GIS

(Geographic Information Systen

Fundamental

Std 12 Practical Geograph

Fundamental sets of GIS

-Data - Management - Science -Decision

GIS -- What is it? *No easy answer anymore!*

- Geographic/Geospatial Information
  - information about places on the earth's surface
  - knowledge about "what is where when" (Don't forget time!)
  - Geographic/geospatial: synonymous

- GIS -- what's in the S?
  - Systems: the technology
  - Science : the concepts and theory
  - Studies : the societal context

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"

GIS definition - layman

"… a special case of information system where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines or area. A geographic information systems manipulates data about these points, lines and areas to retrieve data for ad hoc queries and analyses"

Why is GIS unique?

- GIS handles SPATIAL information
  - Information referenced by its location in space
- GIS makes connections between activities based on spatial proximity

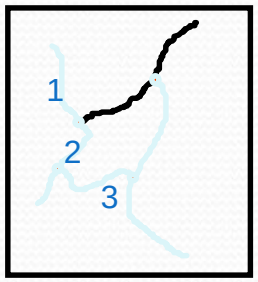
GIS concepts are not new!

London cholera epidemic 1854

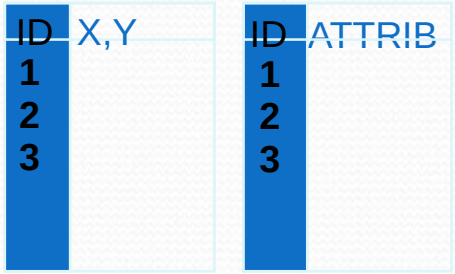
GIS: historical background

This technology has developed from:

Digital cartography and CAD - Data Base Management Systems



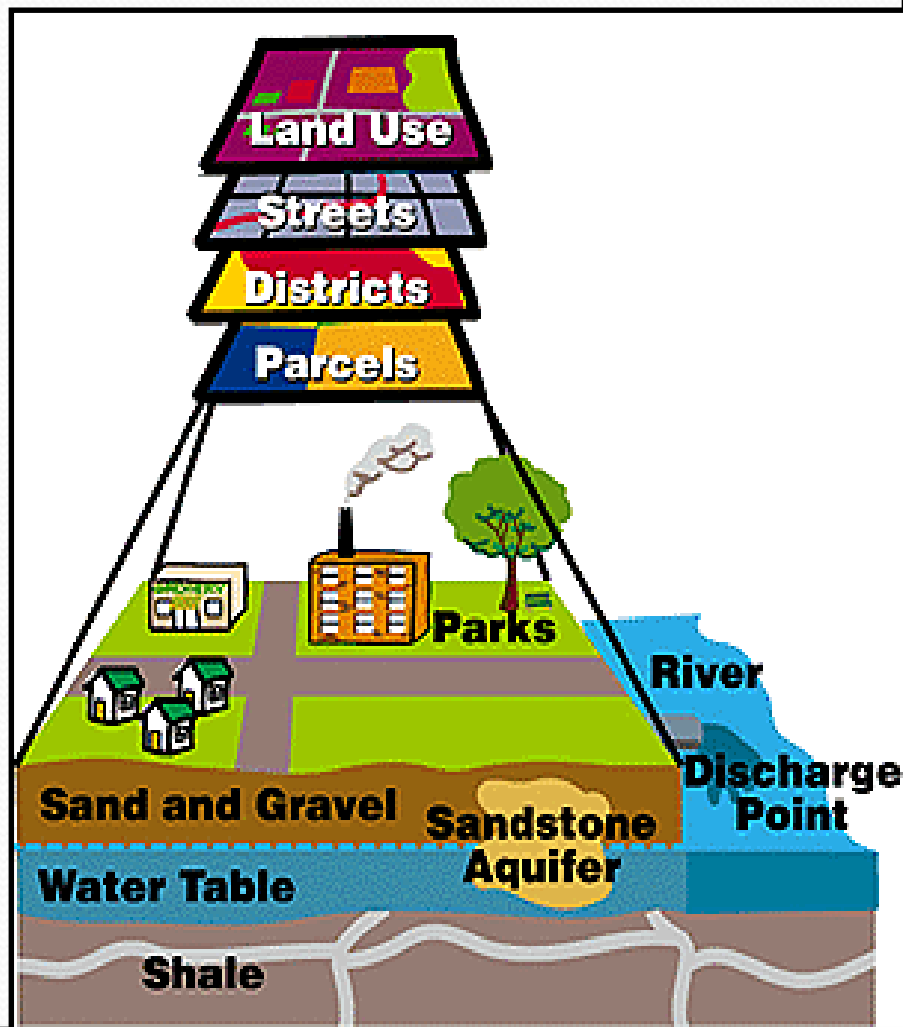
CAD System



Data Base Management System

GIS: Today

Abstracting the Real World

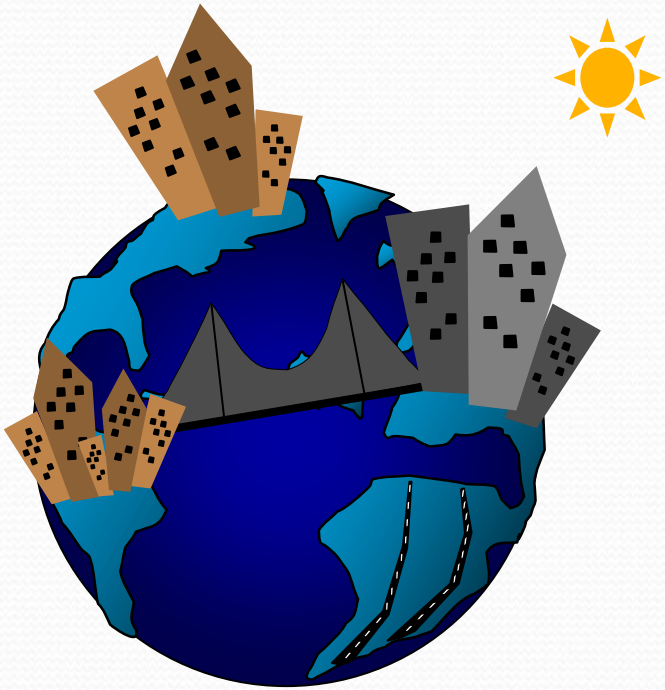


We Live in Two Worlds

Natural World

Self-Regulating

Constructed World

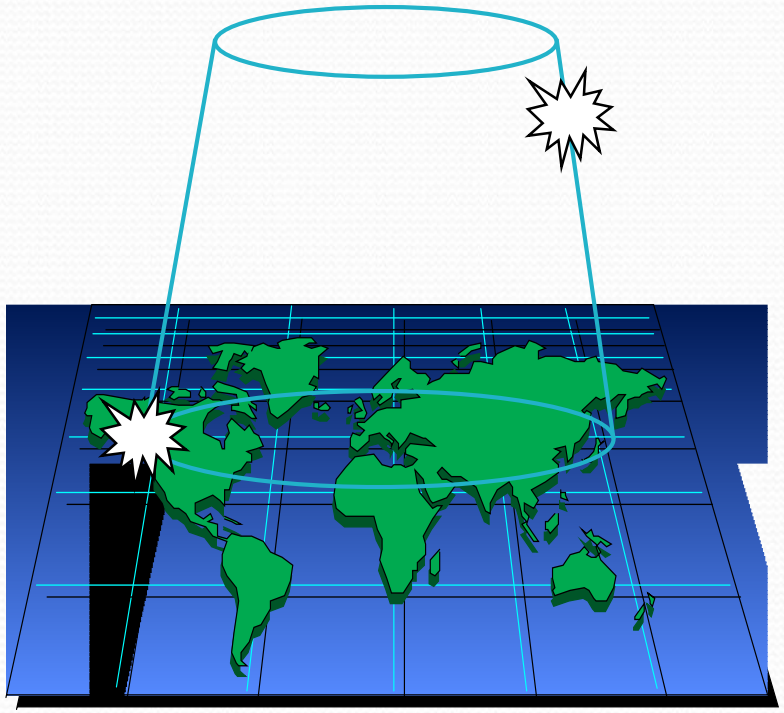


Managed

. . . These Are Increasingly In Conflict

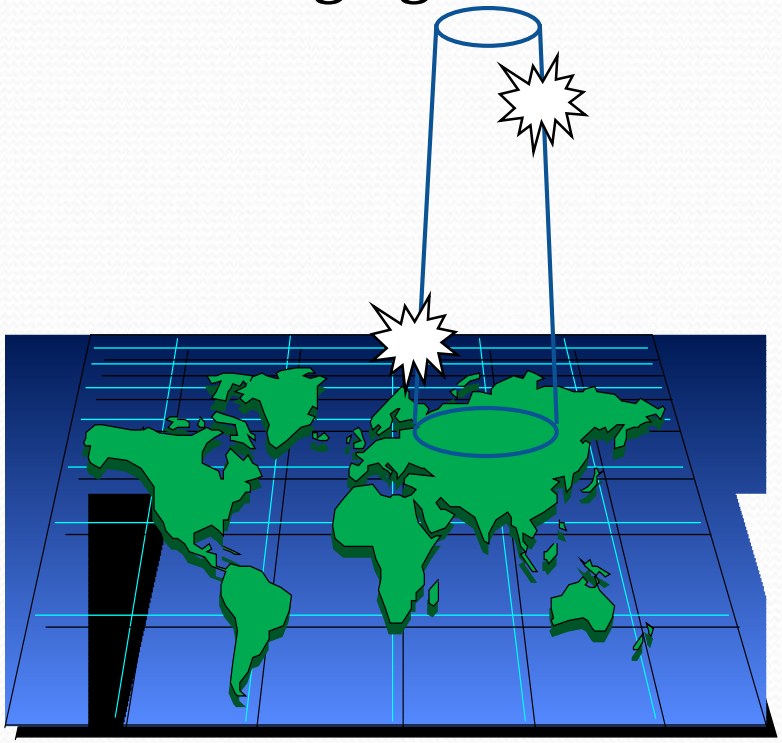
Context and Content

Seeing the Whole



- Patterns
- Linkages
- Trends

Managing Places



- Watersheds
- Communities
- Neighborhoods
- Districts

Who uses GIS?

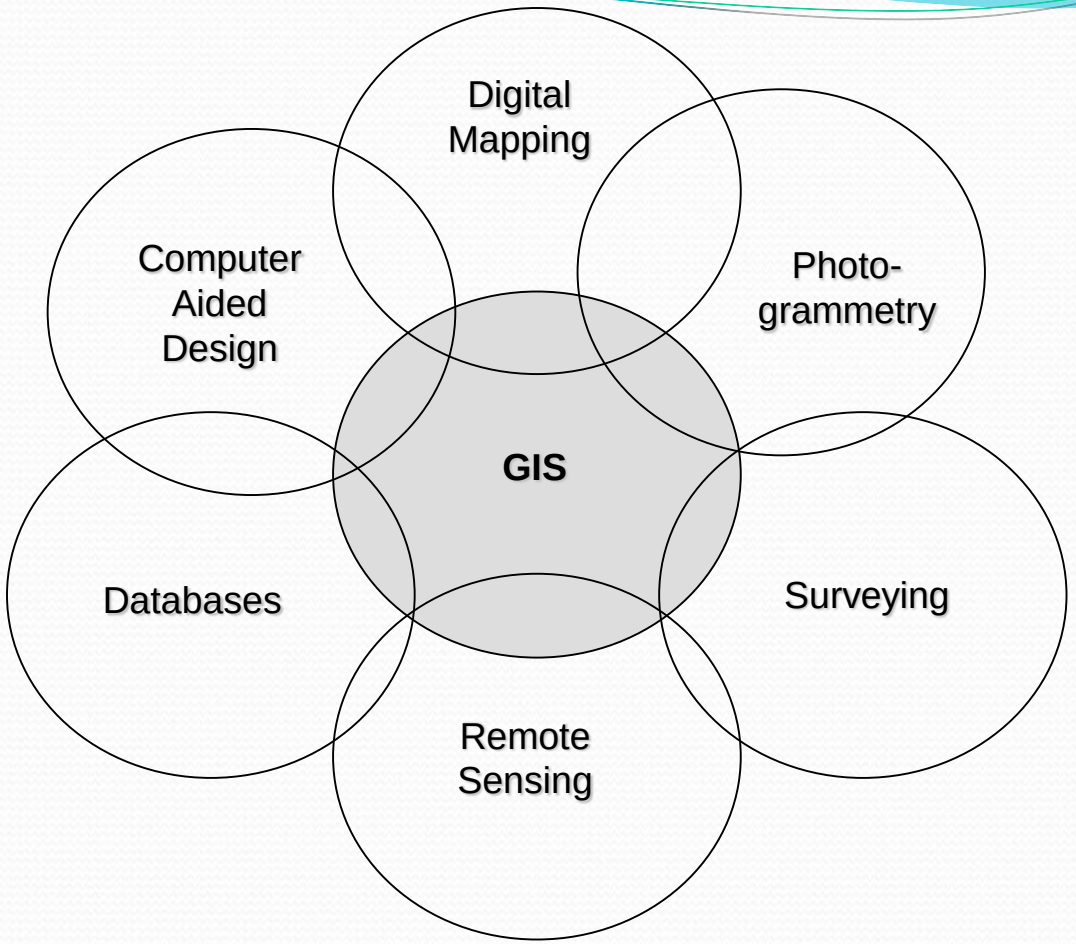
- International organizations
  - UN, The World Bank, UNEP, WHO, etc.
- Private industry
  - Transport, Real Estate, Insurance, etc.
- Government
  - Ministries of Environment, Housing, Agriculture, etc.
  - Local Authorities, Cities, Municipalities, etc.
  - Provincial Agencies for Planning, Parks, Transportation, etc.
- Non-profit organizations/NGO's
  - World Resources Institute, WWF, etc.
- Academic and Research Institutions
  - IITs
  - MITs
  - NASA
  - SAC
  - NRSA etc

Why Study GIS? And What can you do with a GIS?

- 80% of **local government** activities estimated to be geographically based
  - Wards, zoning, public works (streets, water supply, sewers), garbage collection, land ownership and valuation, public safety (fire and police)
- a significant portion of **state government** has a geographical component
  - natural resource management
  - highways and transportation
- **businesses** use GIS for a very wide array of applications
  - retail site selection & customer analysis
  - logistics: vehicle tracking & routing
  - natural resource exploration (petroleum, etc.)
  - precision agriculture
  - civil engineering and construction
- **Military and defense (War analysis)**
  - Battlefield management
  - Satellite imagery interpretation
- **scientific research** employs GIS
  - geography, geology, botany
  - anthropology, sociology, economics, political science
  - Epidemiology, criminology
- EIA
- Land use planning
- Disasters Management
- Crime control
- SDSS

Examples of Applied GIS

- **Urban Planning, Management & Policy**
  - Zoning, subdivision planning
  - Land acquisition
  - Economic development
  - Code enforcement
  - Housing renovation programs
  - Emergency response
  - Crime analysis
  - Tax assessment
- **Environmental Sciences**
  - Monitoring environmental risk
  - Modeling storm water runoff
  - Management of watersheds, floodplains, wetlands, forests, aquifers
  - Environmental Impact Analysis
  - Hazardous or toxic facility siting
  - Groundwater modeling and contamination tracking
- **Political Science**
  - Redistricting
  - Analysis of election results
  - Predictive modeling
- **Civil Engineering/Utility**
  - Locating underground facilities
  - Designing alignment for freeways, transit
  - Coordination of infrastructure maintenance
- **Business**
  - Demographic Analysis
  - Market Penetration/ Share Analysis
  - Site Selection
- **Education Administration**
  - Attendance Area Maintenance
  - Enrollment Projections
  - School Bus Routing
- **Real Estate**
  - Neighborhood land prices
  - Traffic Impact Analysis
  - Determination of Highest and Best Use
- **Health Care**
  - Epidemiology
  - Needs Analysis
  - Service Inventory



Cross-disciplinary nature of GIS

Geographic Information *Technologies*

- Global Positioning Systems (GPS)
  - a system of earth-orbiting satellites which can provide precise (100 meter to sub-cm.) location on the earth's surface (in lat/long coordinates or equiv.)
- Remote Sensing (RS)
  - use of satellites or aircraft to capture information about the earth's surface
  - Digital ortho images a key product (map accurate digital photos)
- Geographic Information Systems (GISy)
  - Software systems with capability for input, storage, manipulation/analysis and output/display of geographic (spatial) information

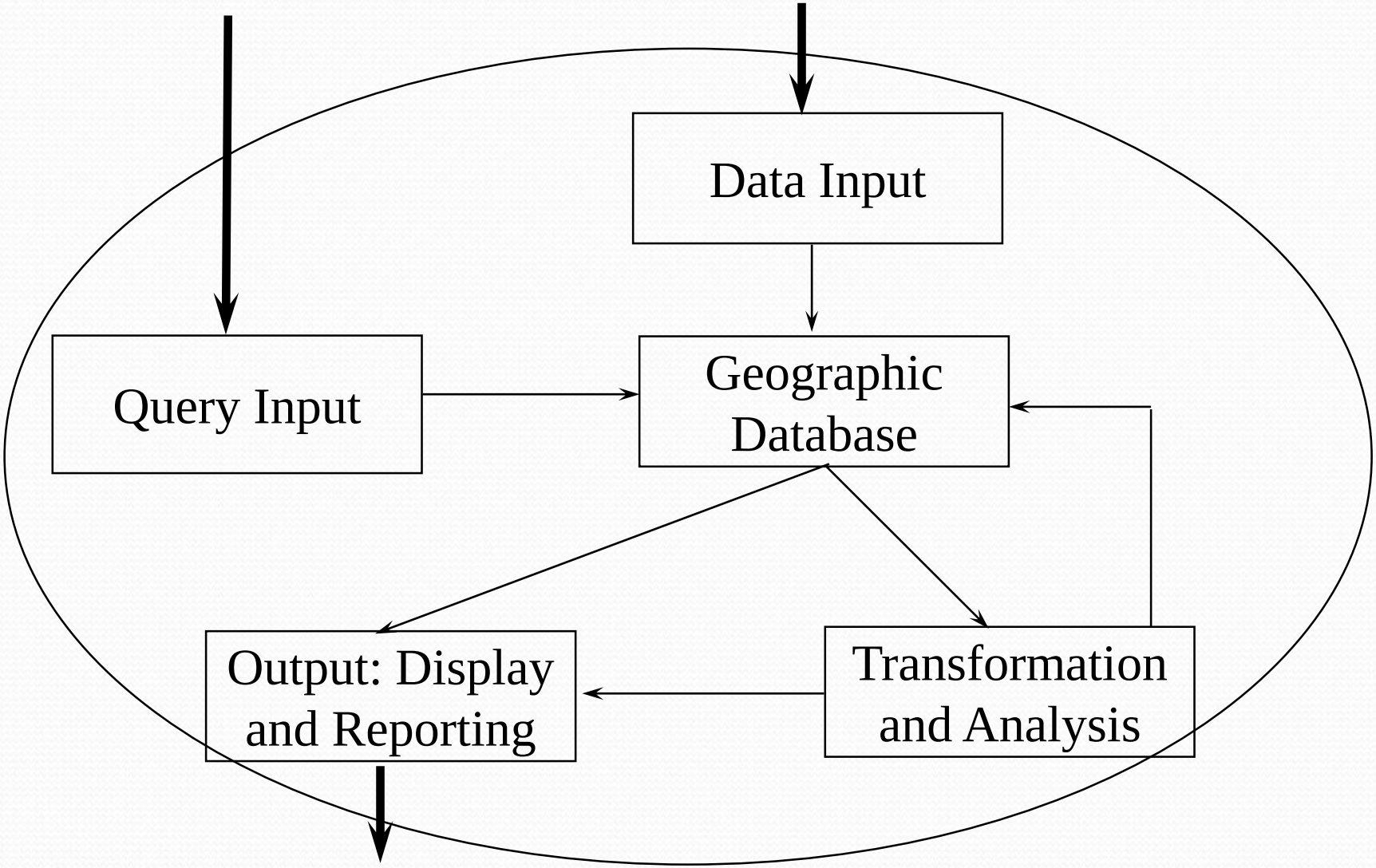
GPS and RS are sources of input data for a GISy.

A GISy provides for storing and manipulating GPS and RS data.

What GIS Applications Do:
manage, analyze, communicate

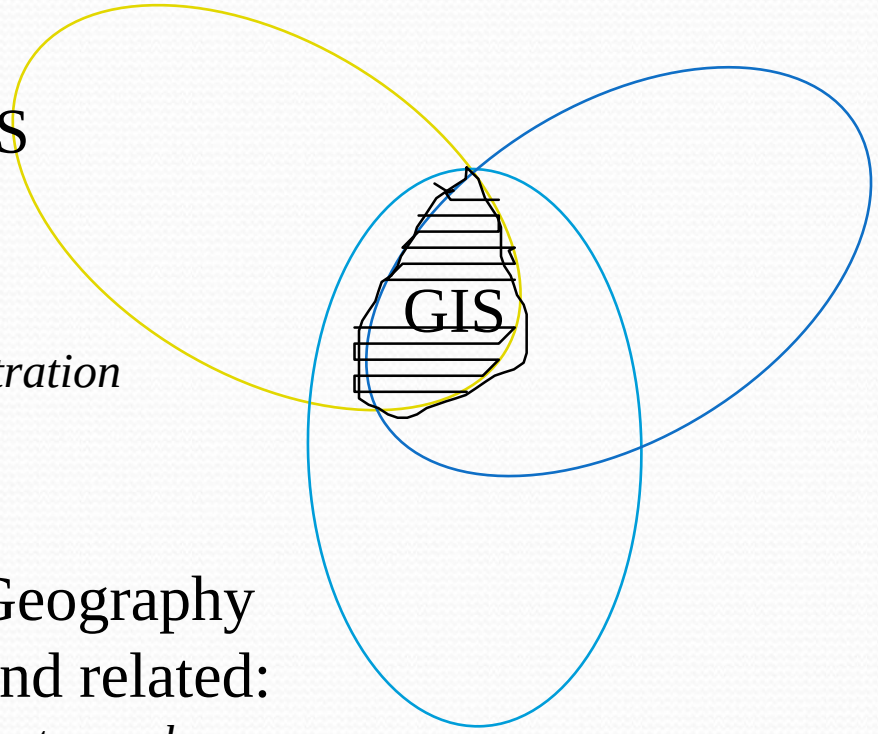
- make possible the **automation** of activities involving geographic data
  - map production
  - calculation of areas, distances, route lengths
  - measurement of slope, aspect, viewshed
  - logistics: route planning, vehicle tracking, traffic management
- allow for the **integration** of data hitherto confined to independent domains (e.g property maps and air photos).
- by tieing data to maps, permits the succinct **communication of complex spatial patterns** (e.g environmental sensitivity).
- provides answers to **spatial queries** (how many elderly in Richardson live further than 10 minutes at rush hour from ambulance service?)
- perform complex **spatial modelling** (*what if* scenarios for transportation planning, disaster planning, resource management, utility design)

GIS System Architecture and Components



Knowledge Base for GIS

Computer Science/MIS
graphics
visualization
database
system administration
security



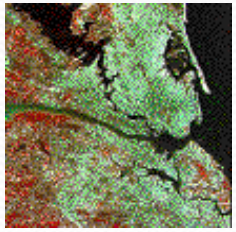
Application Area:
public admin.
planning
geology
mineral exploration
forestry
site selection
marketing
civil engineering
criminal justice
surveying

Geography and related:
cartography
geodesy
photogrammetry
landforms
spatial statistics.

The convergence of technological fields and traditional disciplines.

GIS components

Spatial data

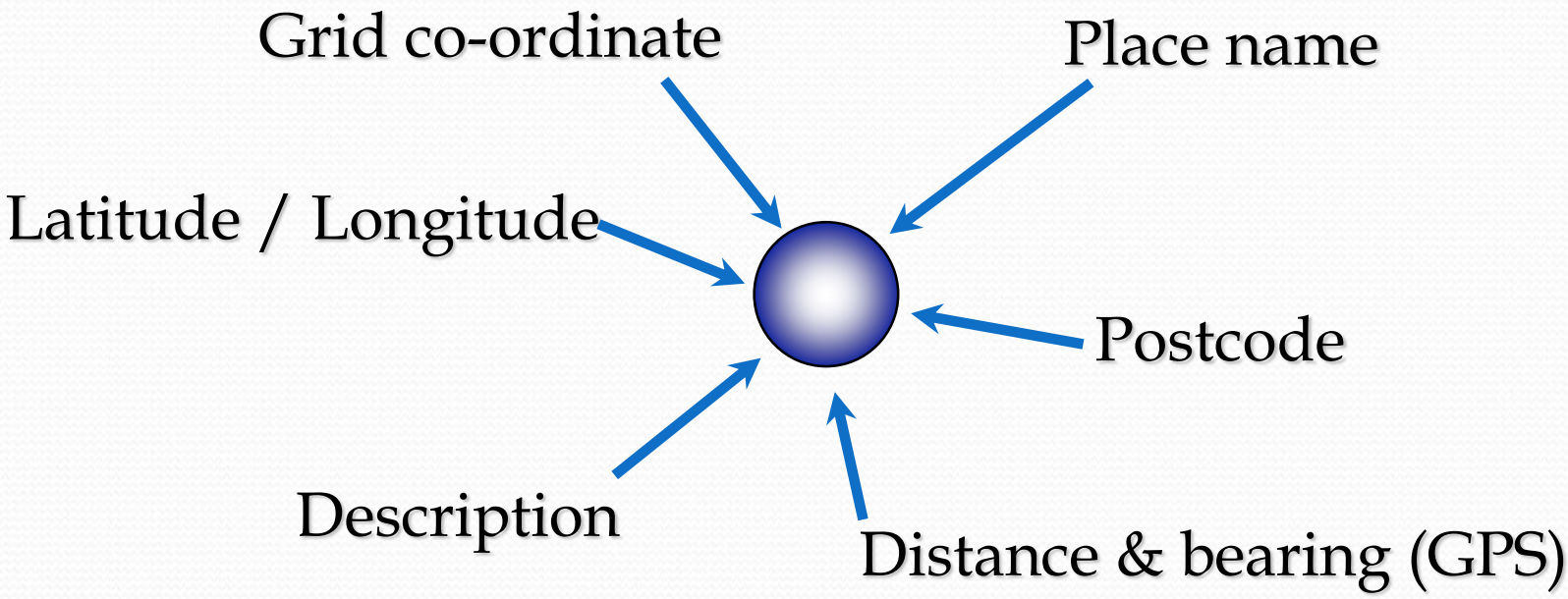


?

Computer hardware / software tools

Specific applications / decision making objectives

What makes data spatial?



Characteristics of spatial data

Location

- **Description** : Rajkot
- **Post Code** : 350006
- **Grid Reference** : 518106.72 168530.37
- **Latitude/Longitude** : 22.3000° N, 70.7800° E

Geometry

- The shape of a building or county
- The course of a river, the route of a road
- The shape of the landscape, relief

Characteristics of spatial data

- **Topology**
  - Connected to
  - Within
  - Adjacent to
  - North of . . .

  - *Within the Rajkot of near South West Slope*
  - *Near garnala*
  - *South West of Dhar*

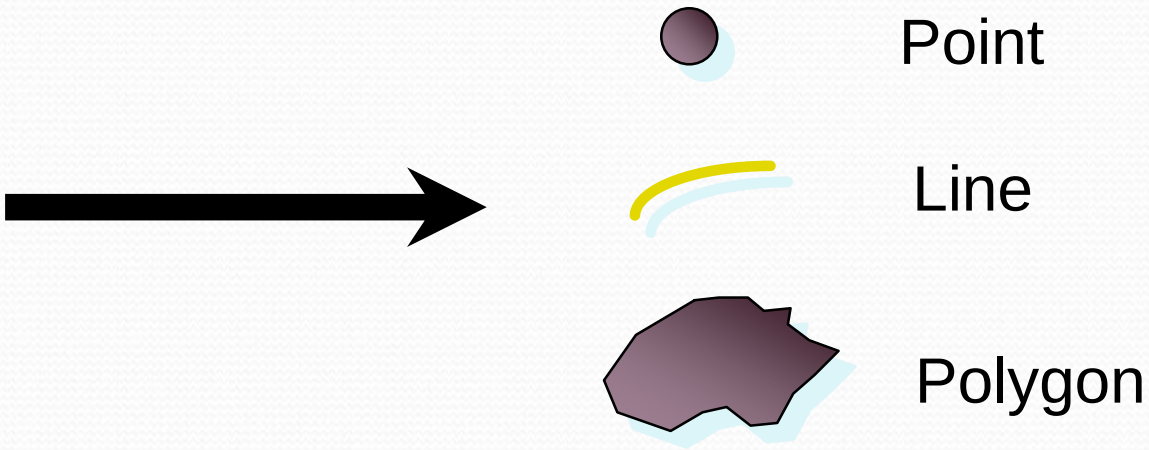
Spatial Data: examples

- Socio-economic data
  - Regional health data
  - Consumer / lifestyle profiles
  - Geo-demographics
- Environmental data
  - Topographic data
  - Thematic data, soils, geology

Data Modelling - step 1

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

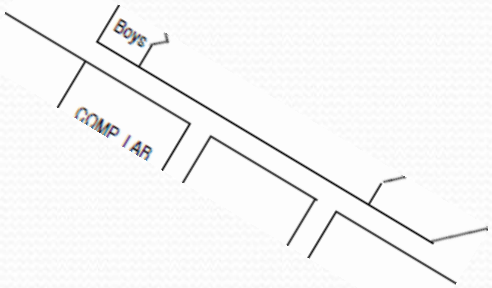
Data Modelling - step 2



Data Modelling - step 3

Attributes data matrix

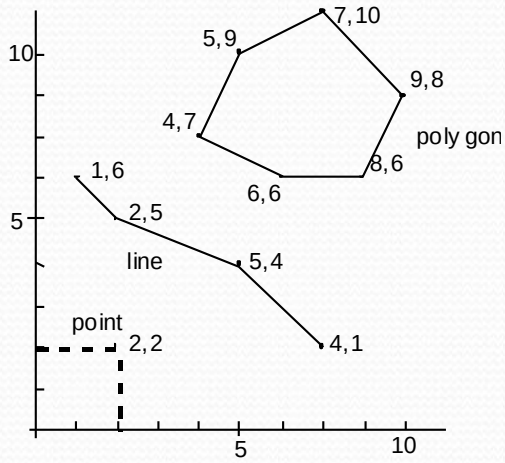
Name :	Next
Address:	School
Town:	Rajkot
Owner:	Kiran Patel
Tel. No:	123456
Floor space	250 sq m



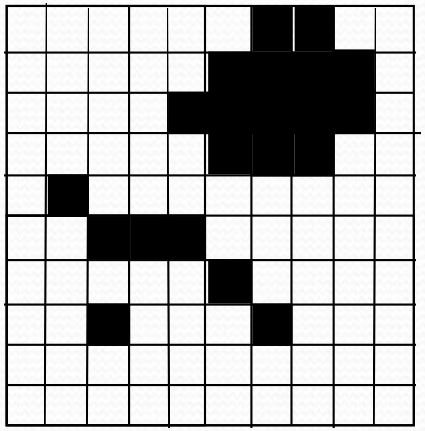
Spatial data storage

- Vector model

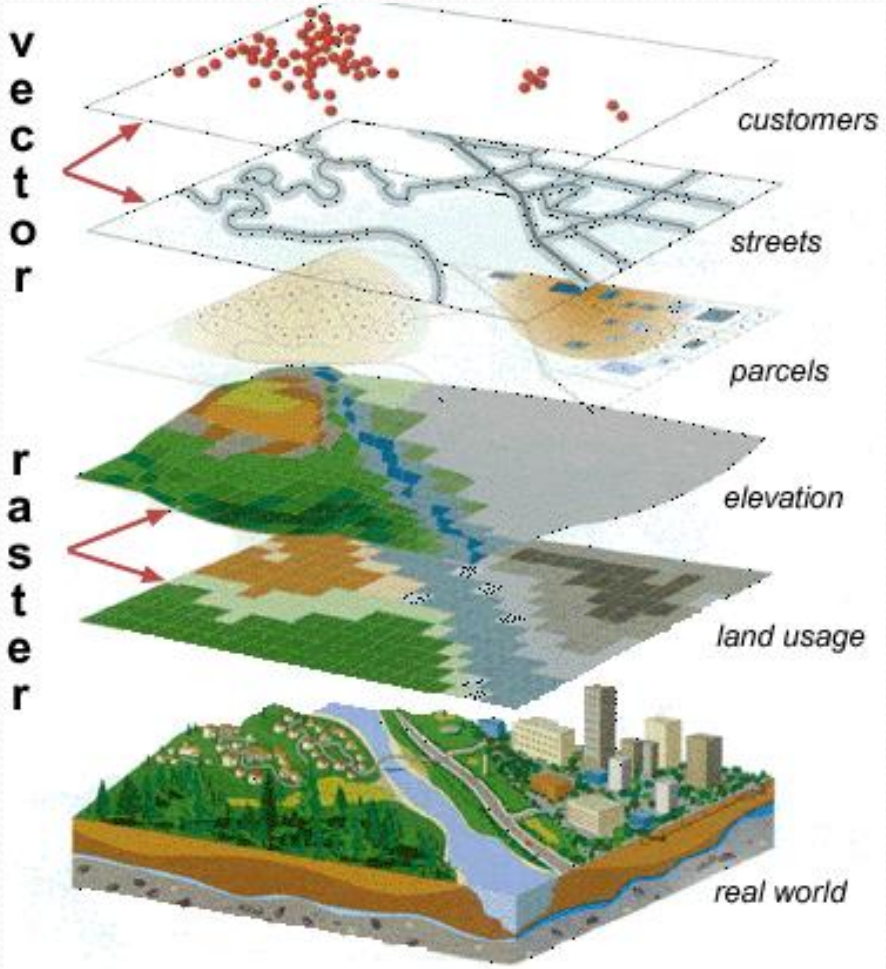
as geometric objects:
points, lines, polygons



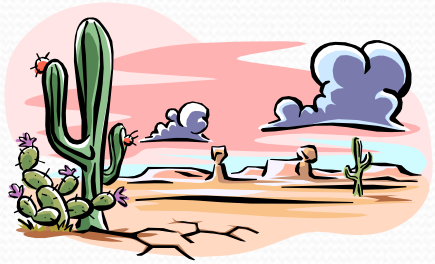
- Raster model

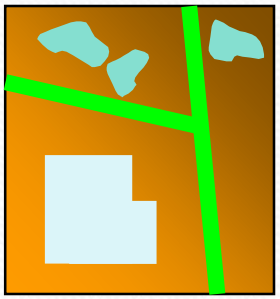


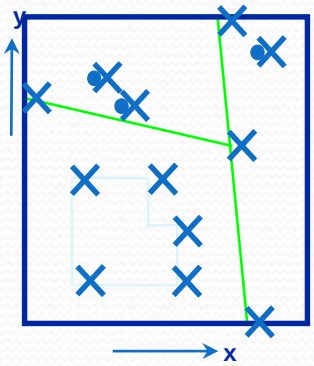
as image files
composed of
grid-cells
(pixels)

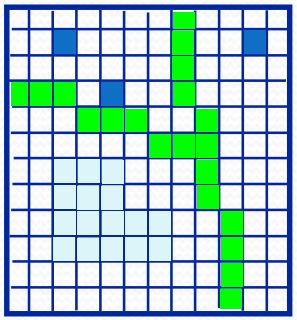


Modelling the real world









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

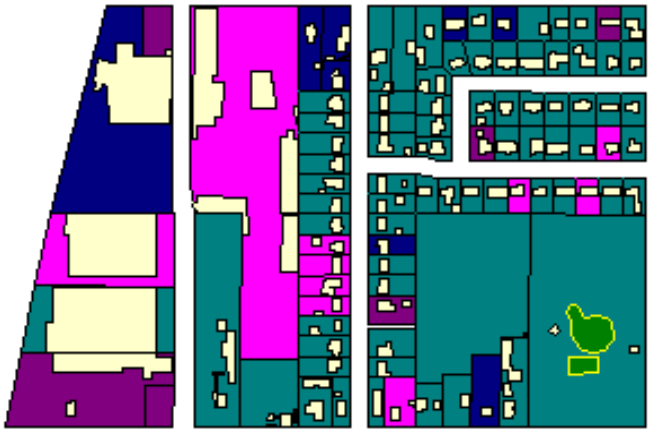
0 2 0 0 1 0 0 0 0

0 0 0 0 2 0 0 0 0

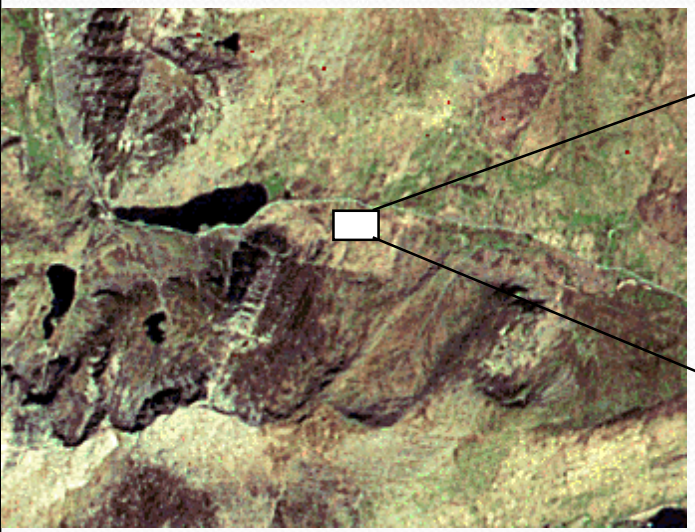
2 2 2 0 1 ...

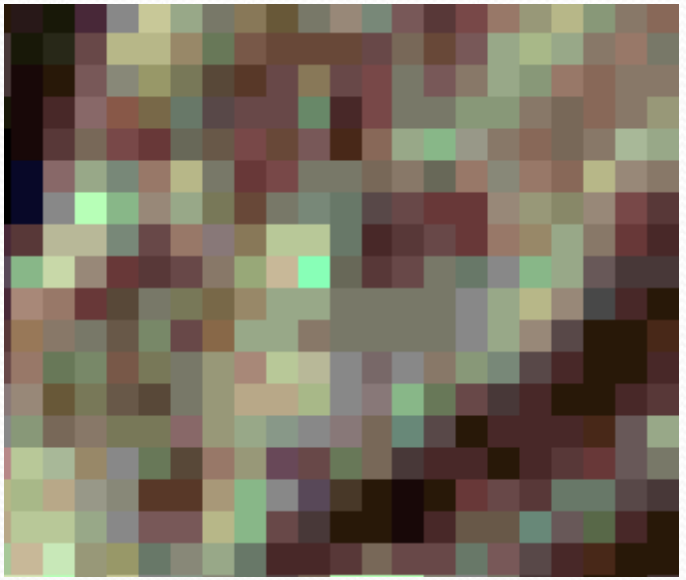
Vector data

Land use parcels



Raster data





Manipulation and analysis

- What would happen if . . .

  A chemical leaked into a tube wells?

- Where does . . .

  The Green Belt exist in relation to the City?

- Has . . .

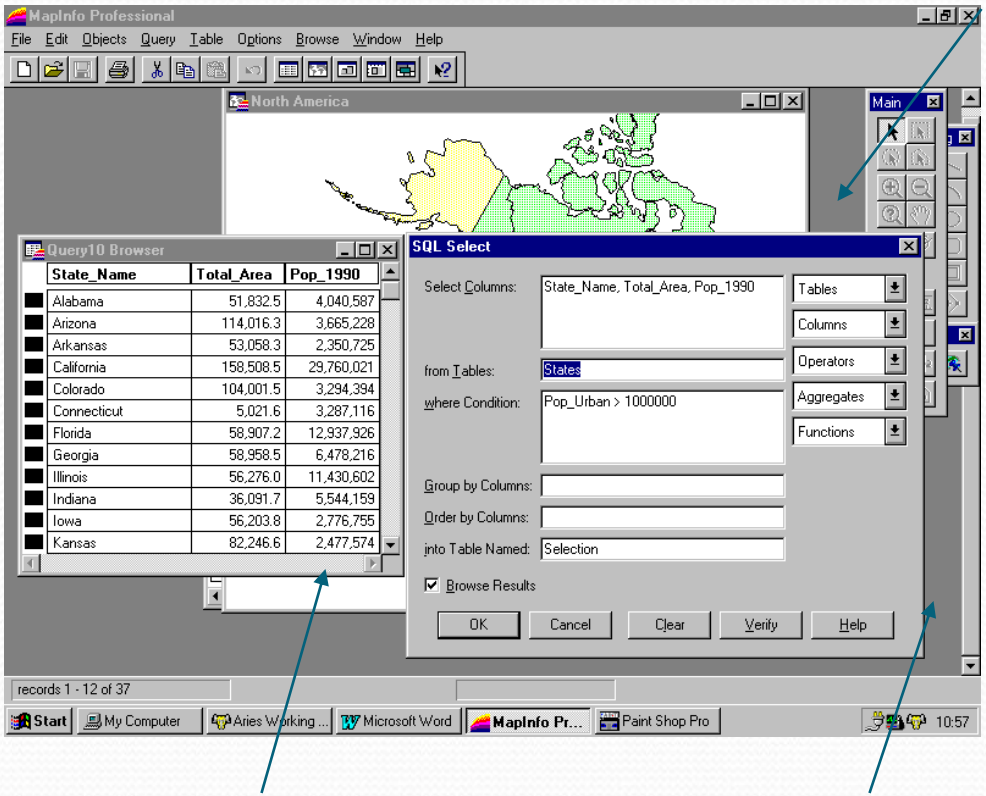
  Population changed over the last ten years?

- Is there a spatial pattern related to . . .

  Car ownership in our area?

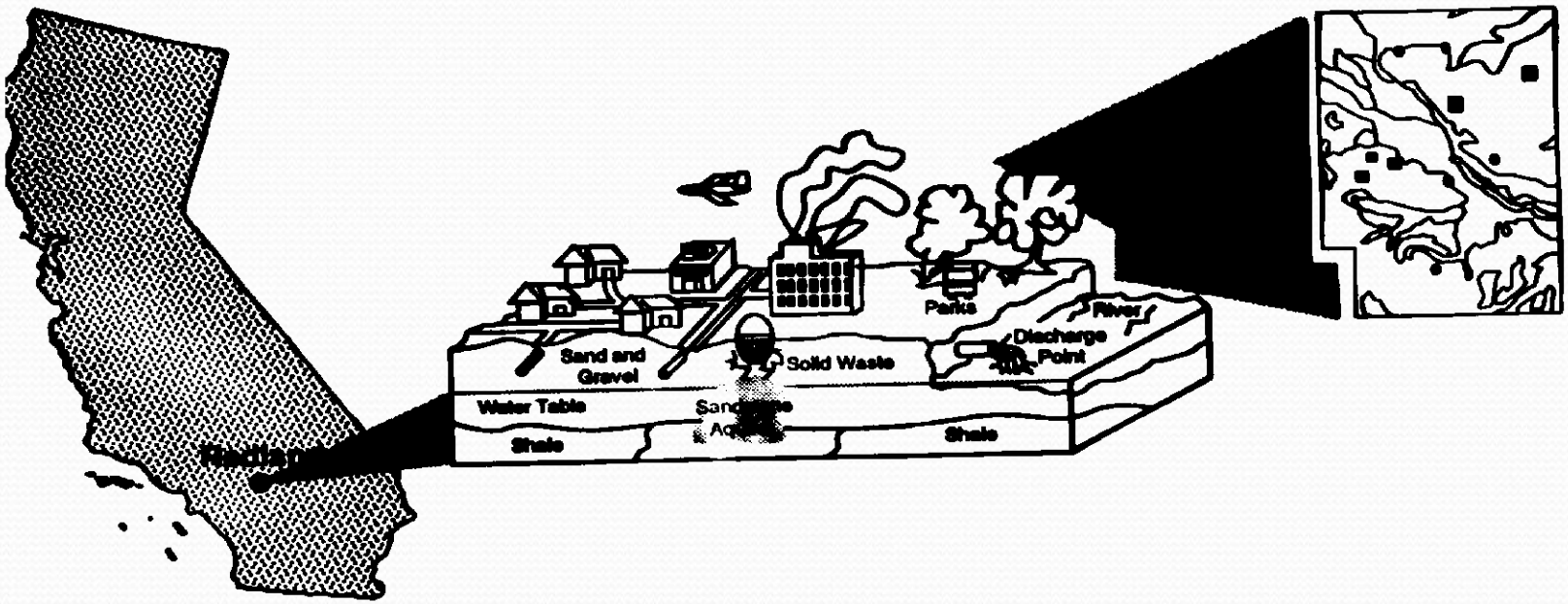
Databases & GIS

- At a simple level a GIS may just form the graphical interface to a database
- The majority of GIS applications follow this example



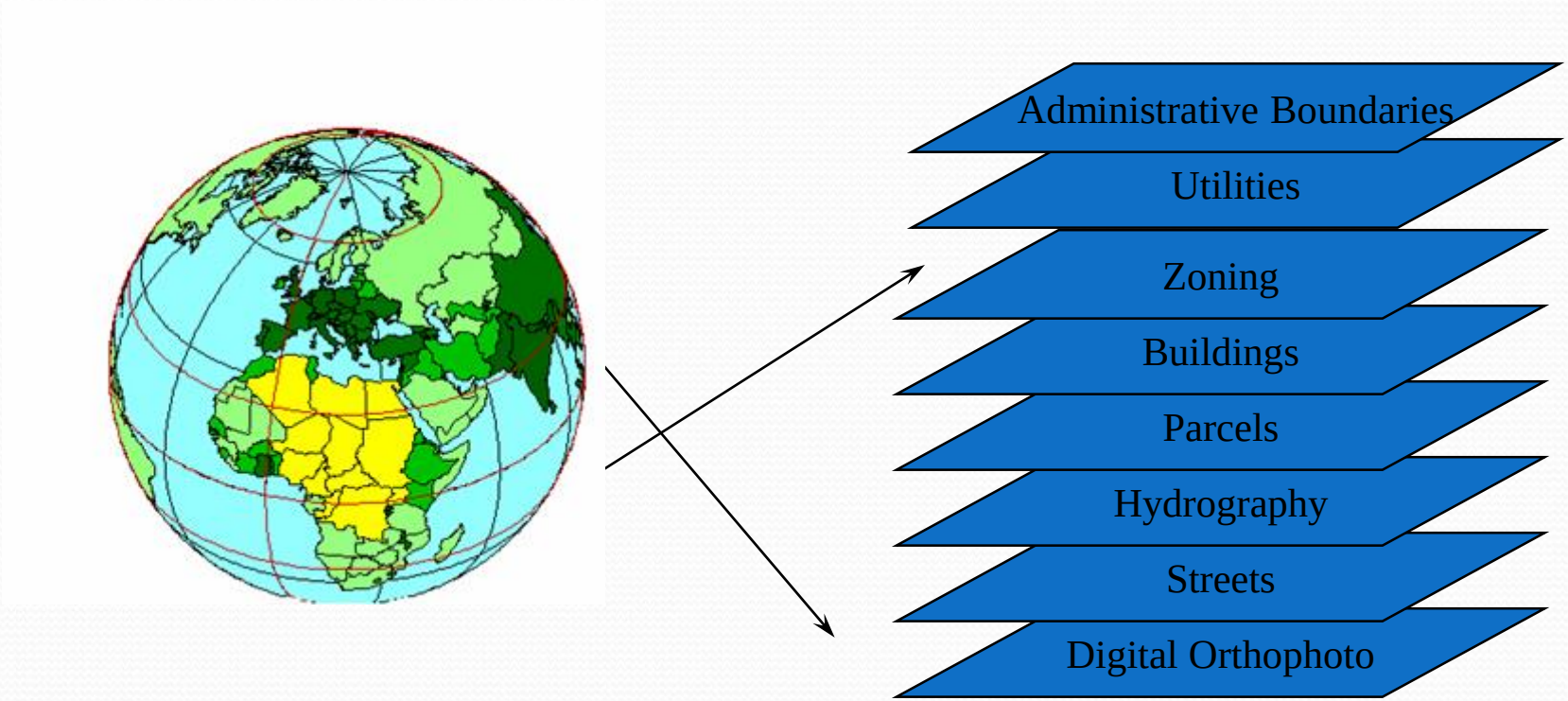
The GIS Data Model: Purpose

- allows the **geographic features** in **real world locations** to be digitally represented and stored in a database so that they can be abstractly presented in **map** (analog) form, and can also be worked with and **manipulated** to address some **problem**



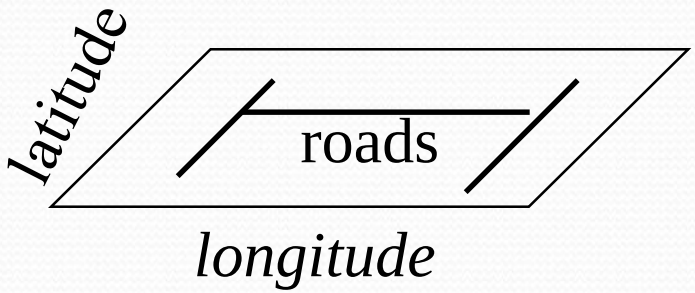
The GIS Data Model: Implementation

Geographic Integration of Information



- Data is organized by layers, coverages or themes **(**synonomous concepts), *with each layer representing a common feature*.
- Layers are integrated using explicit location on the earth's surface, *thus geographic location is the organizing principal*.

The GIS Model: example



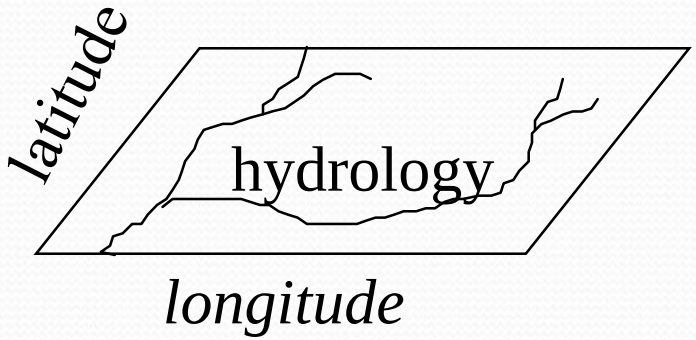
Here we have three layers or themes:

--*roads*,

--*hydrology (water)*,

--*topography (land elevation)*

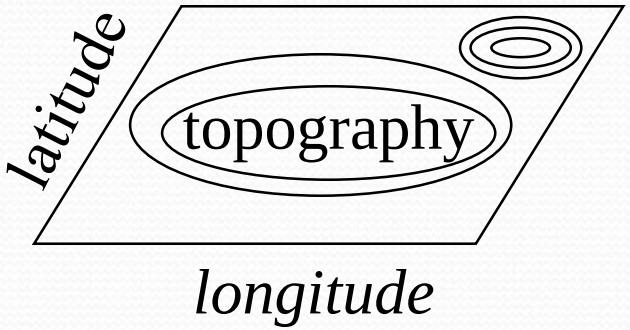
They can be related because precise geographic coordinates are recorded for each theme.



Layers are comprised of two data types

•*Spatial data* which describes location (where)

•*Attribute data* specifing what, how much,when



Layers may be represented in two ways:

•in *vector* format as points and lines

•in *raster(or image)* format as pixels

All geographic data has 4 properties:

projection, scale, accuracy and resolution

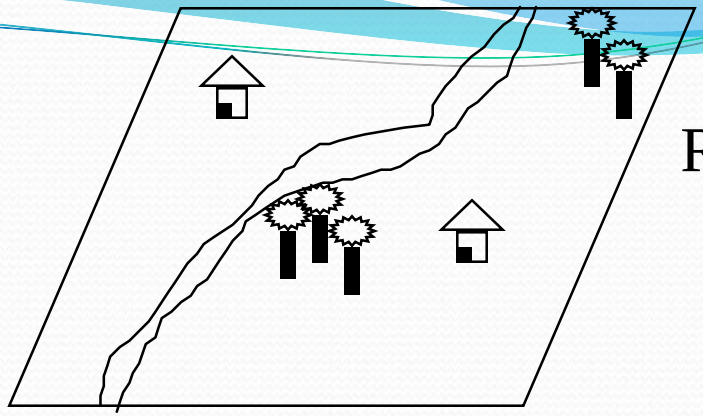
Spatial and Attribute Data

- Spatial data *(where)*
  - specifies location
  - stored in a *shape file, geodatabase* or similar geographic file
- Attribute (descriptive) data *(what, how much, when)*
  - specifies characteristics at that location, natural or human-created
  - stored in a data base *table*

GIS systems traditionally maintain spatial and attribute data separately, then "join" them for display or analysis

- for example, in ArcView, the *Attributes of …* table is used to link a *shapefile* (spatial structure) with a *data base table* containing attribute information in order to display the attribute data spatially on a map

Concept of Vector and Raster

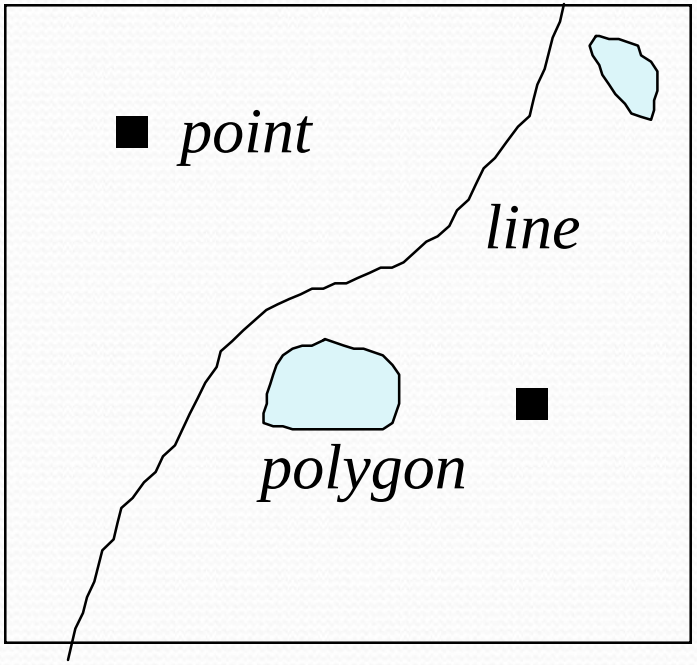


Real World

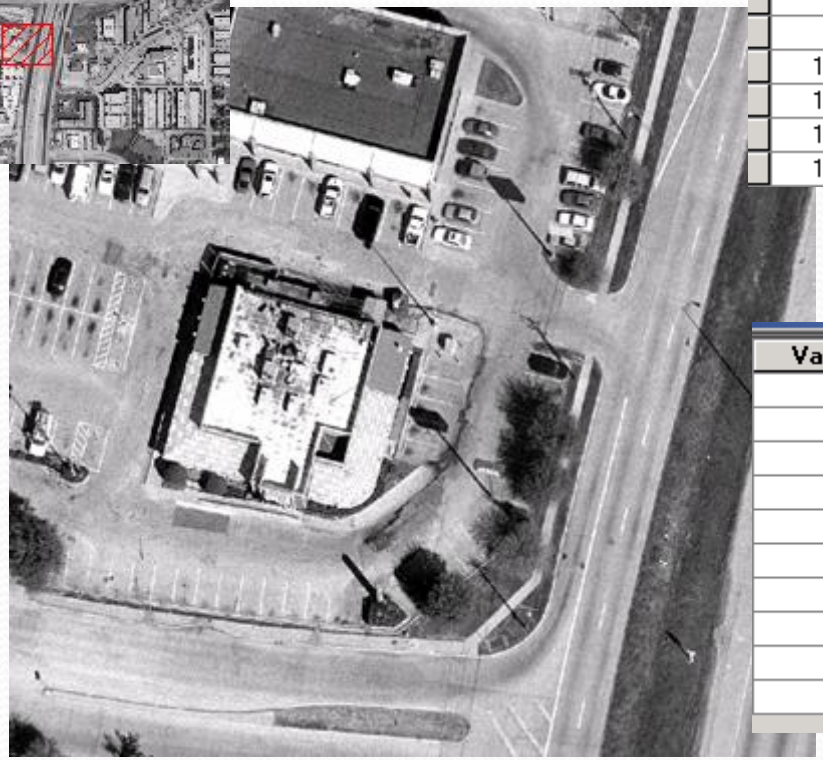
Raster Representation

	0	1	2	3	4	5	6	7	8	9
0								R	T	
1							R			T
2		H					R			
3							R			
4					R	R				
5				R						
6			R		T	T		H		
7			R		T	T				
8		R								
9		R								

Vector Representation



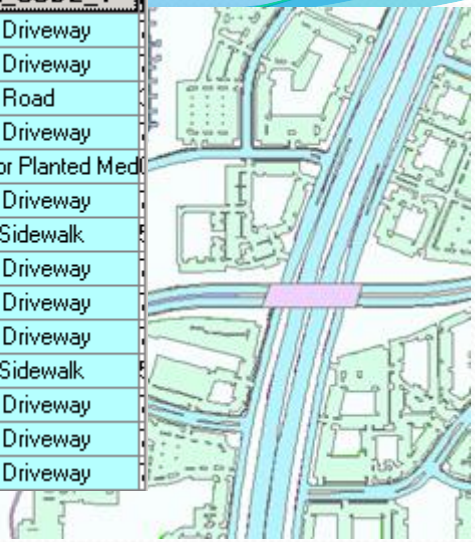
Dumb Images & Smart GIS Data



Images—dumb rasters
(although they look good!)

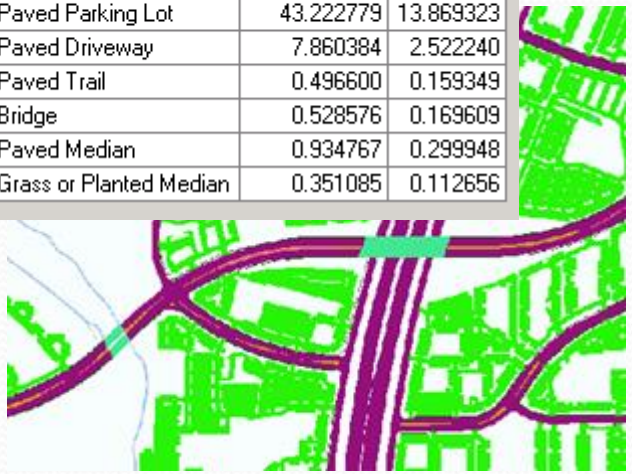
Smart Vector—Pavement polygons

OID	FEA_C	Area_PC	FEA_CODE_1
0	165	2.557509	Paved Driveway
1	165	0.177594	Paved Driveway
2	161	404.664113	Paved Road
3	165	25.081809	Paved Driveway
4	169	11.185954	Grass or Planted Med
5	165	85.809233	Paved Driveway
6	163	27.941142	Public Sidewalk
7	165	104.295646	Paved Driveway
8	165	85.484622	Paved Driveway
9	165	80.315827	Paved Driveway
10	163	17.667767	Public Sidewalk
11	165	147.556552	Paved Driveway
12	165	75.181746	Paved Driveway
13	165	199.456888	Paved Driveway



Smart Raster—5 feet grids

Value	Count	FEA_CODE	Prct_tran	Prct_land
160	62306	Paved Alley	5.056571	1.622552
161	441326	Paved Road	35.816712	11.492865
162	350	Unpaved Road	0.028405	0.009115
163	70285	Public Sidewalk	5.704123	1.830339
164	532582	Paved Parking Lot	43.222779	13.869323
165	96854	Paved Driveway	7.860384	2.522240
166	6119	Paved Trail	0.496600	0.159349
167	6513	Bridge	0.528576	0.169609
168	11518	Paved Median	0.934767	0.299948
169	4326	Grass or Planted Median	0.351085	0.112656



Projection, Scale, Accuracy and Resolution

the key properties of spatial data

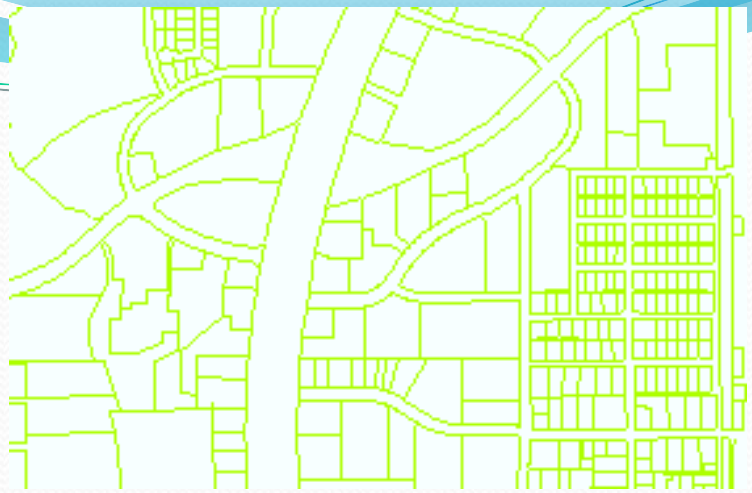
- **Projection:** the method by which the curved 3-D surface of the earth is represented by X,Y coordinates on a 2-D flat map/screen
  - distortion is inevitable
- **Scale:** the ratio of distance on a map to the equivalent distance on the ground
  - in theory GIS is scale independent but in practice there is an implicit range of scales for data output in any project
- **Accuracy:** how well does the database info match the real world
  - *Positional*: how close are features to their real world location?
  - *Consistency*: do feature characteristics in database match those in real world
    - is a road in the database a road in the real world?
  - *Completeness*: are all real world instances of features present in the database?
    - Are all roads included.
- **Resolution:** the size of the smallest feature able to be recognized
  - for raster data, it is the *pixel* size

The tighter the specification, the higher the cost.

Examples

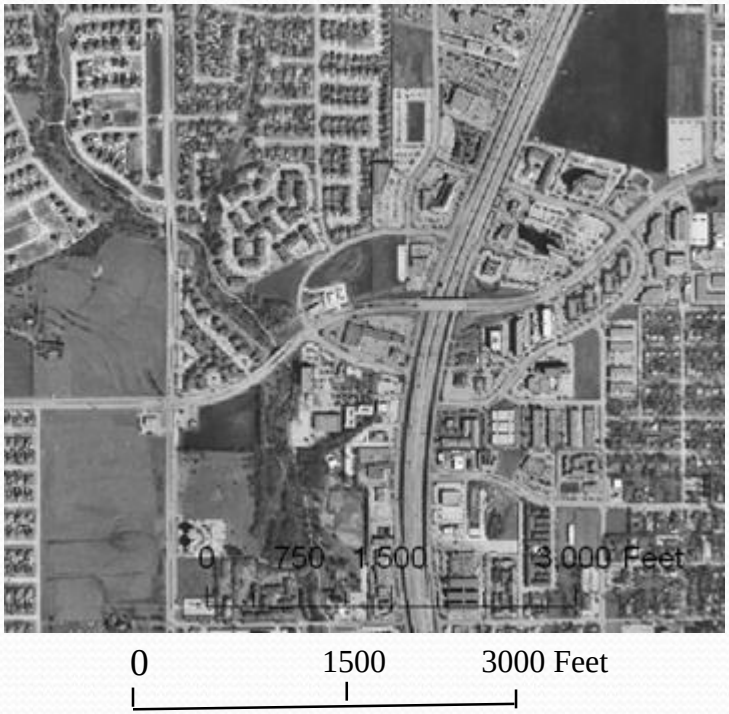
Layers

Vector Layers



Street Network layer: lines

Land Parcels layer: polygons



Raster (image) Layer

Digital Ortho Photograph Layer:

Digital Ortho photo: *combines the visual properties of a photograph with the positional accuracy of a map, in computer readable form.*

Projection: State Plane, North Central Texas Zone, NAD 83
Resolution: 0.5 meters
Accuracy: 1.0 meters
Scale: see scale bar

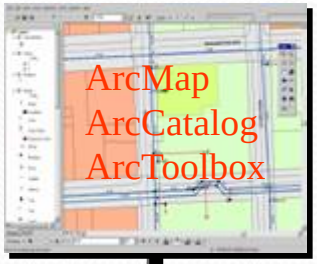
ESRI ArcGIS System

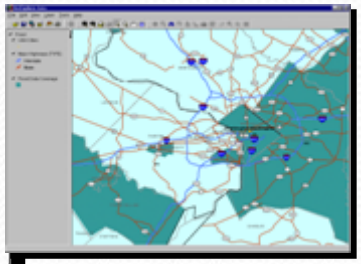
c:\ ArcGIS Workstation

Clients

Consistent interface
Increasing capability

ArcInfo | ArcEditor | ArcView | $ | ArcExplorer | Browser





ArcEngine/ ArcObjects
Application Development & Customization

ArcServer Services
Full GIS analysis

ArcIMS Services
Map display & query

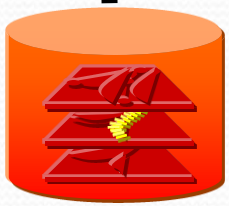
ArcSDE Services
Database storage/access

Internet

ArcPad

Handheld/Wireless

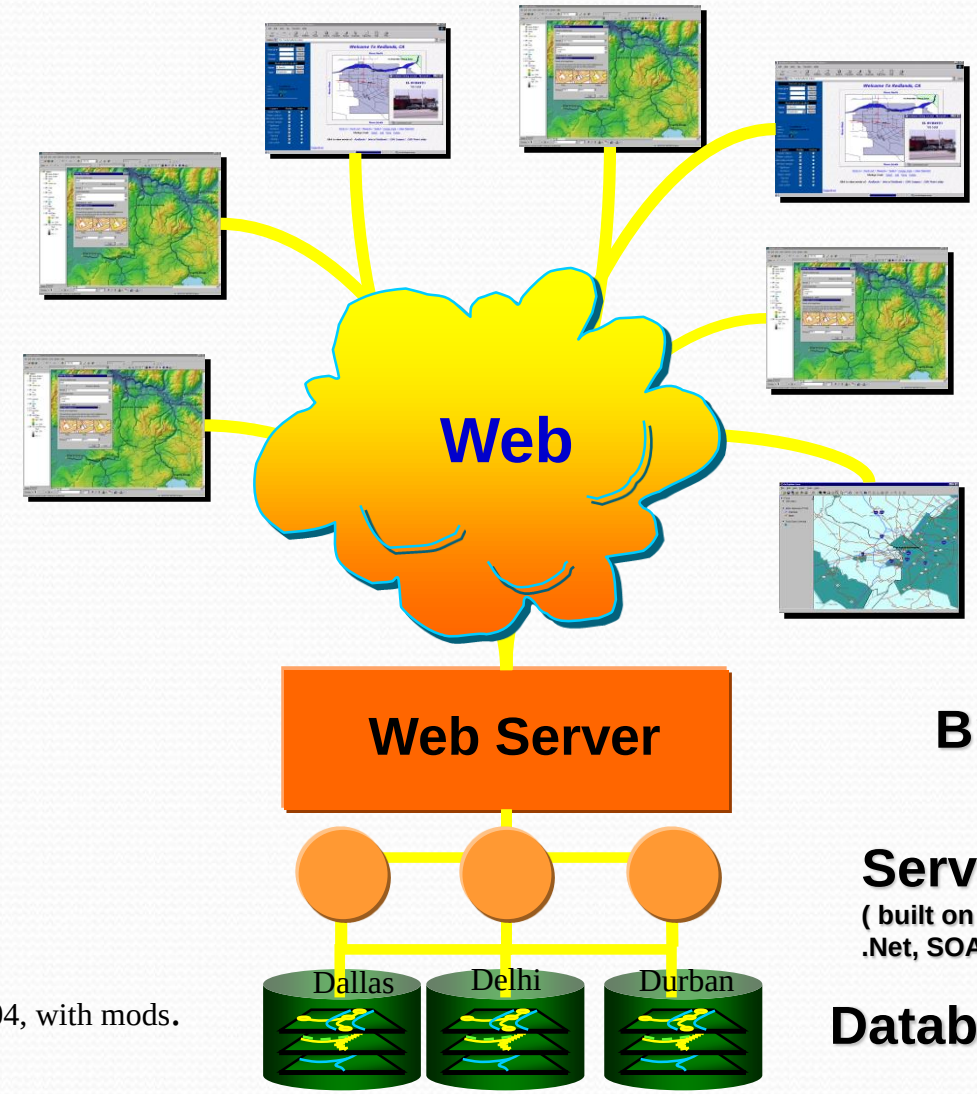
Files
(Personal Geodatabase, Shapefiles, Coverages, Grids, tins, etc)



Databases
Multi-user Geodatabases (in Oracle, SQL Server, IBM DBII, etc)

Source: ESRI with mods.

Future Generic GIS Internet Enterprise



Source: Reza Wahadj, CSIG04, with mods.

Courtesy

USGS, ESRI,
and
National Remote Sensing Agency