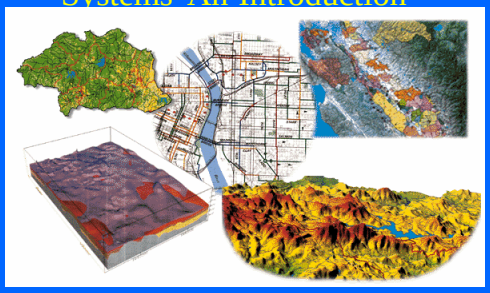
Geographic Information Systems-An Introduction



GEOGRAPHIC INFORMATION SYSTEM (GIS)

Formal Definition

An information system designed to work with spatial or geographic data.

Practical Definition

A Spatial Database Management System

What do we know about GIS?

- **G**eographic ⇨ Maps
- **I**nformation ⇨ Data
- **S**ystem ⇨ Computerized

What is GIS?

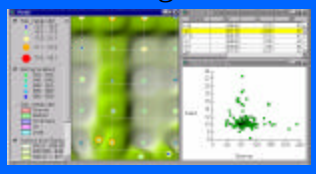
- Stands for "*geographic information system*"
  - Is a special kind of "information system"
    - information systems are used to work (manipulate, summarize, query, edit, visualize) with information stored in computer databases
  - Uses special information about *what is where* on the Earth's surface

What is a GIS ?

- A geographic information system (GIS) is a computer-based tool for *mapping* and *analysing* things that exist and events that happen on Earth.
- GIS technology integrates common *database* operations such as query and *statistical* analysis with the unique *visualisation* and *geographic* analysis benefits offered by maps.
- These abilities distinguish GIS from other *information systems* and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

What is a GIS—Core Ingredients

- mapping
- analyzing
- database
- statistical analysis
- visualization
- geographic analysis
- information systems



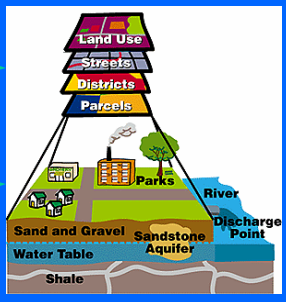
How GIS works

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

Conceptual Model of GIS

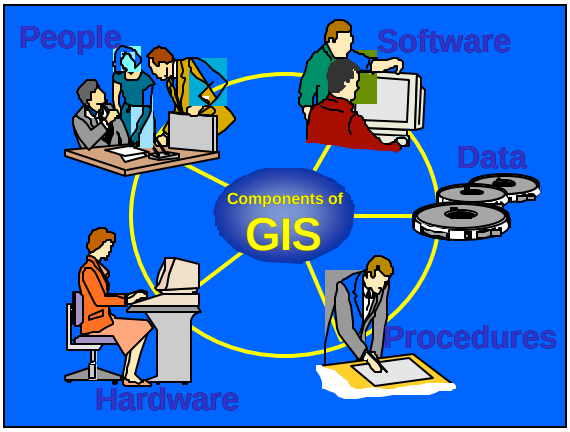
GIS "themes," "layers," or "coverages"

The real world



Who Uses GIS?

- Before GIS technology, only a few people had the skills necessary to use geographic information to help with decision making and problem solving.
- Today, GIS is a multi-billion-dollar industry employing hundreds of thousands of people worldwide.
- GIS is taught in schools, colleges, and universities throughout the world.
- Professionals in many fields are increasingly aware of the advantages of thinking and working geographically.



Hardware

- Hardware is the computer on which a GIS operates, including the resources available to the computer:
  - printers
  - plotters
  - digitizers
  - scanners
  - monitors
  - network
  - wide area communications
- Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software

- GIS software provides the functions and tools needed to
  - store
  - query
  - display
  - analyze
  - create
  - modify

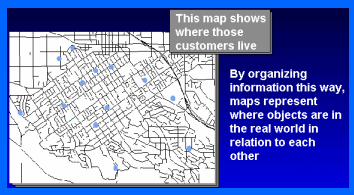
  data.

List and Tables

Traditionally information is organized in lists, maps add information about the "where" of the data

This list organizes customers alphabetically

ID	Name	Address
2132	Bond, Janie	1261 Maple
2567	Boyd, Michael	1565 La Verne
1002	Frunzi, Eileen	879 Grove
1005	Karman, William	1231 Colton
1028	Miller, Judy	887 Oak
1015	Napoleon, Nick	4245 Robin
1031	Ospina, Randy	552 State

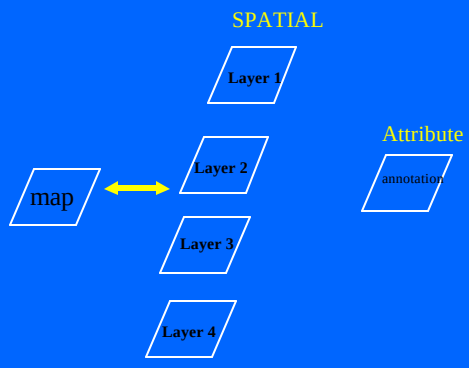


Example: Pittsburgh Ballet Theatre

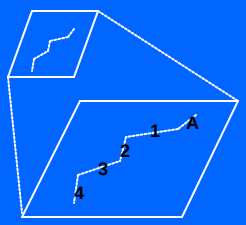
- One example of the effectiveness of GIS is a project that was done for the Pittsburgh Ballet Theatre (PBT)
  - Several years ago every Ballet theatre is the US was eligible for a substantial grant if they could demonstrate that they were a regional asset.
  - The Pittsburgh Ballet Theatre had a computer printout (several inches thick) from Ticketron enumerating ticket purchases by zip code

Example (PBT, continued)

- The problem was how to utilize this to demonstrate that they were a regional asset
  - The Ticketron data file was obtained in computer disk form and, unaltered, the data were linked in a GIS to a zip code spatial file



Rather than an annotation layer, the information can be put into a database and linked to the map



A	ELM ST
1	ASH ST
2	ROW ST
3	DUE ST

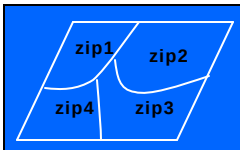
IN GIS --THE MAP DATA ARE ALL DIGITAL

spatial

x	y	xx	yy	A
X	Y	xy	yx	1
u	v	uv	vu	2
v	u	xu	xv	3

attribute

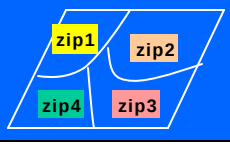
A	Elm St
1	Ash St
2	Row St
3	Due St

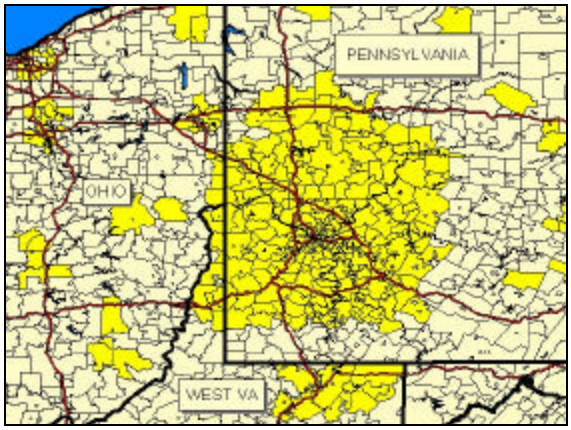


x	y	xx	yy	zip1
X	Y	xy	yx	zip2
u	v	uv	vu	zip3
v	u	xu	xv	zip4

PITTSBURGH BALLET

TICKETRON		
zip1	43	5
zip2	20	4
zip3	54	7
zip4	12	3





VISUAL REPRESENTATION OF DATA

-communicates to the right (visual) side of your brain with logical expressions

-80% of the input pathways in the human nervous system are devoted to bringing visual information to the brain

"The human eye is the best data assimilation and integration machine ever invented"

PBS–SHAPE OF THE WORLD

"A PICTURES IS WORTH ONE THOUSAND WORDS"

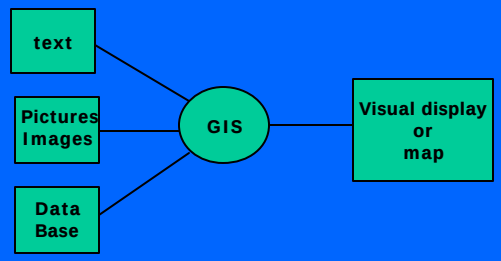
"A MAP IS WORTH ONE THOUSAND NUMBERS"

- Although the visual display of a GIS looks like a map, it is much more.
  - It is an intelligent map.
  - Each graphic feature has a detailed database associated with it.
  - And, these databases can be readily accessed and queried.
  - Additionally, other databases can also be linked to these.

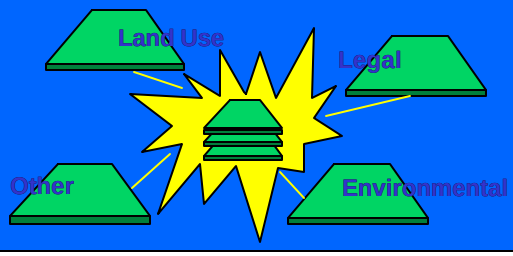
GIS

- GIS is a complementary technology
  - GIS does not replace any other types of databases or storage
  - It complements them

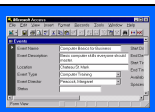
GIS is Multimedia—integrating all type of data



Information From Many Sources Can Be Integrated for Problem Solving

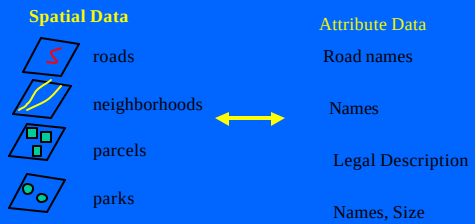


Data



- Possibly the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organizations to organize and maintain their data, to manage spatial data.

GIS DATA STRUCTURE



SPATIAL DATA

- Objects or entities that are referenced by their location
  - Latitude / longitude coordinates
  - x / y coordinates
  - Street address
  - Zip Code

VECTOR DATA

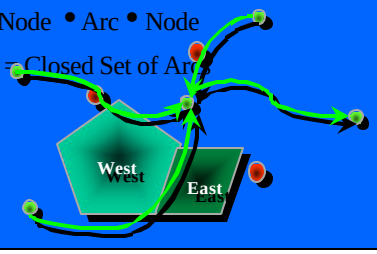
--points are represented by Cartesian (x.y) coordinates

--a line by a string of coordinates

--and, a polygon by a string of coordinates starting and ending at the same point

GIS Maps Spatial Objects as Graphic Features

- Points
- Lines -- Node • Arc • Node
- Polygons = Closed Set of Arcs
- Text



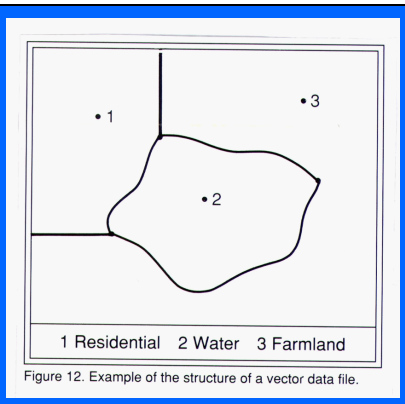
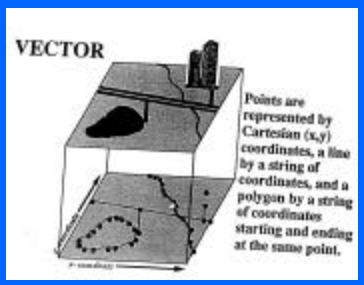


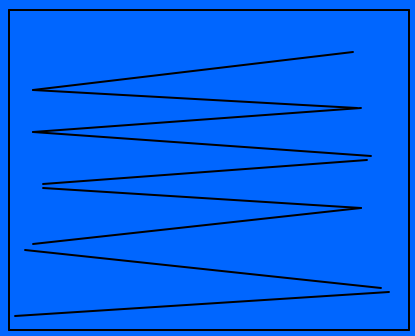
Figure 12. Example of the structure of a vector data file.



RASTER DATA

--represents a point, line, or polygon as a matrix

--the resolution of the representation depends on the size of the cells in the matrix

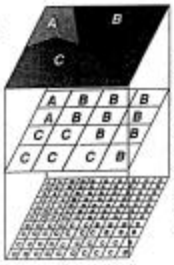


1	1	1	3	3	3	3	3	3
1	1	1	3	3	3	3	3	3
1	1	2	2	2	2	3	3	3
1	1	2	2	2	2	2	3	3
1	2	2	2	2	2	3	3	3
3	3	3	2	2	2	3	3	3
3	3	3	3	2	3	3	3	3
3	3	3	3	3	3	3	3	3

1 Residential 2 Water 3 Farmland

Figure 11. Example of the structure of a raster data file.

RASTER



Represents a point, line, or polygon as a matrix. The resolution of the representation and, therefore, the data being represented, depends on the size of the cells in the matrix.

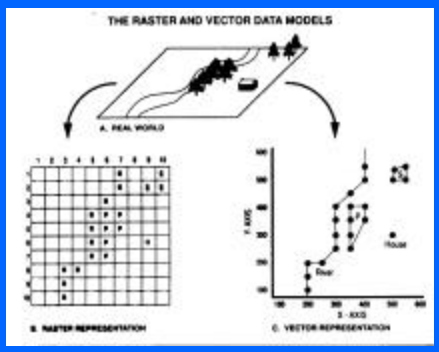


Table 6.1 Comparison of Raster and Vector Data Models.

RASTER MODEL	VECTOR MODEL
Advantages:	**Advantages:**
1. It is a simple data structure.	1. It provides a more compact data structure than the raster model.
2. Overlay operations are easily and efficiently implemented.	2. It provides efficient encoding of topology, and, as a result, more efficient implementation of operations that require topological information, such as network analysis.
3. High spatial variability is efficiently represented in a raster format.	3. The vector model is better suited to supporting graphics that closely approximate hand-drawn maps.
4. The raster format is more or less required for efficient manipulation and enhancement of digital images.	
Disadvantages:	**Disadvantages:**
1. The raster data structure is less compact. Data compression techniques can often overcome this problem.	1. It is a more complex data structure than a simple raster.
2. Topological relationships are more difficult to represent.	2. Overlay operations are more difficult to implement.
3. The output of graphics is less aesthetically pleasing because boundaries tend to have a blocky appearance rather than the smooth lines of hand-drawn maps. This can be overcome by using a very large number of cells, but may result in unacceptably large files.	3. The representation of high spatial variability is inefficient.
	4. Manipulation and enhancement of digital images cannot be effectively done in the vector domain.

Attribute data

- Data that are linked to the spatial objects
  - Census data by administrative unit
  - Land parcel ownership records
  - Soil or vegetation characteristics
  - Health records by medical center
  - Road quality information