



# GIS

*(Geographic Information System)*

**Fundamentals**

**Std 12 Practical Geography**

[Ketabton.com](http://Ketabton.com)

# 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

### Soho

+ Cholera death

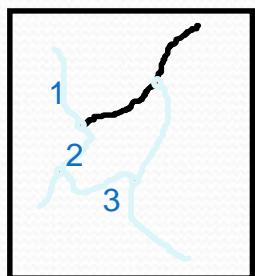
● Water pump



# GIS: historical background

This technology has developed from:

Digital cartography and CAD - Data Base Management Systems



ID	X,Y
1	
2	
3	

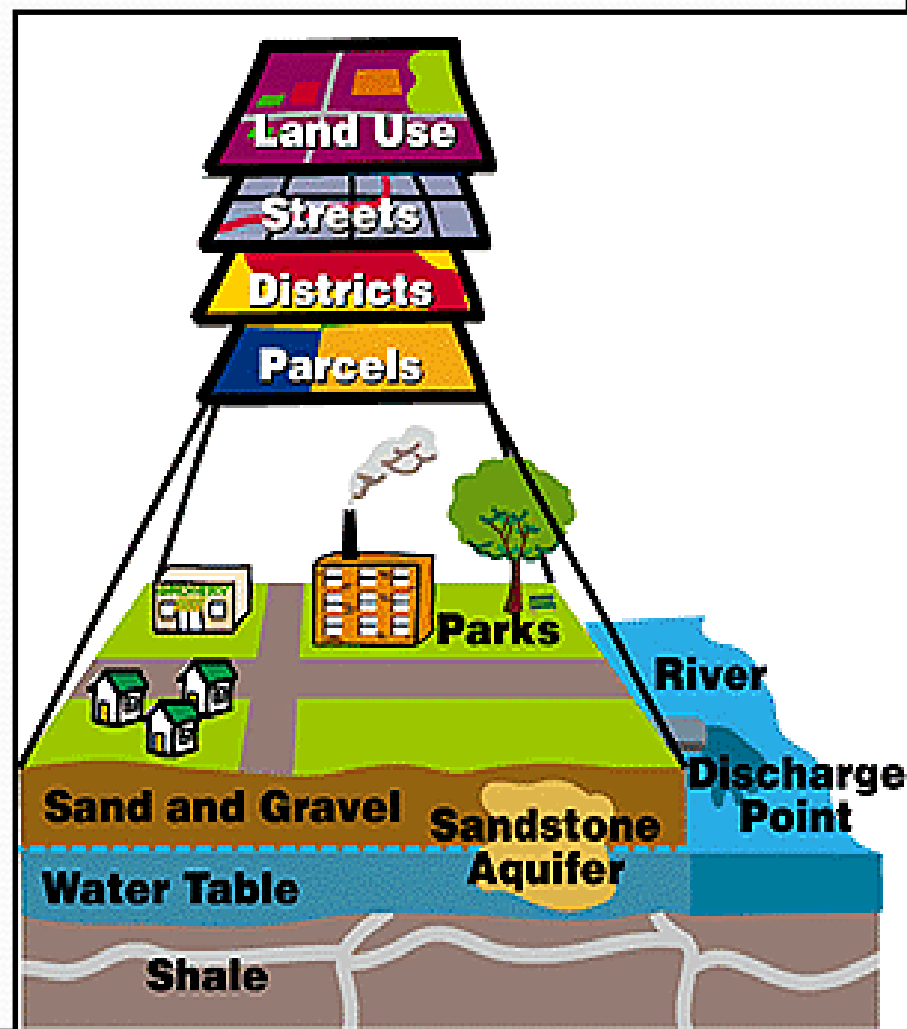
ID	ATTRIB
1	
2	
3	

CAD System

Data Base Management System

## GIS: Today

Abstracting  
the Real  
World





# We Live in Two Worlds

## Natural World



**Self-Regulating**

## Constructed World

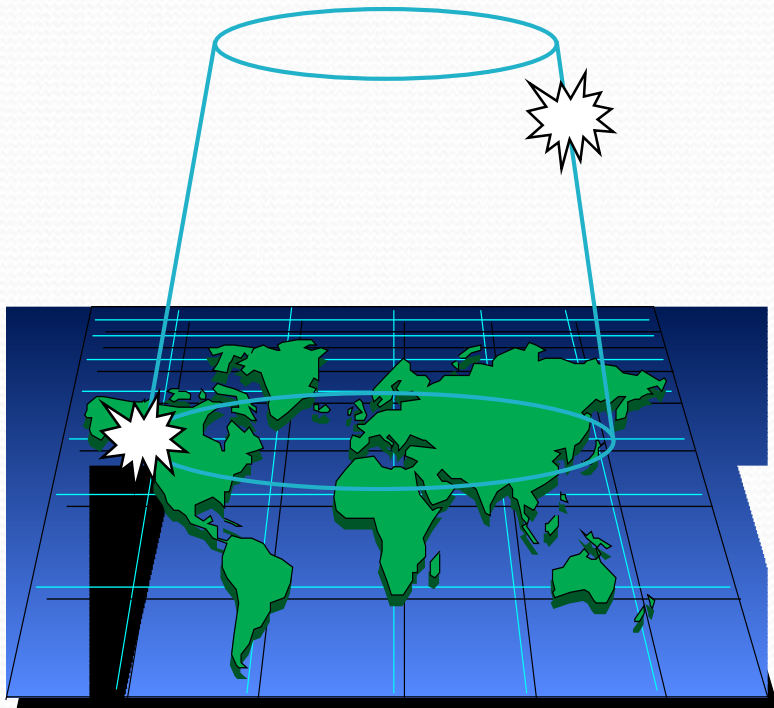


**Managed**

**... These Are Increasingly In Conflict**

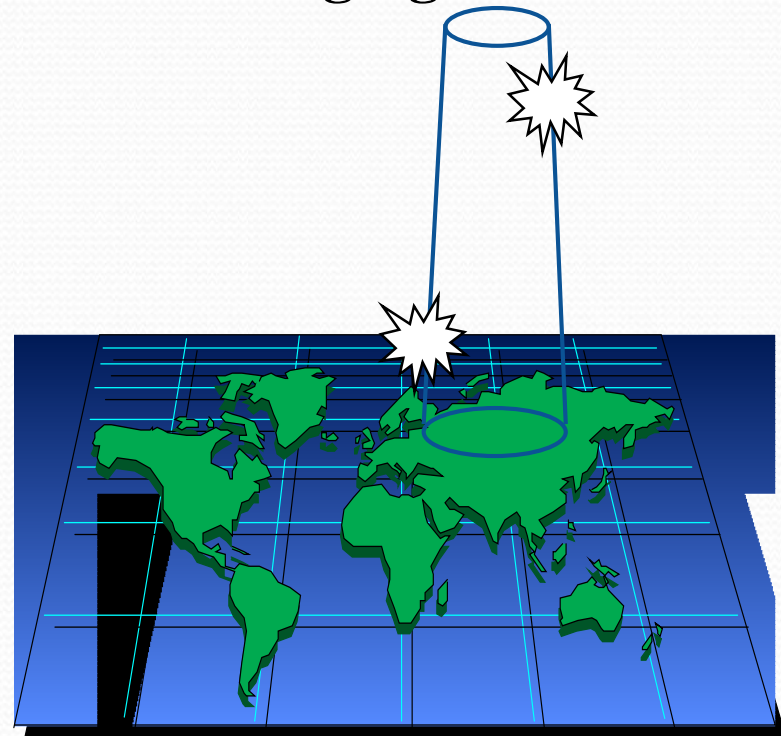
# Context and Content

## 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



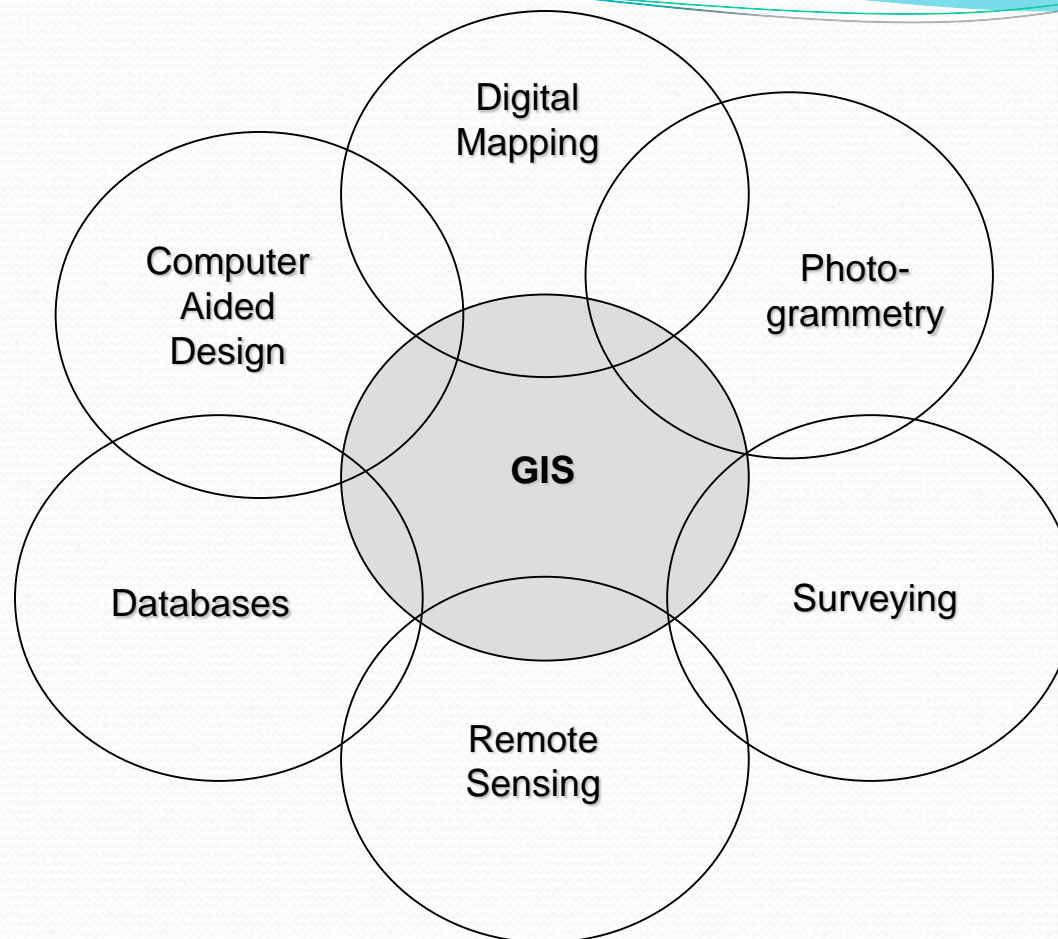
# Why Study GIS? And What can you do with a GIS?

- 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.*

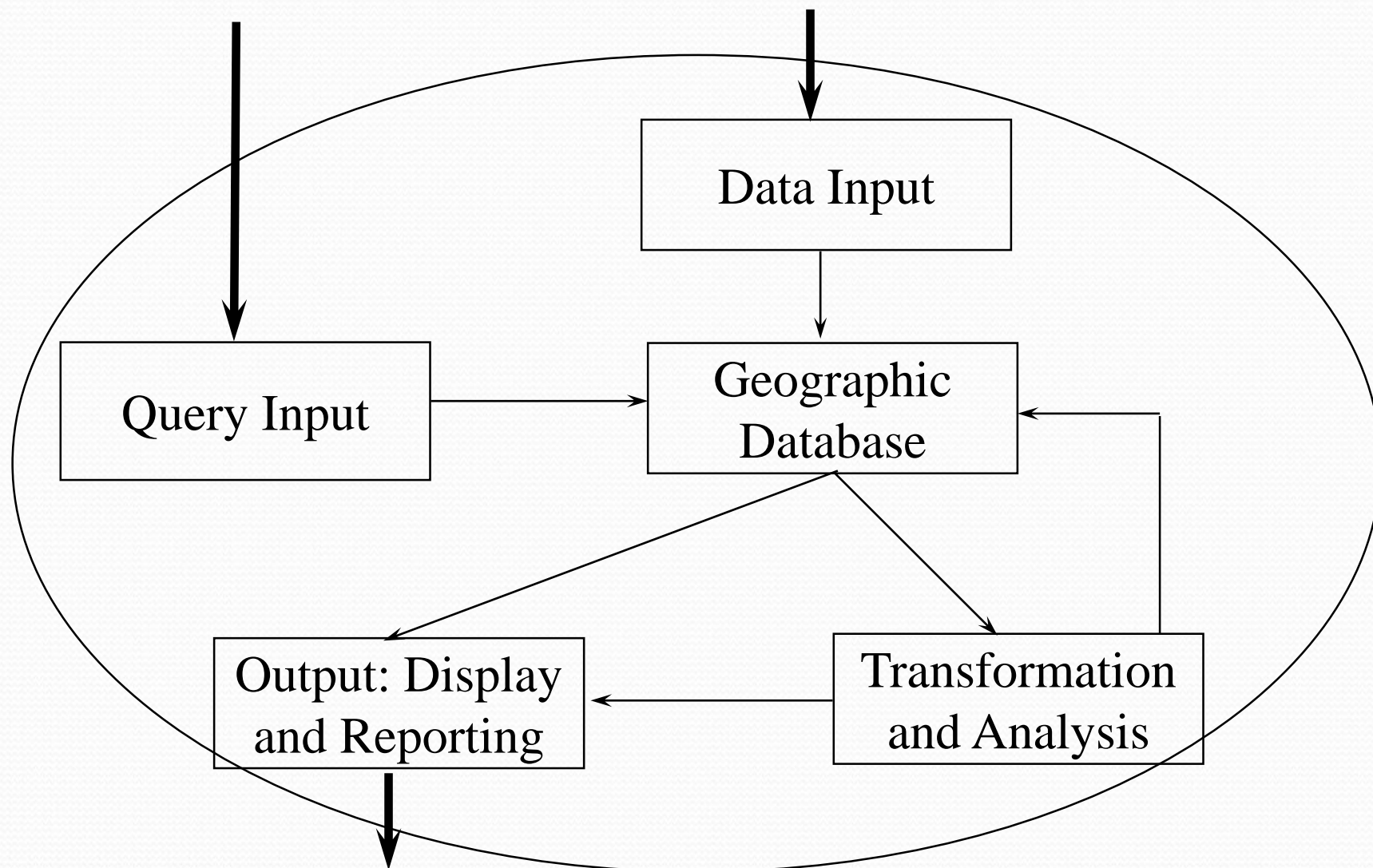
# What GIS Applications Do:

## *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 tying 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*

## Geography and related:

*cartography  
geodesy  
photogrammetry  
landforms  
spatial statistics.*

## Application Area:

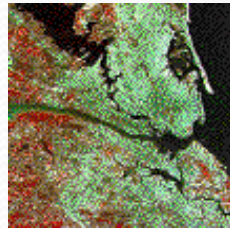
*public admin.  
planning  
geology  
mineral exploration  
forestry  
site selection  
marketing  
civil engineering  
criminal justice  
surveying*



*The convergence of technological  
fields and traditional disciplines.*

# GIS components

Spatial  
data



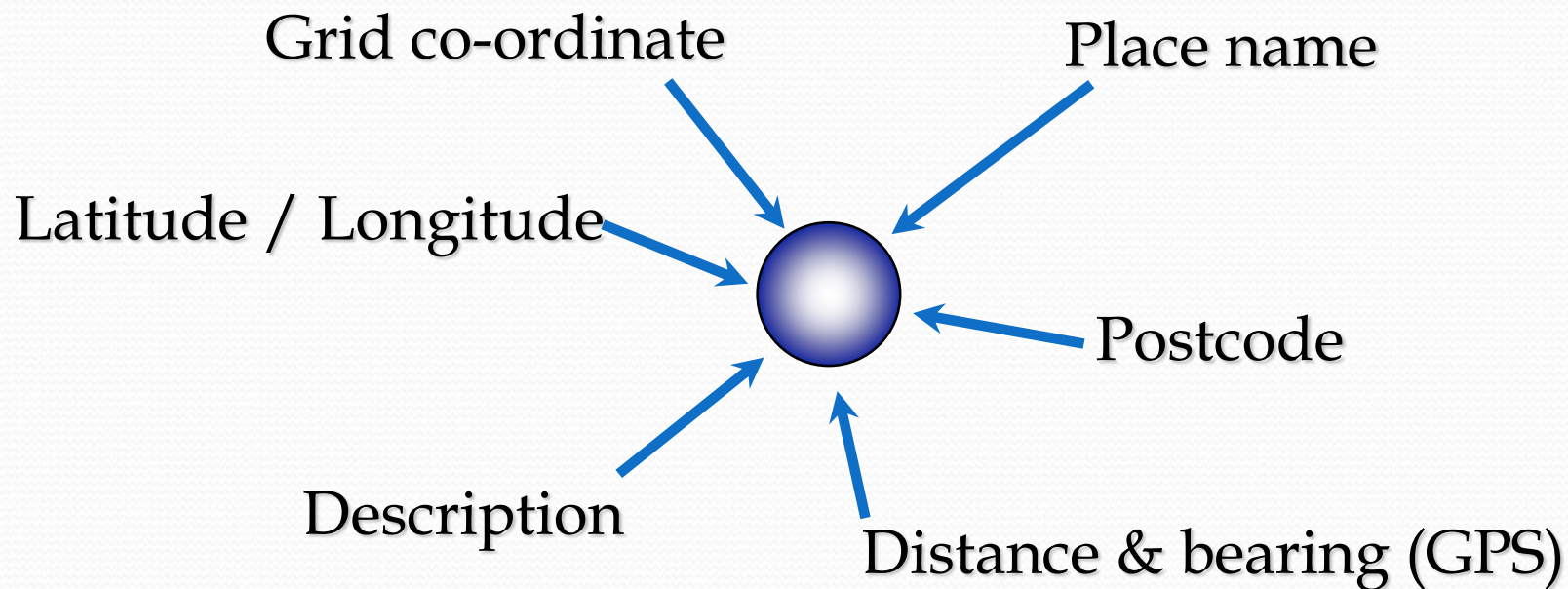
Computer hardware /  
software tools



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



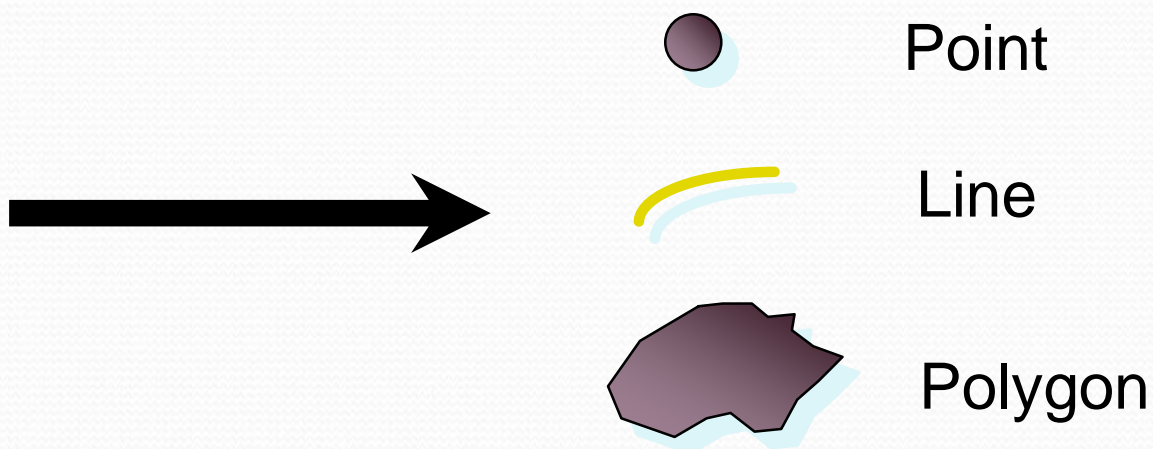
# Data Modelling - step 1

- Features



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

# Data Modelling - step 2





# Data Modelling - step 3

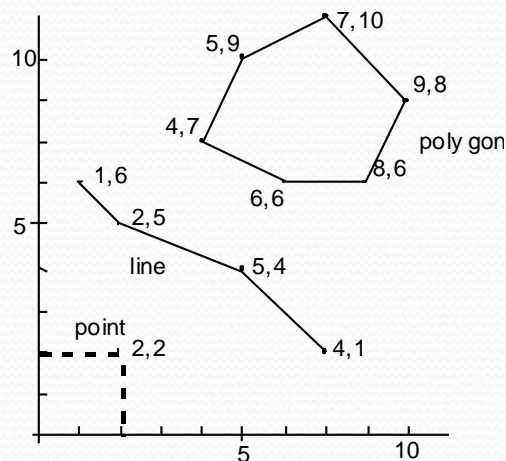


## Attributes data matrix

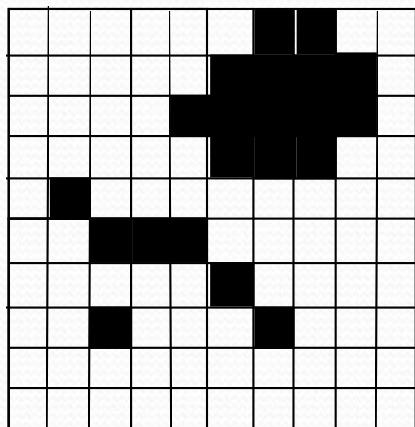
Name :	Next
Address:	School
Town:	Rajkot
Owner:	Kiran Patel
Tel. No:	123456
Floor space	250 sq m

# Spatial data storage

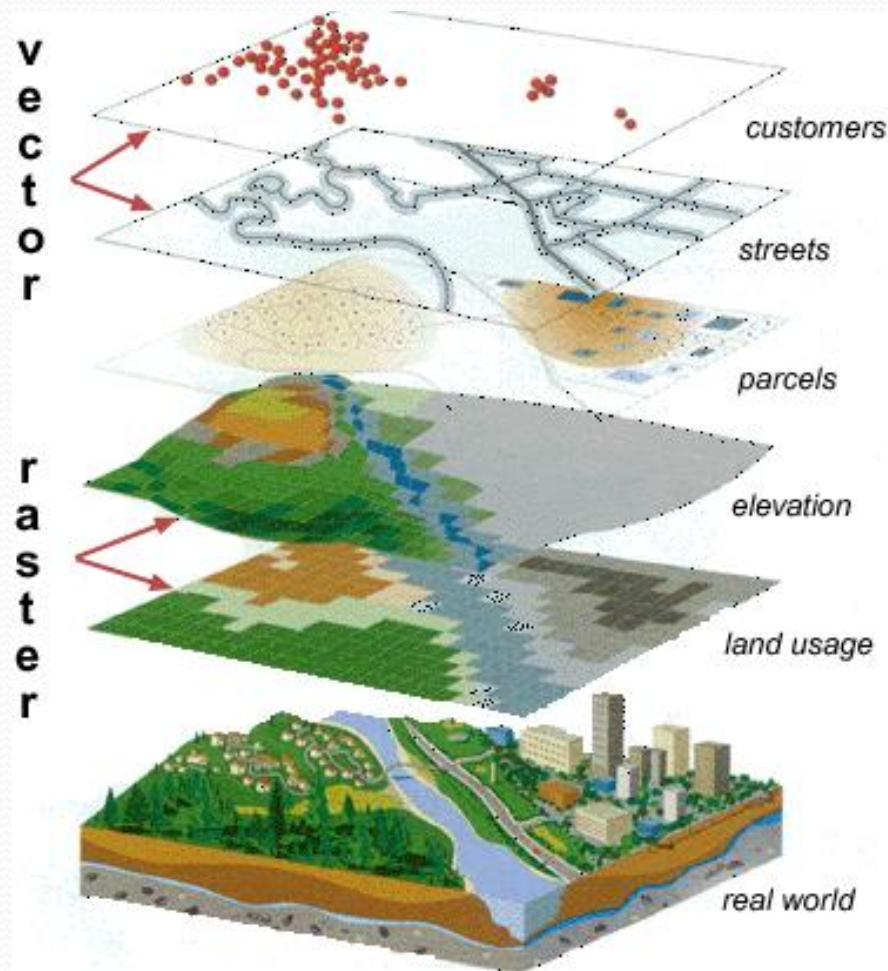
- **Vector model** as geometric objects:  
points, lines, polygons



- **Raster model**

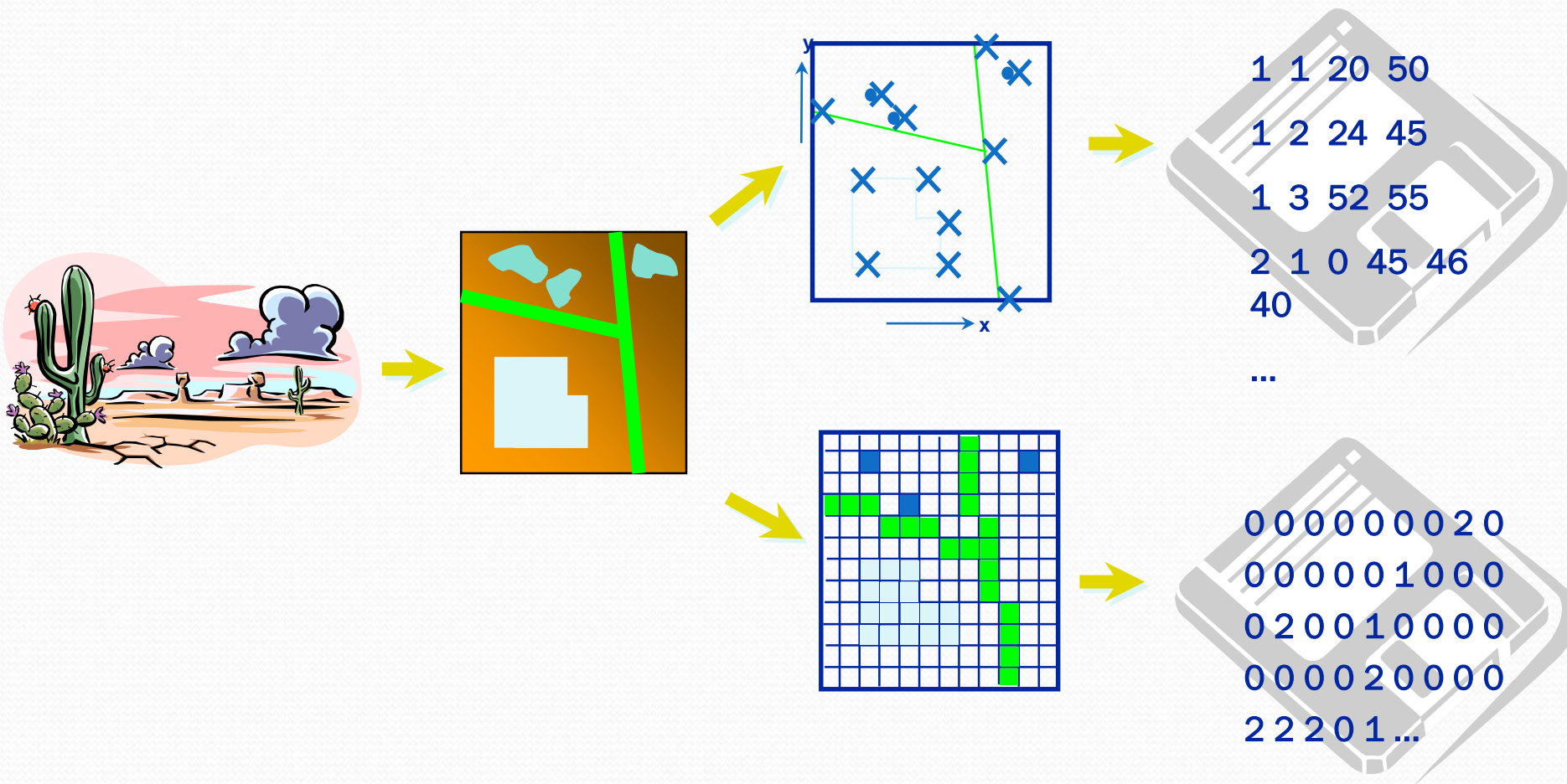


as image files  
composed of  
grid-cells  
(pixels)



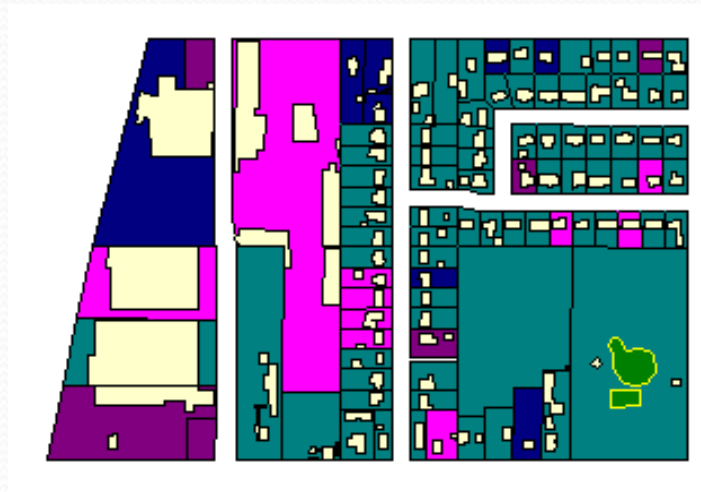


# Modelling the real world

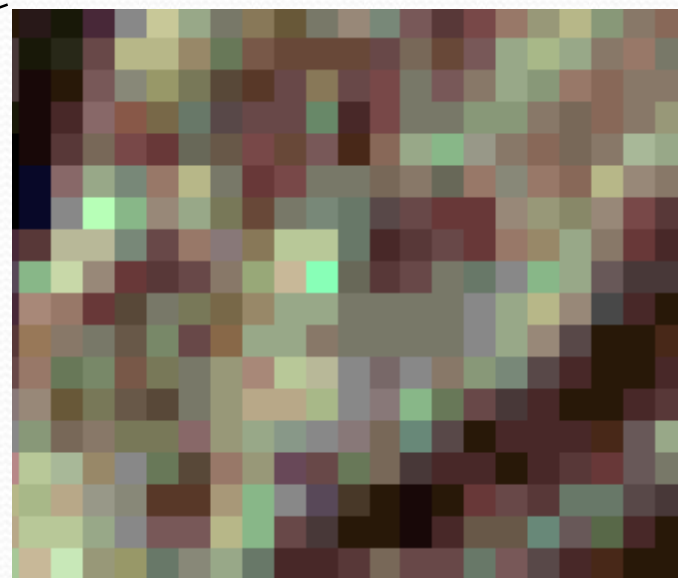
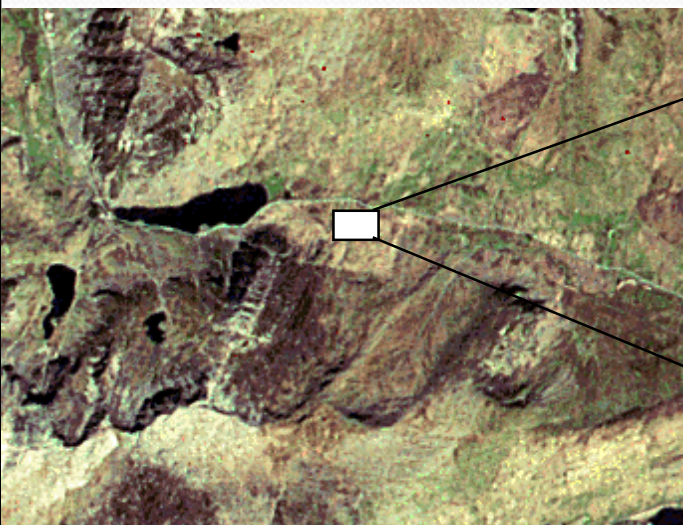


# Vector data

Land use parcels



# Raster data





(c) ketabton.com: The Digital Library

# 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 . . .

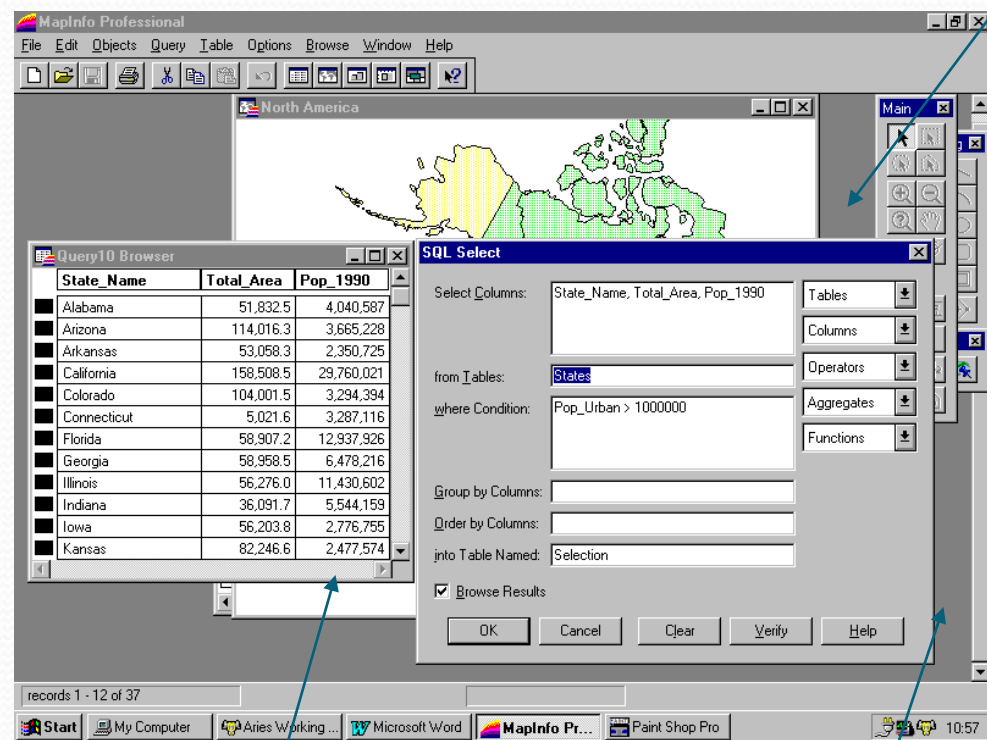
*Population changed over the last ten years?*

- 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



*Spatial data*

*Linked database table*

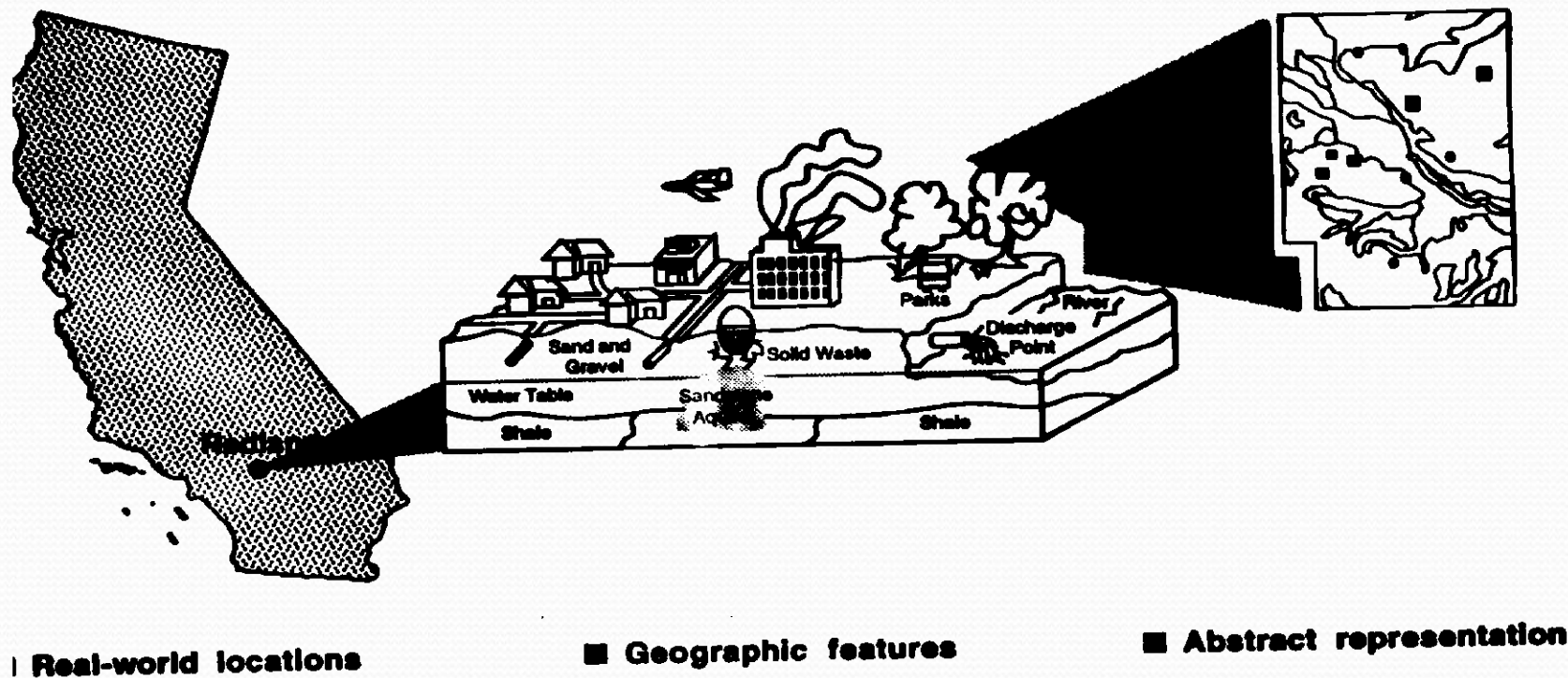
*SQL Query Manager*

MapInfo



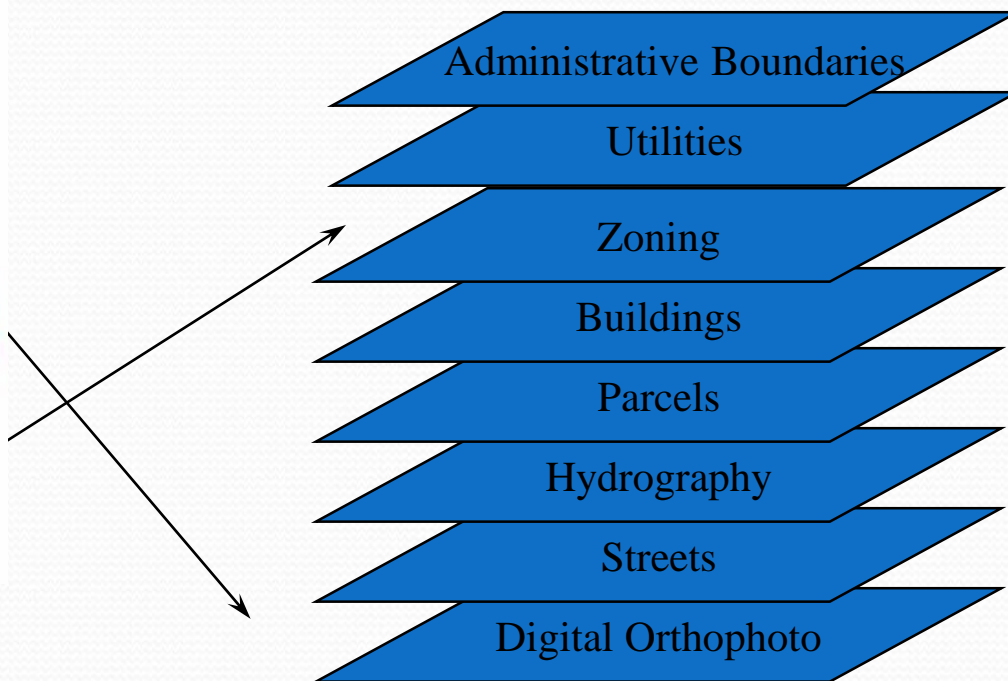
# The GIS Data Model: Purpose

- 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 (synonymous 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.*

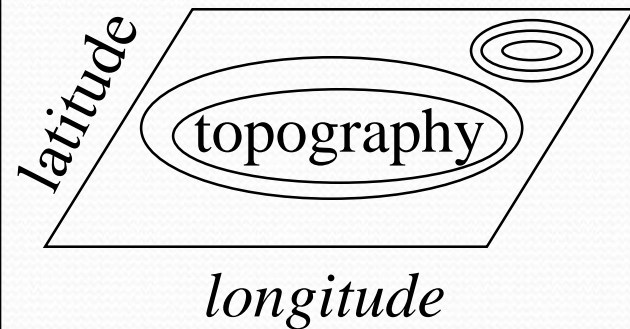
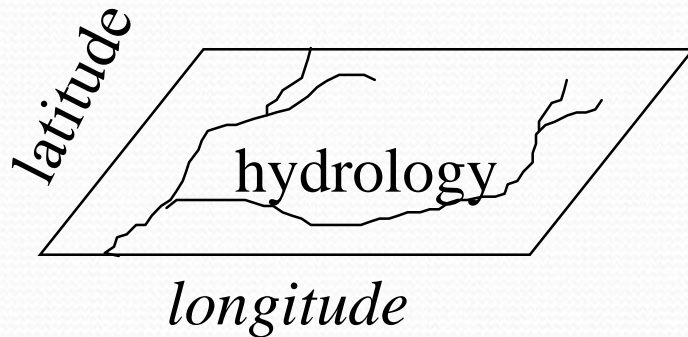
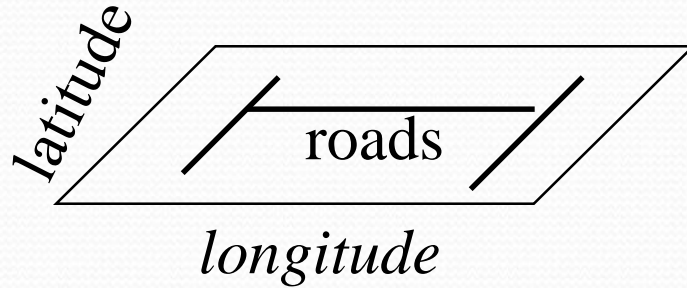


# The GIS Model: example

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* specifying 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

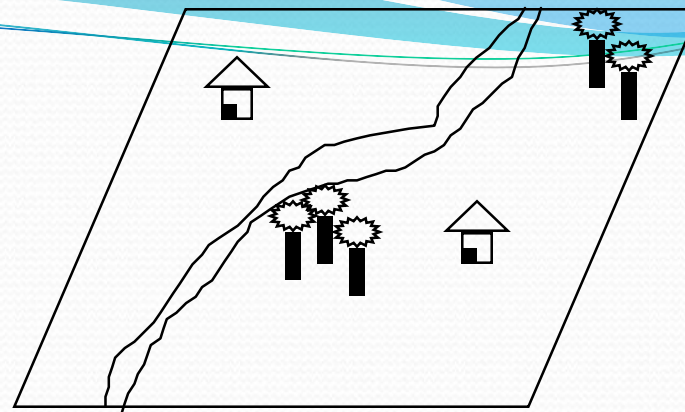
- Spatial data (*where*)
  - specifies location
  - stored in a *shape file*, *geodatabase* or similar geographic file
- Attribute (descriptive) data (*what, how much, when*)
  - specifies characteristics at that location, natural or human-created
  - stored in a data base table

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

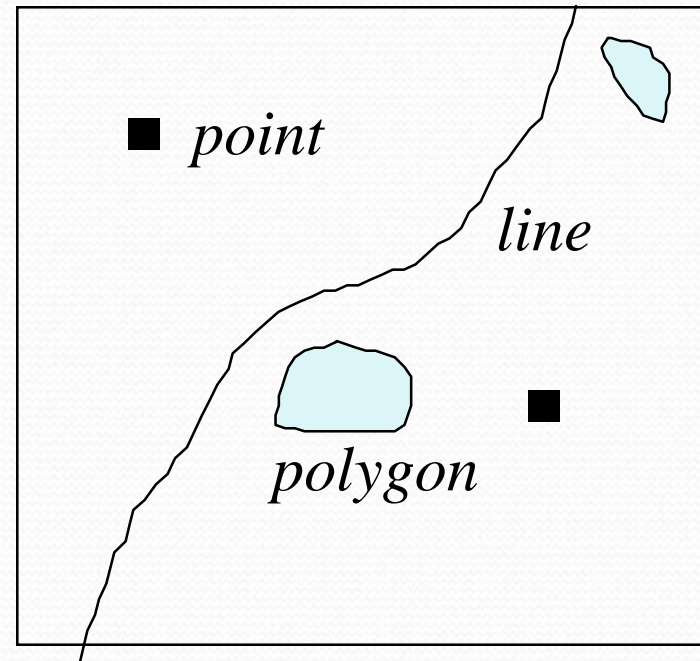


Real World

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



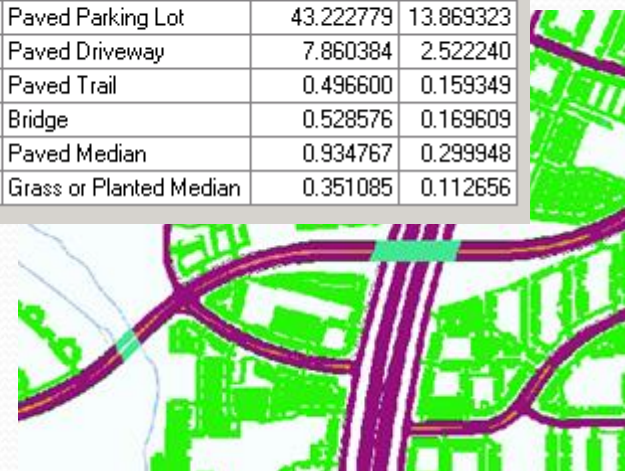
## Smart Vector—Pavement polygons

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



Images—dumb rasters  
(although they look good!)



# 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



0 1500 3000 Feet

*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

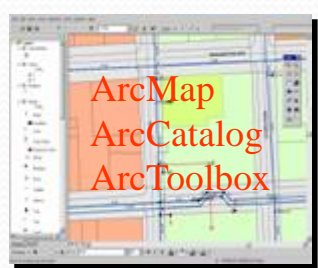
## Clients

Consistent interface  
Increasing capability

**ArcInfo**



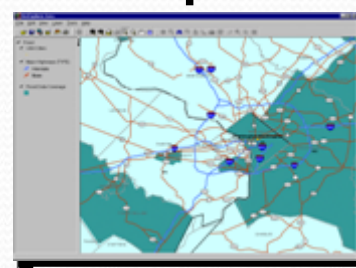
**ArcEditor**



**ArcView**



**ArcExplorer**



**Browser**

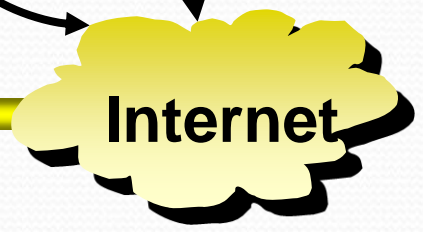


**ArcEngine/  
ArcObjects**  
*Application  
Development &  
Customization*

**ArcSDE Services**  
Database storage/access

**ArcServer Services**  
Full GIS analysis

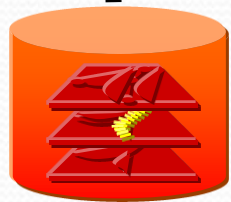
**ArcIMS Services**  
Map display & query



*Handheld/Wireless*



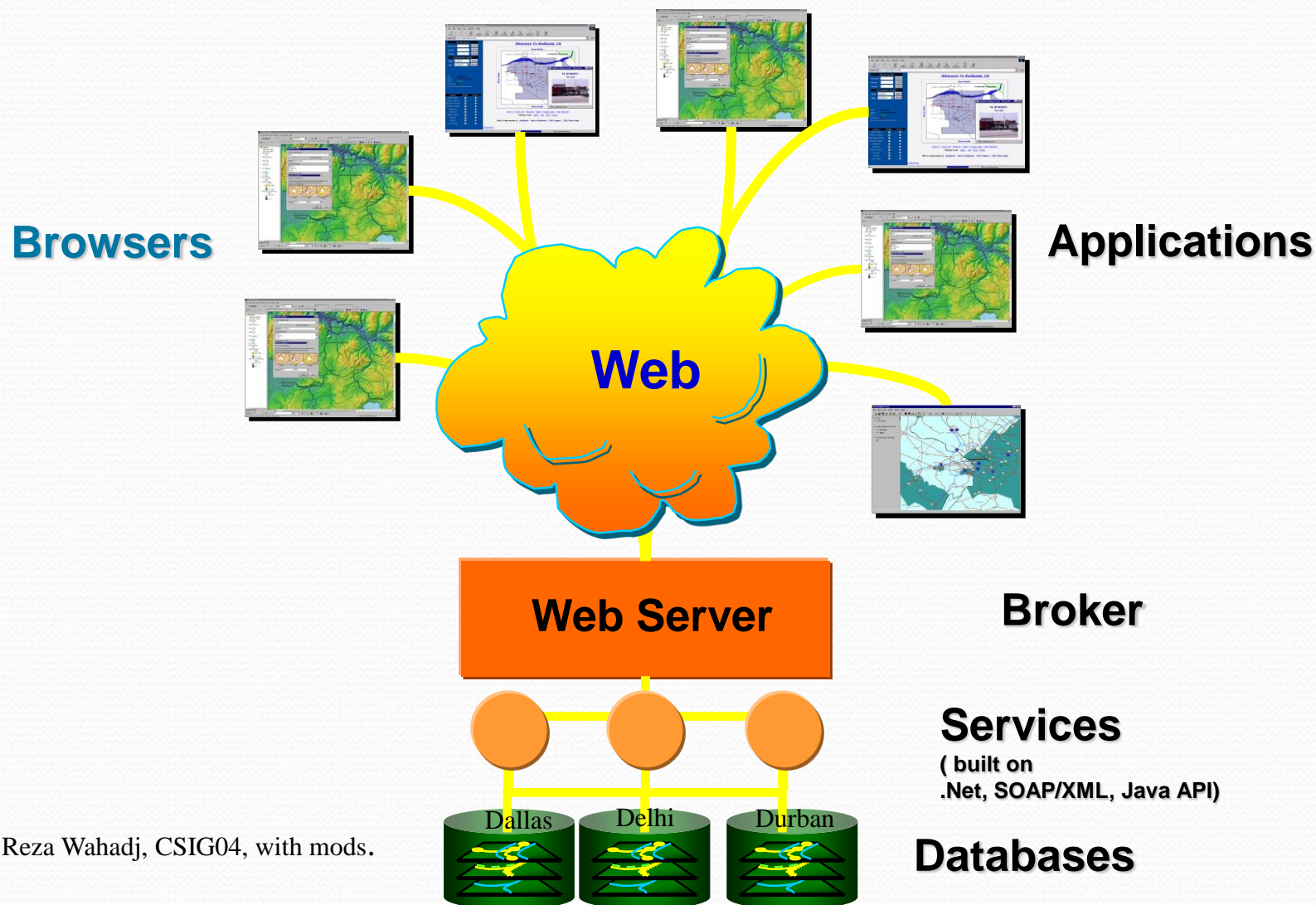
**Files**  
(Personal Geodatabase,  
Shapefiles, Coverages,  
Grids, tins, etc)



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



# Future Generic GIS Internet Enterprise



Source: Reza Wahadj, CSIG04, with mods.

Courtesy  
USGS, ESRI,  
and  
National Remote Sensing Agency



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