather than trying to understand the data

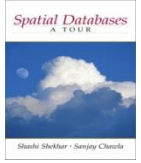


How is a SDBMS different from a GIS ?

- 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

Three Layer Architecture





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?