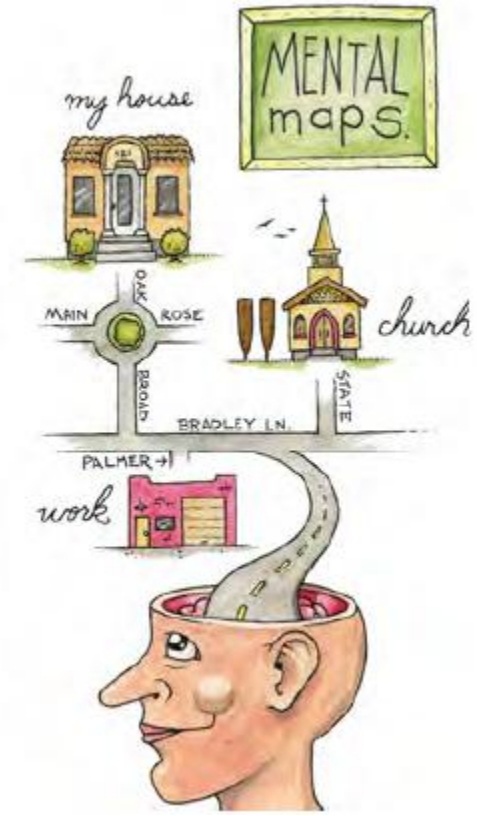
GIS introduction

Mental maps

- maps of our environment stored in our brain
- to get from one place to another,
- to plan daily activities,
- to situate events



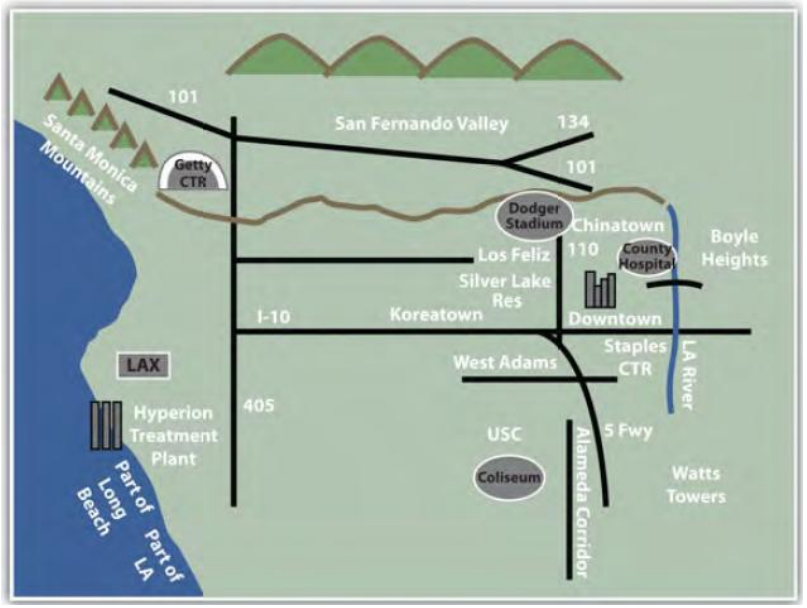
- reflects the amount and extent of geographic knowledge and spatial awareness

Mental maps

- rough approximation of your local geographic knowledge,
- illustrates your relation to your local environment,
- certain similarities how to think spatially and organize geographical information in our minds,
- discovers artistic, creative, and cartographic abilities

Mental maps

- maps are oriented so that north is up,
- depict a motorway network,
- identify some prominent features and landmarks,
- landmarks represented as text, abbreviation or symbol



Basic questions

Questions about geographic location:

- Where is it?
- Why is it here or there?
- How much of it is here or there?

Questions about geographic distribution:

- Is it distributed locally or globally?
- Is it spatially clustered or dispersed?
- Where are the boundaries?

Basic questions

Questions about geographic association:

- What else is near it?
- What else occurs with it?
- What is absent in its presence?

Questions about geographic interaction:

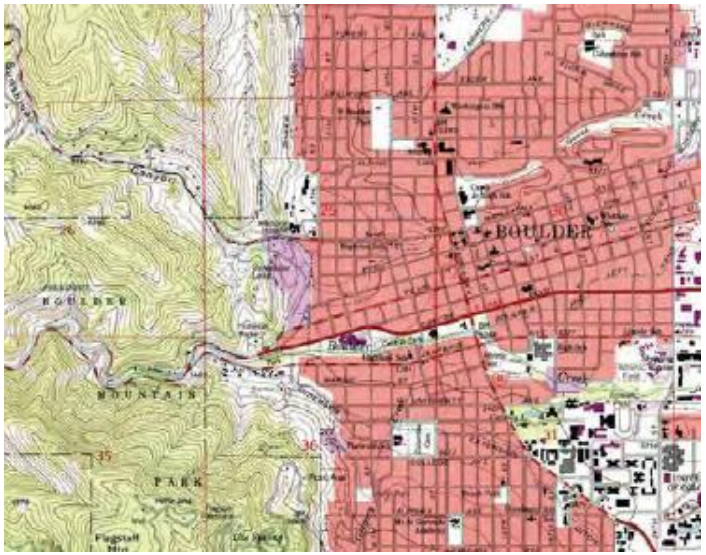
- Is it linked to something else?
- What is the nature of this association?
- How much interaction occurs between the locations?

Questions about geographic change:

- Has it always been here?
- How has it changed over time and space?

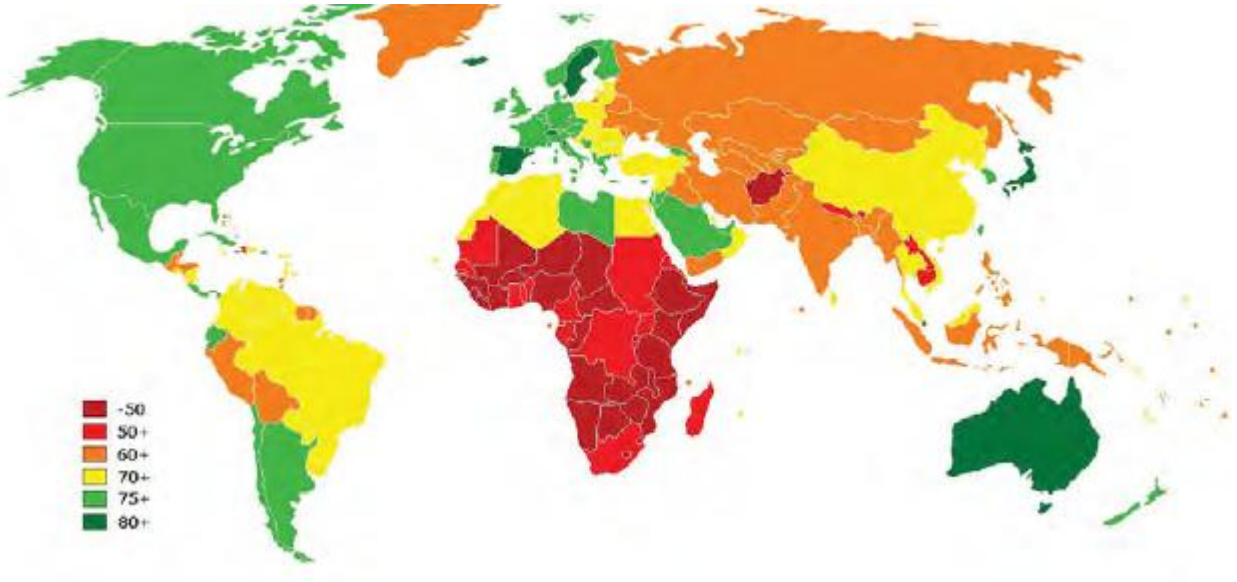
Maps

- Reference map:
  - to provide location information,
  - represent geographic reality accurately,
  - topographic or image

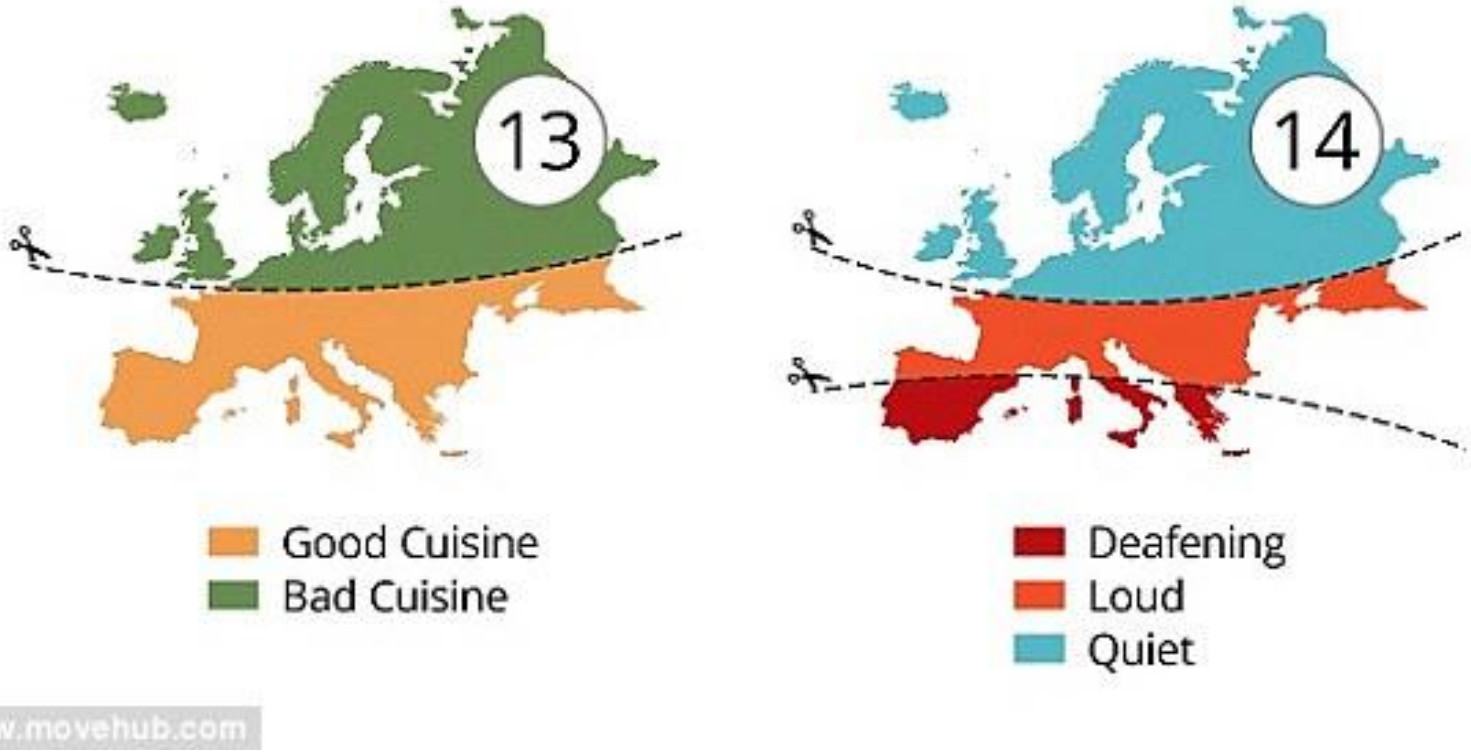


Maps

- Thematic map:
  - concerned with a particular topic of interest,
  - how things are distributed across space,
  - abstract concepts visible and comparable

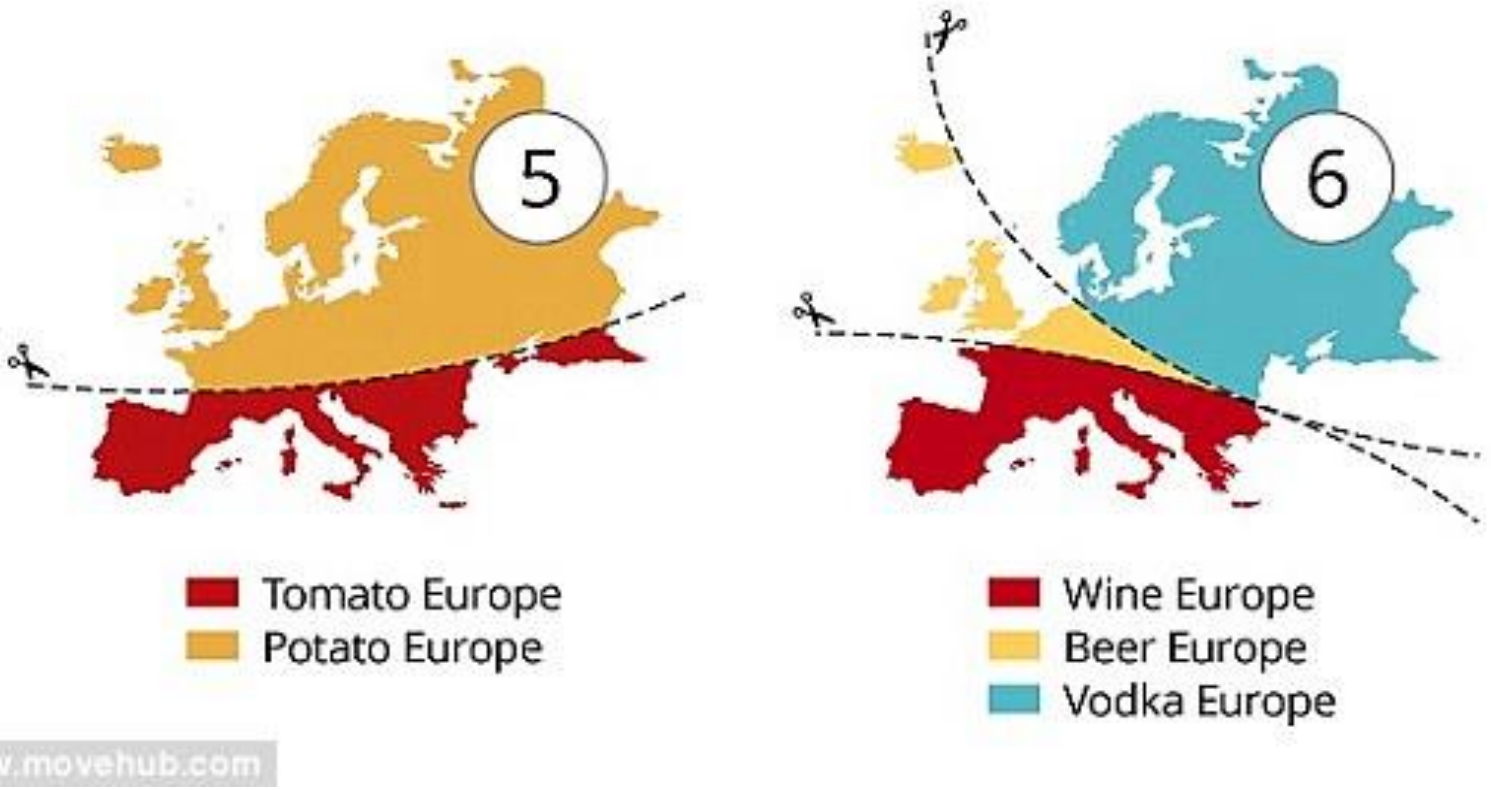


Maps


13
Good Cuisine
Bad Cuisine
14
Deafening
Loud
Quiet
© www.movehub.com

Maps

Maps


5
Tomato Europe
Potato Europe
6
Wine Europe
Beer Europe
Vodka Europe
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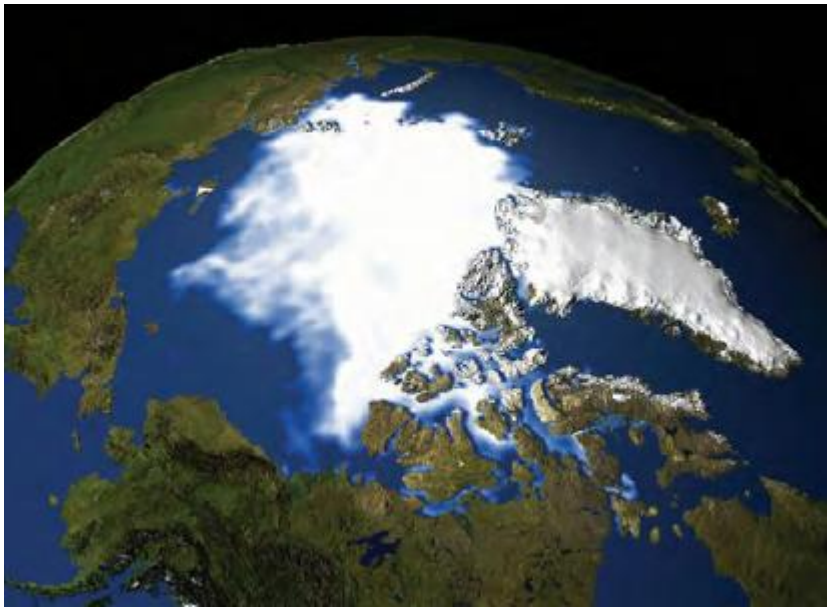
Maps

- Dynamic map:
  - interactive representations,
  - require user interaction,
  - online mapping tools and applications

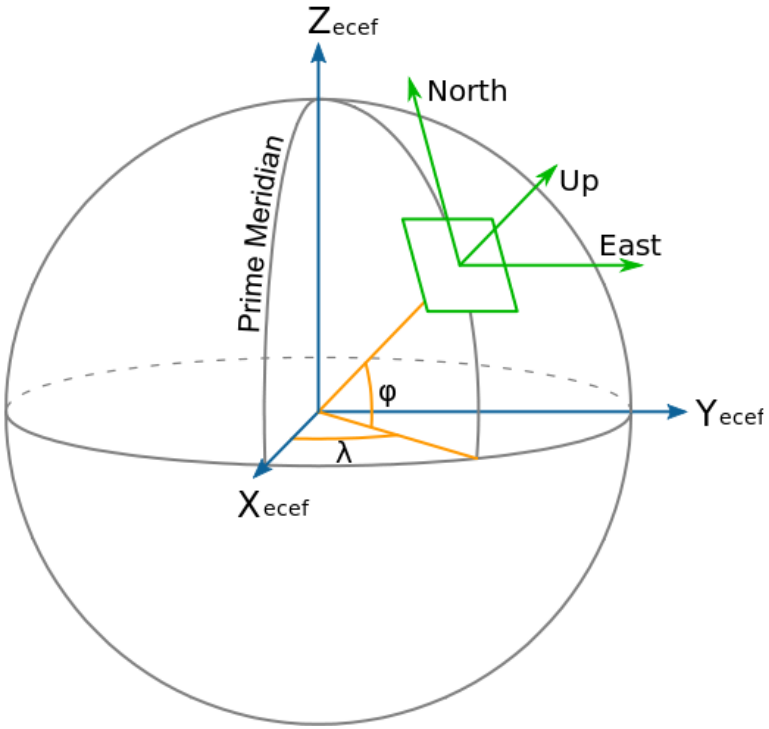


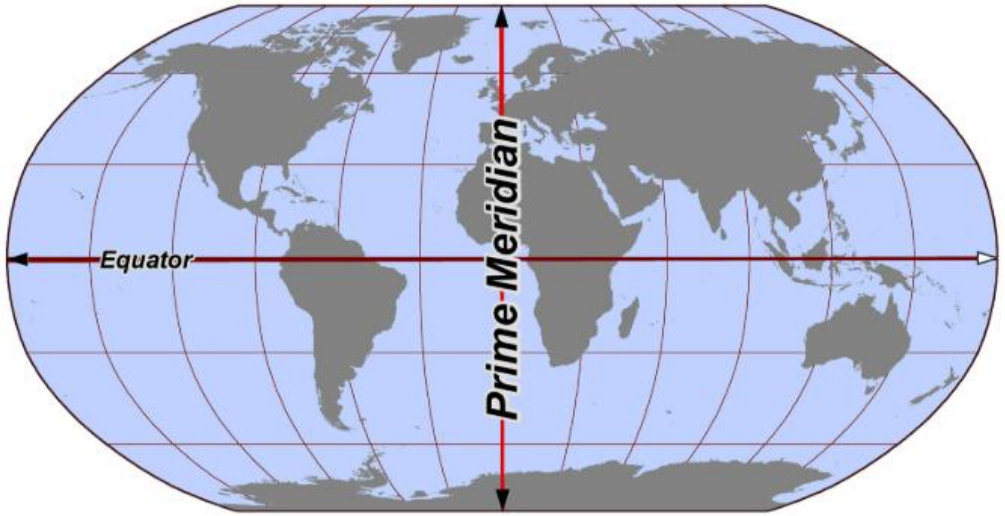
Map measures

- Scale: describes a simple ratio, e.g. 1 : 10 000
- Coordinate system: to define unique positions
- Geographic coordinate system (GCS): to define locations on the three-dimensional earth
  - unit of measure: degrees,
  - latitude: measured relative to the equator at zero degrees with max 90 degrees to the south/north pole,
  - longitude: measured relative to the prime meridian at zero degrees with max 180 degrees to the west/east

Map measures

- Geographic coordinate system (GCS):





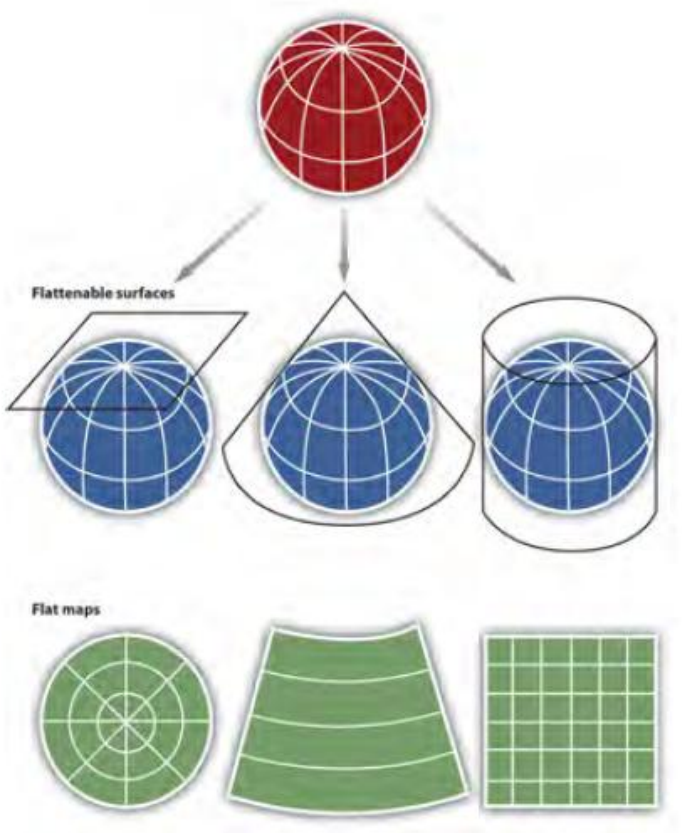
Map measures

- Geographic coordinate system (GCS):

Nominal location	Absolute location (DMS)	Absolute location (DD)
Los Angeles, US	34° 3′ North, 118° 15′ West	+34.05, –118.25
Mumbai, India	18° 58′ North, 72° 49′ East	+18.975, +72.8258
Sydney, Australia	33° 51′ South, 151° 12′ East	–33.859, 151.211
Sao Paolo, Brazil	23° 33′ South, 46° 38′ West	–23.550, –46.634

Map projections

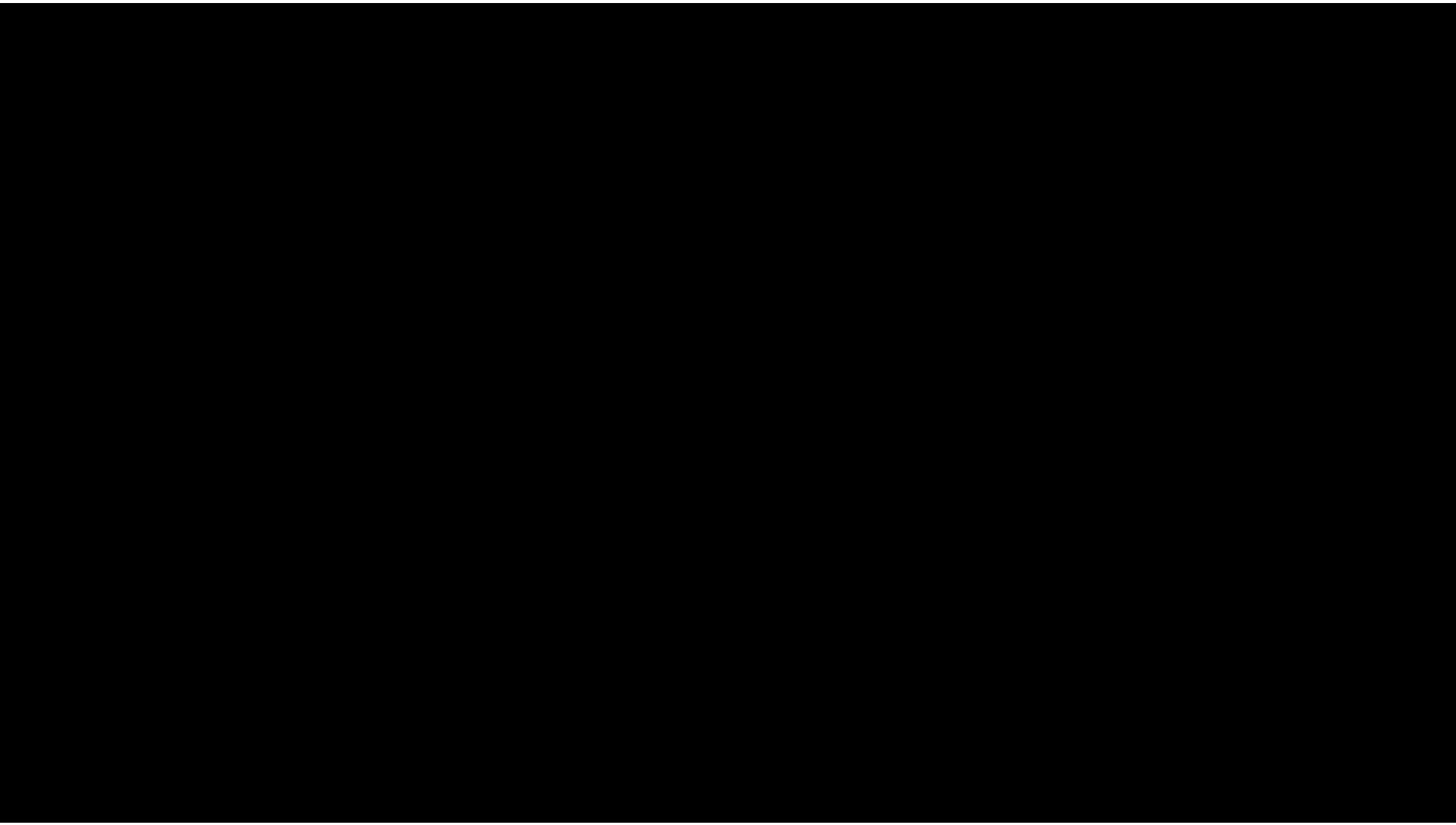
- methods to transform the spherical three-dimensional earth into two-dimensional planar surface
  - Planar
  - Cylindrical
  - Conic



Definitions

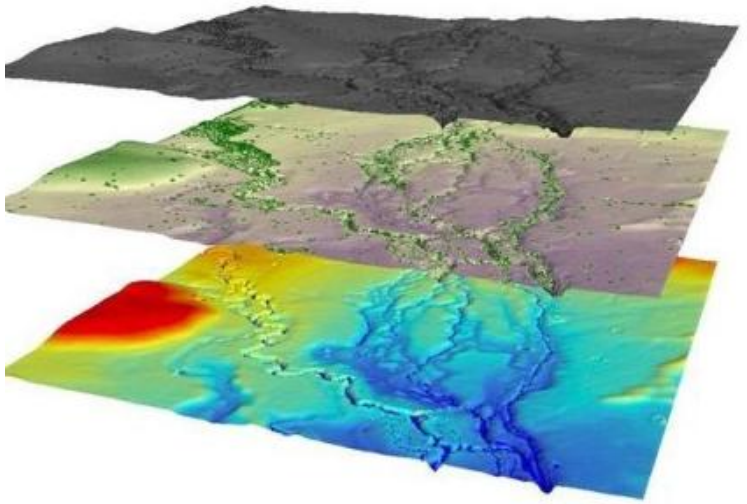
- Location: nominal or absolute (addresses traslated with geocoding)
- Direction: egocentric, landmark, true north
- Distance: nominal or absolute
- Space: nature of relationships and the connectivity of locations
- Navigation: destination oriented movement through space

Geographic Information System



Geographic Information System

- describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information
- Storage of geographic data
- Analysis of geographic data
  - Positioning
  - Measuring distance and area
  - Explore relationships between objects
- Visualization of geographic information

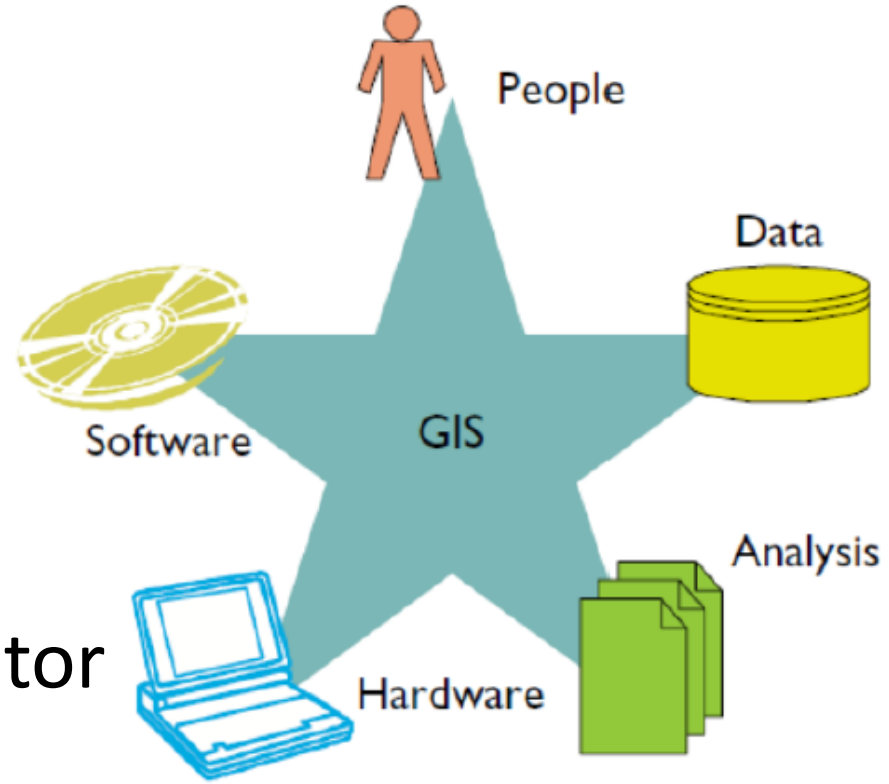


History

- 1950s: thematic map overlay
- 1960s: early computer mapping and spatial data banks
- 1970s: advances in algorithms and data structure
- 1980s: advances in hardware and GIS software
- 1990s: desktop GIS
- 2000s: internet based and networked GIS
- 2010s: every day applications

Components

- Map user
- Map builder
- Map publisher
- Analyist
- Data builder
- Database desinger
- Database administrator
- Developer



Data sources

Primary data

- Pro:
  - acquired directly from the source
  - results in creation of new data sets
  - relevant and appropriate
  - data collection procedures can be designed
- Con:
  - time consuming and costly
  - require post-processing and error checking
- Methods:
  - Surveying: taking direct measurements
  - GPS mapping: collecting coordinates

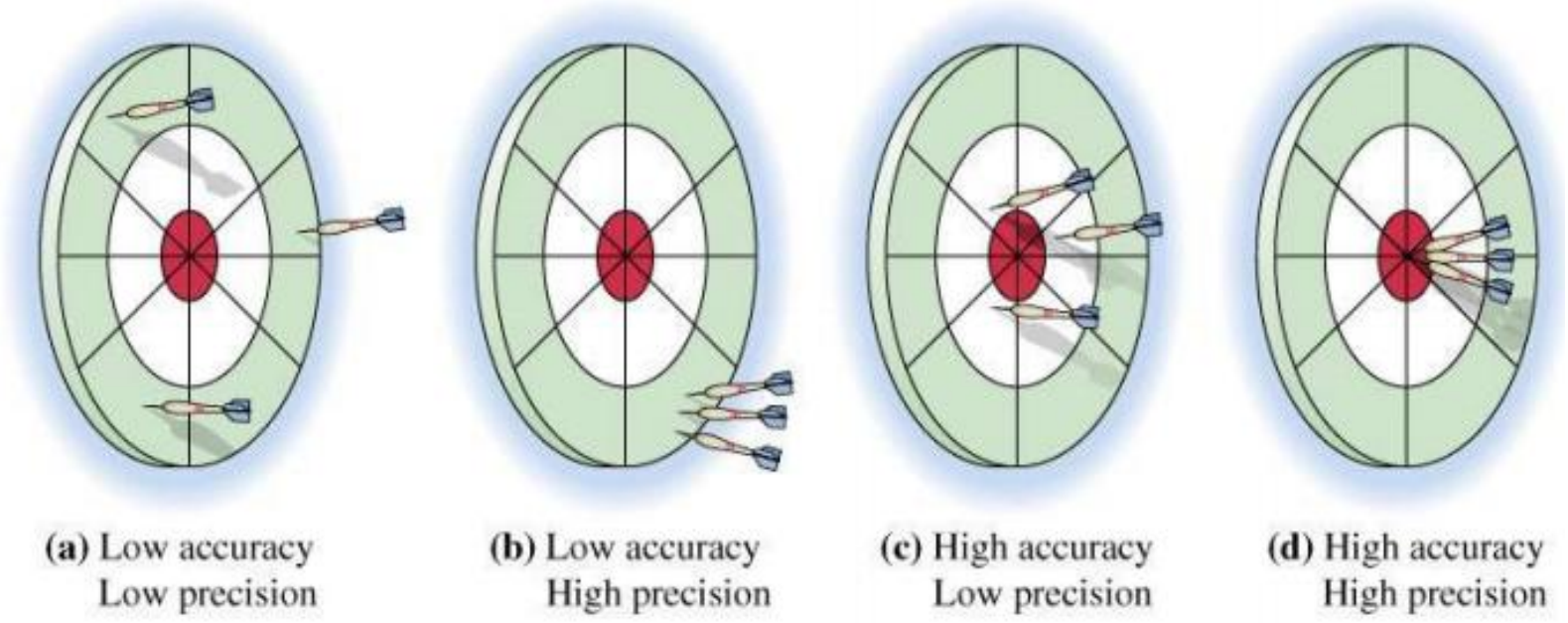
Data sources

Secondary data

- Pro:
  - already collected data from a variety of sources
  - using existing dataset with a predefined data collection design
  - time and cost efficient
- Con:
  - Possibly less accurate and data quality
  - Possibly not appropriate with missing attributes
  - Different scale of collection
  - Different formats
- Methods:
  - GIS data: processed data in the GIS system
  - Remotely sensed data: satellites or aerial cameras
  - Tabular data: huge datasets, e.g. census data

Data quality

- Precision: how much the measured values of the same observation differ from each other
- Accuracy: how well the measured value corresponds to the real world value



Data quality

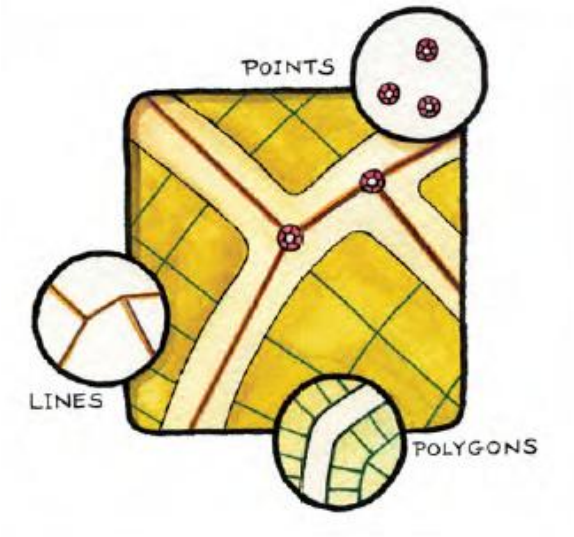
- Validity: completeness and appropriateness of the attributes for each of the attribute fields
- Data types:
  - Text
  - Integer
  - Float
  - Date

Representation of data

- Location: contains information to create features
- Features: discrete objects on a map
- Network: set of connected features
- Surface: triangulated irregular network
- Image: provides an informative background

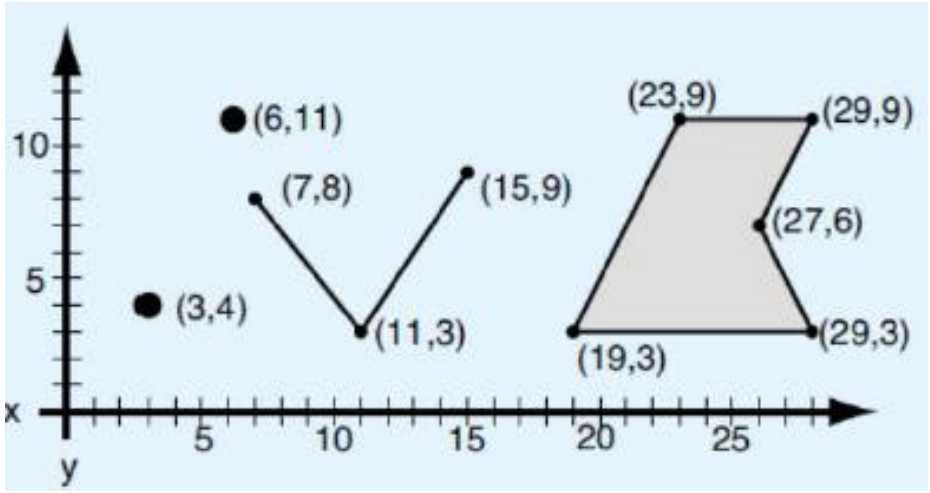
Representation models

- Vector:
  - focused on modeling discrete features with precise shapes and boundaries,
  - represents features as points, lines, and polygons



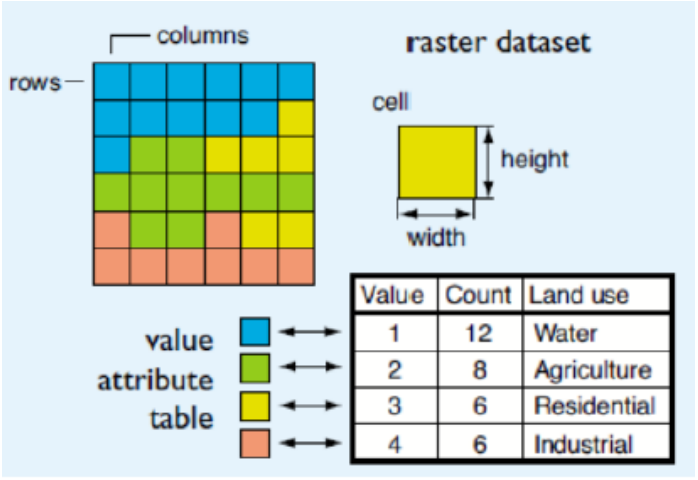
Representation models

- Vector:
  - points are recorded as a single coordinate,
  - lines are recorded as a series of x,y coordinates,
  - polygons are recorded as a series of x,y coordinates defining line segments that enclose an area



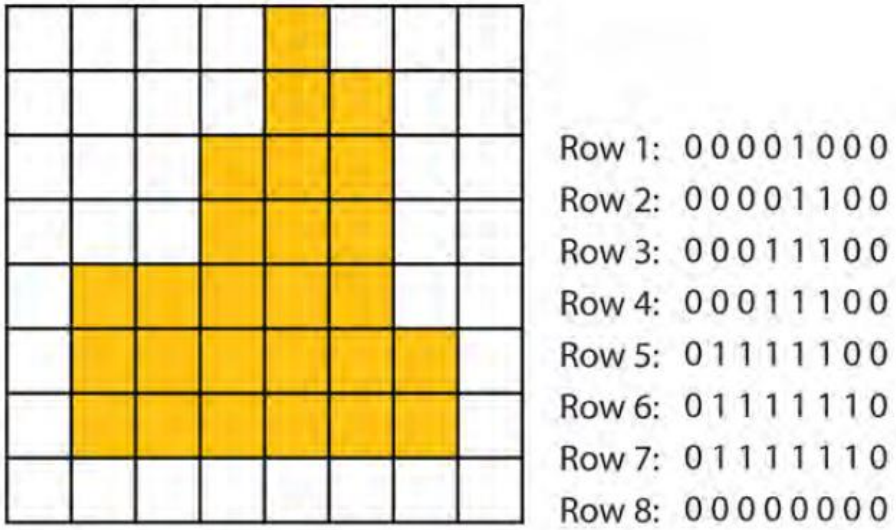
Representation models

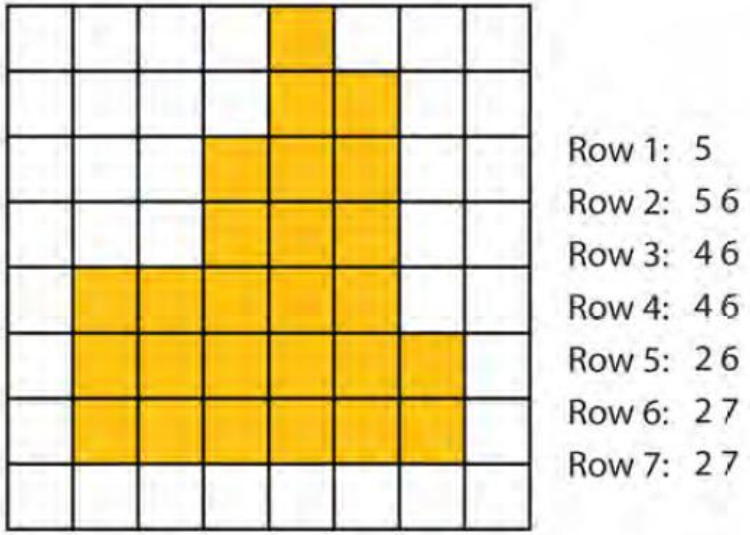
- Raster:
  - represents imaged or continuous data,
  - each cell or pixel in a raster is a measured quantity
  - best applied to feature extraction, grid surface models



Representation models

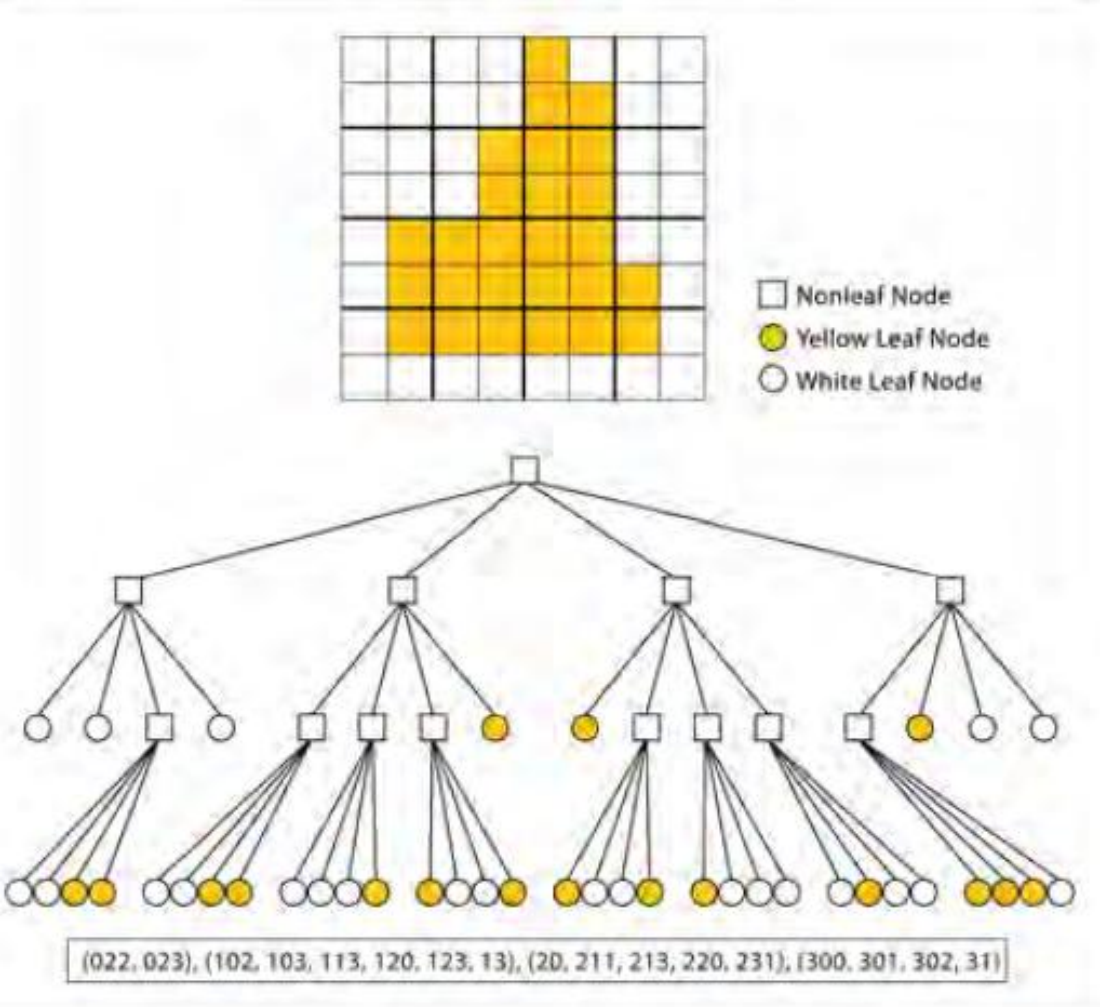
- Raster:
  - Cell-by-cell raster encoding
  - Run-length raster encoding
  - Quad-tree raster encoding





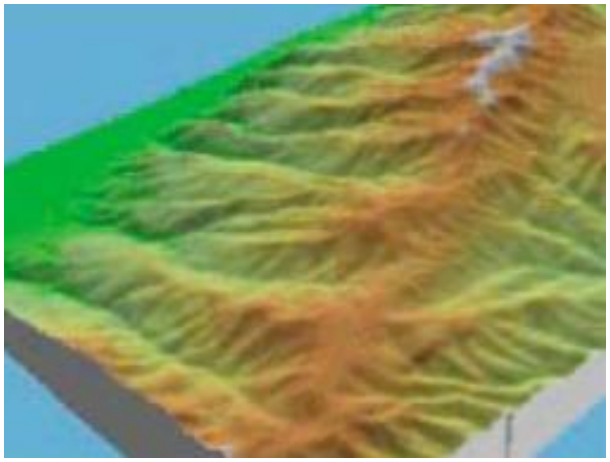
Representation models

- Raster:
  - Cell-by-cell
  - Run-length
  - Quad-tree



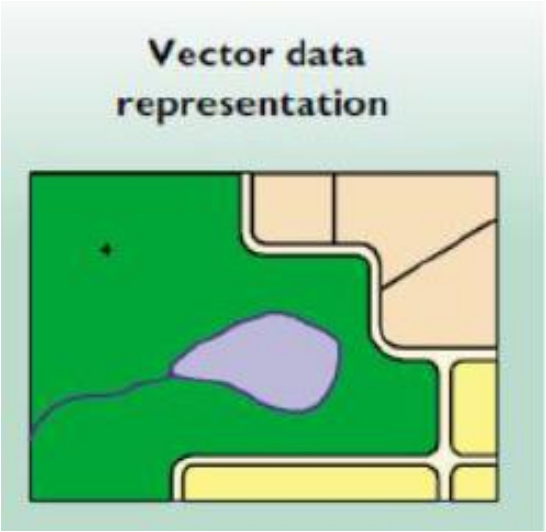
Representation models

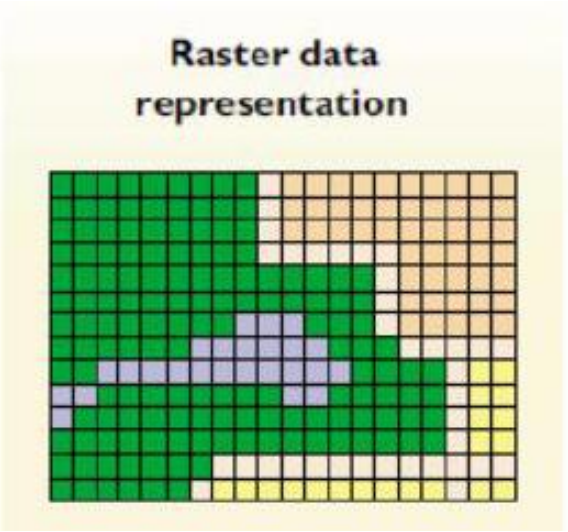
- Triangulated:
  - to capture the surface of a piece of land,
  - support perspective views,
  - particularly useful for modeling water, slope, aspect and volumetrics

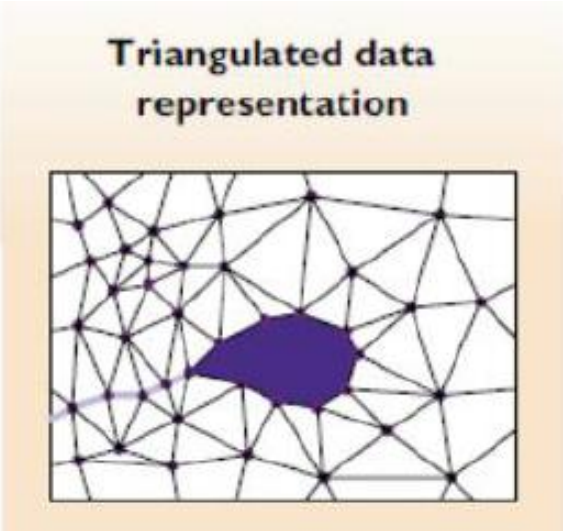


Representation models

- Comparison:

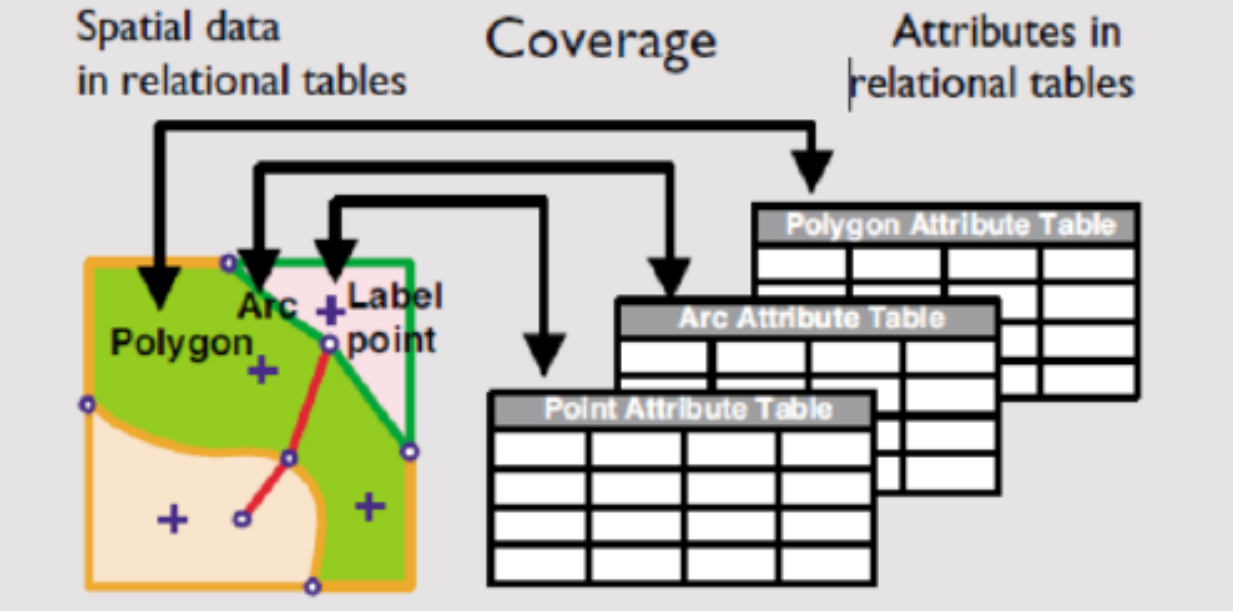






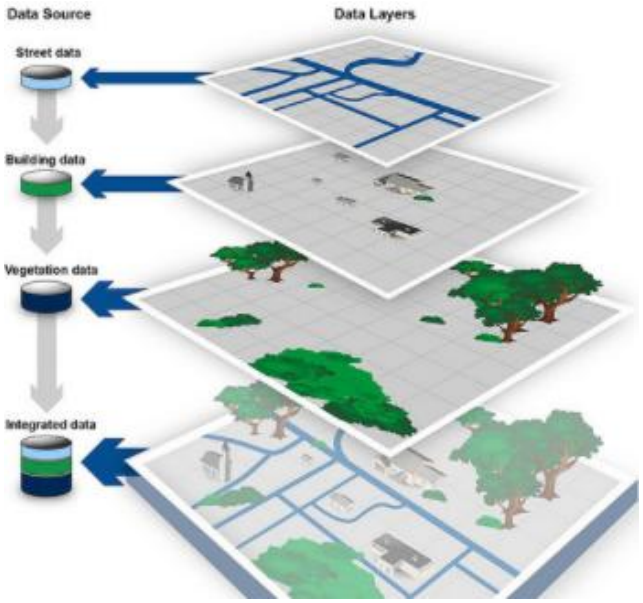
Data storage

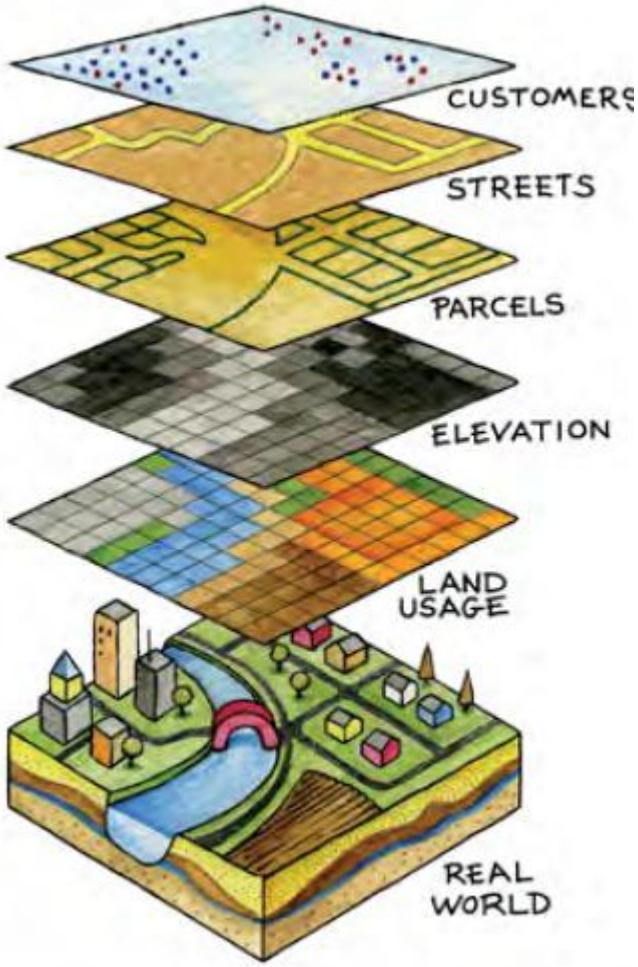
- Location:
  - spatial data: stored in indexed files
  - attribute data: stored in tables
  - database relations can be build



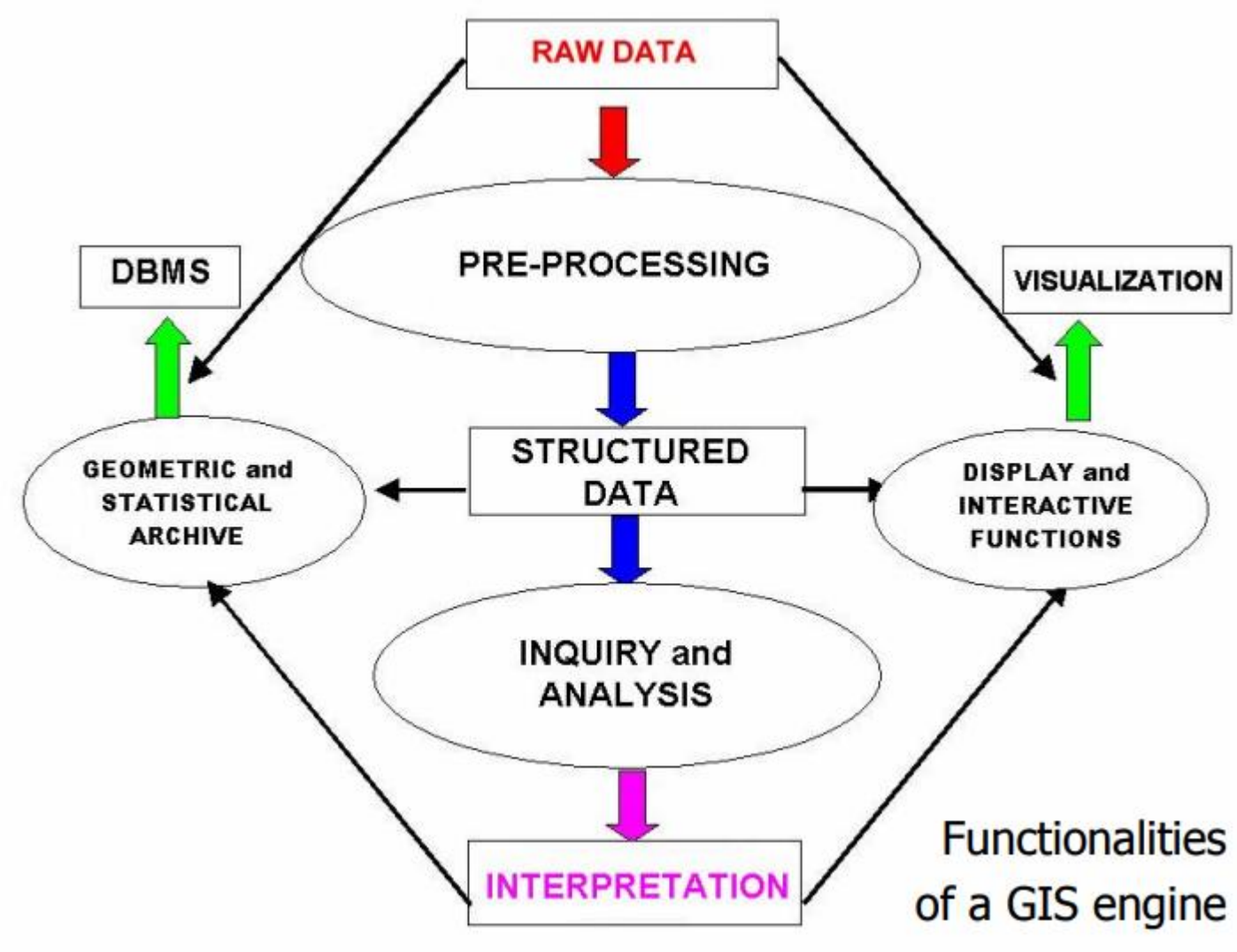
Layers

- Represent different geographic themes, combines spatial and attribute data



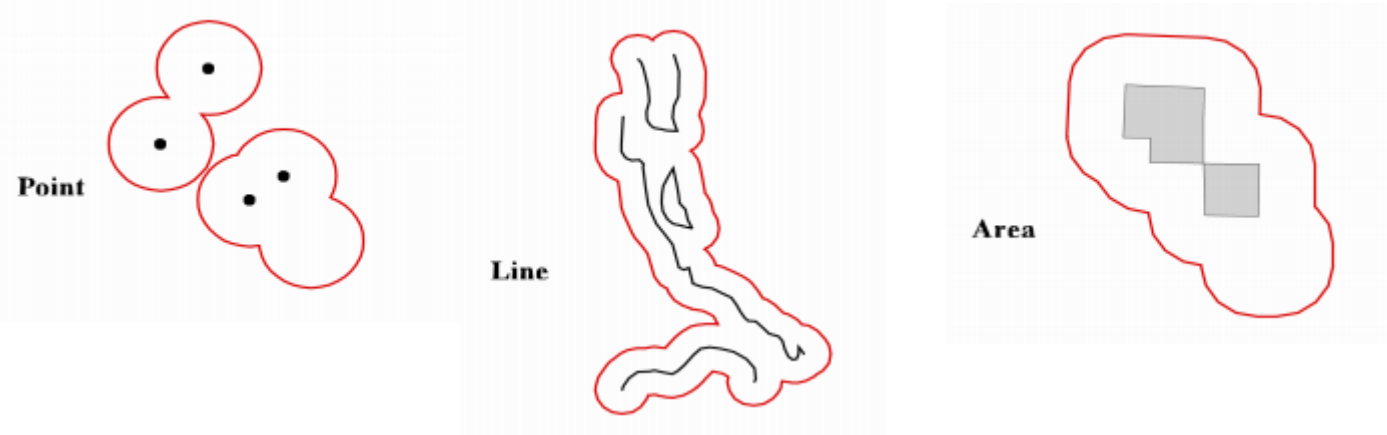


Functionalities



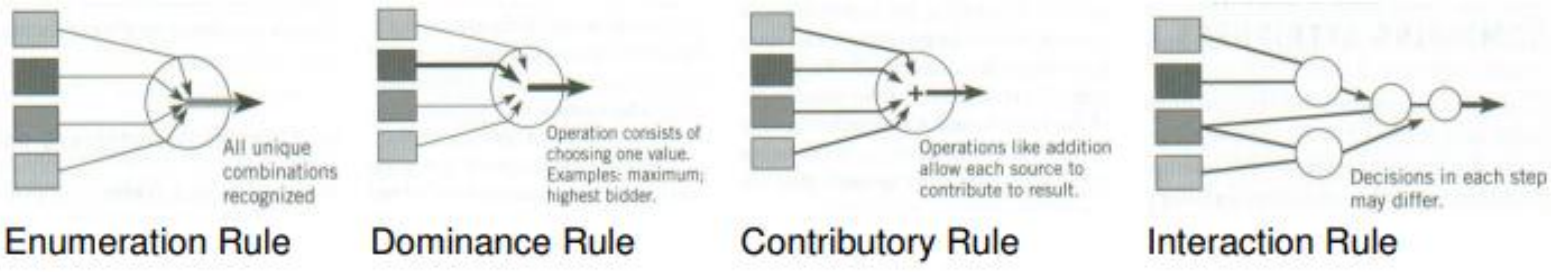
Data analysis

- Buffering: creates new polygons by expanding or shrinking existing polygons or by creating polygons from points and lines



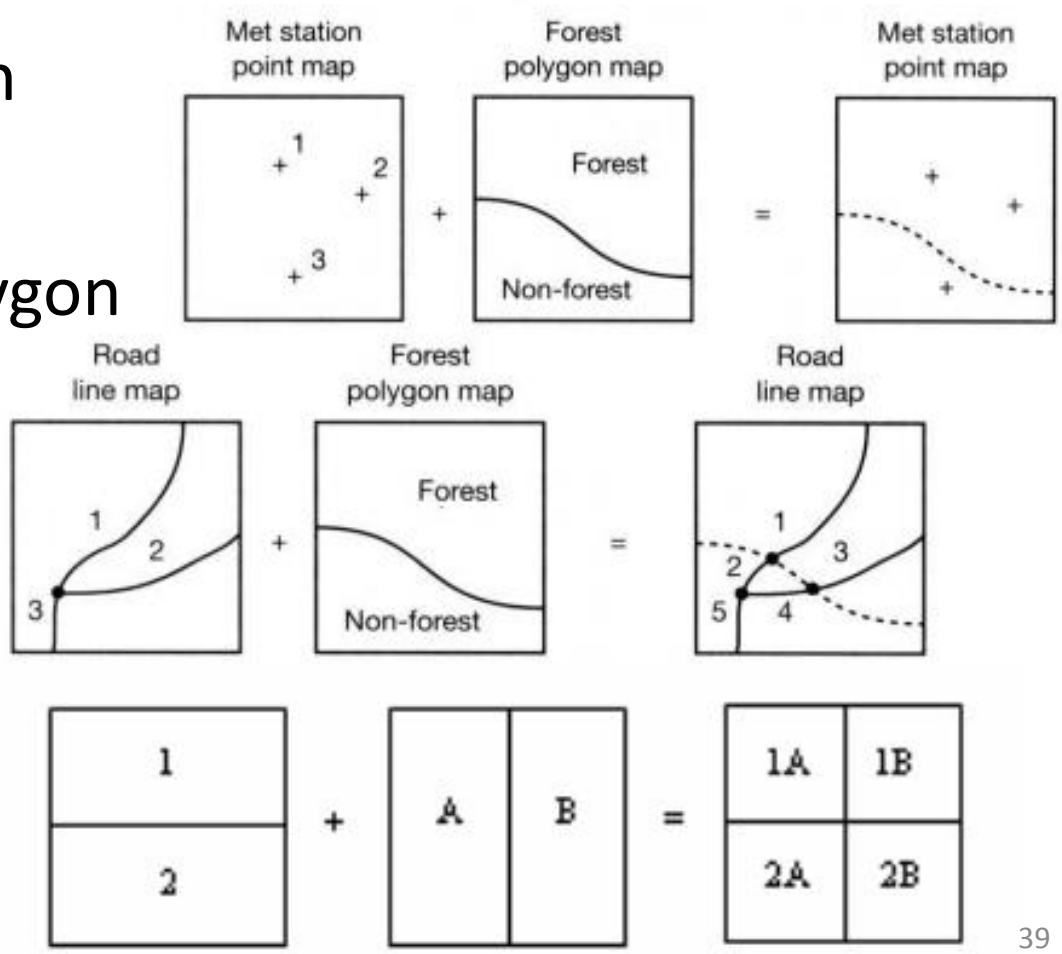
Data analysis

- Overlay: creates new shapes implementing arithmetic and logical mathematical operations
  - Enumeration Rule: each attribute preserved in output and all unique combinations recognized
  - Dominance Rule: one value wins, means that the only one value should be chosen
  - Contributory Rule: each attribute value contributes to result (example: operation of addition)
  - Interaction Rule: pair of values contribute to result, i.e. decision in each step may differ



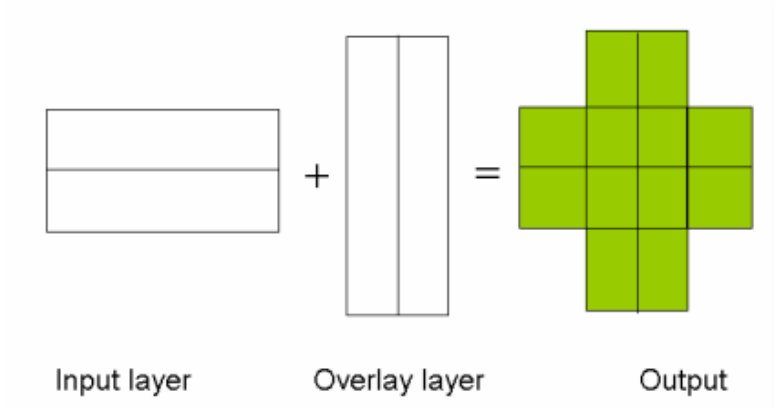
Data analysis

- Overlay:
  - Point-in-polygon
  - Line-in-polygon
  - Polygon-on-polygon

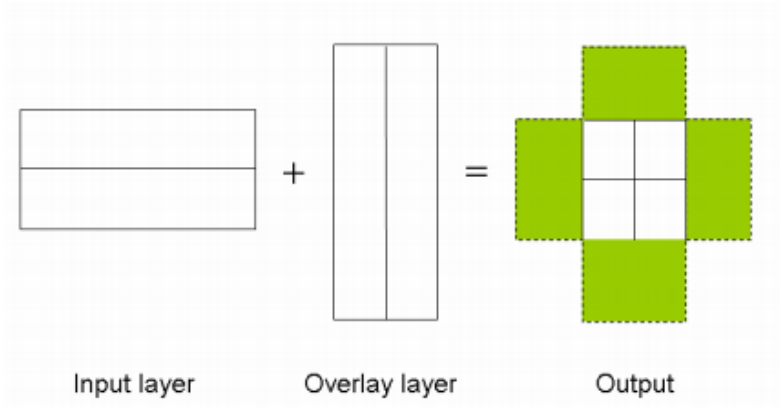


Data analysis

- Map manipulation:
  - Union: preserves and combines all features from both input and overlay layers
  - Erase: discards areas of the input layer that fall inside the overlay layer



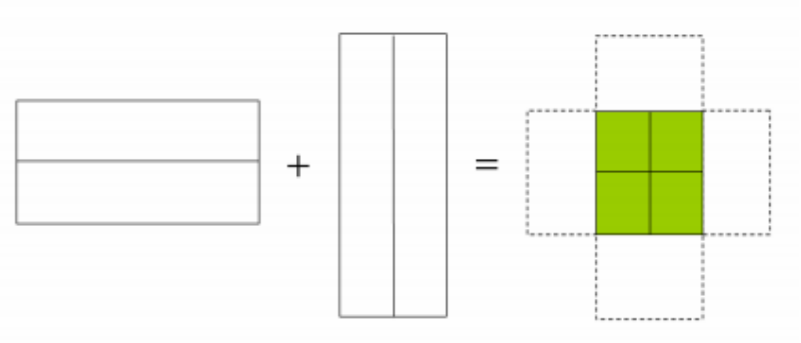
Union



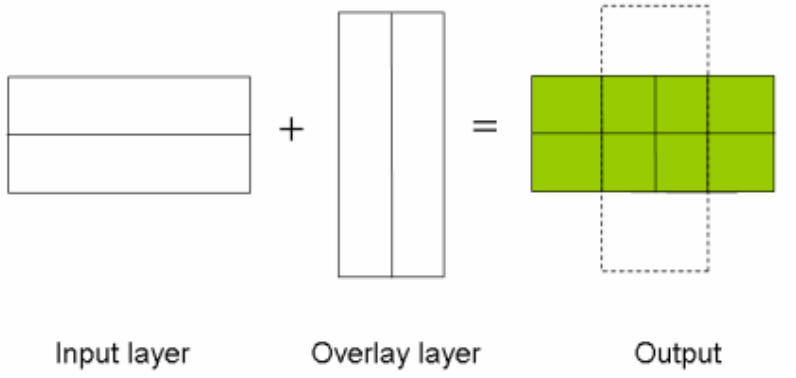
Erase

Data analysis

- Map manipulation:
  - Intersect: combines features that fall within the same area from both input and overlay layer
  - Identity: produces an output that has the same extent as input layer and preserves only features that fall within the input layer



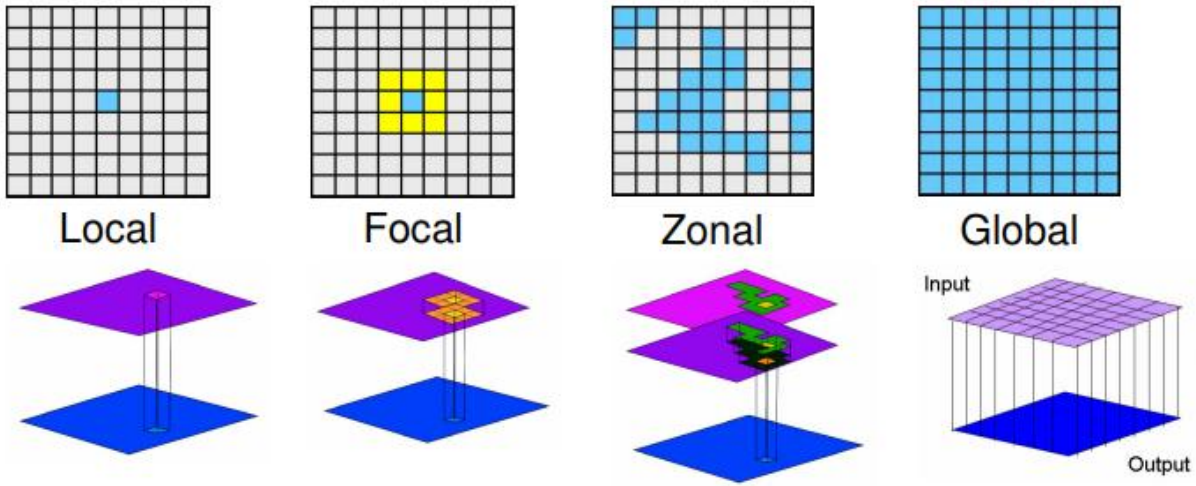
Intersect



Identity

Data analysis

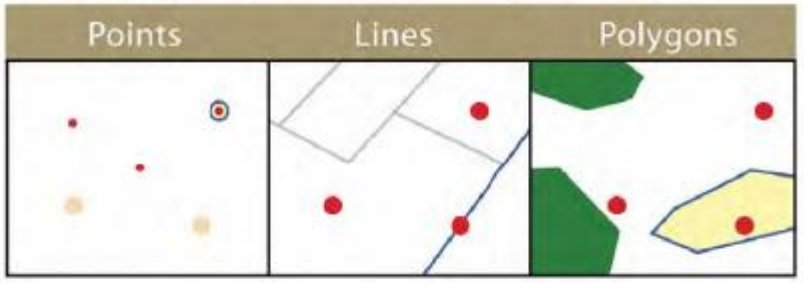
- Raster analysis: mathematical structure consisting of operands and operations
  - Local: only those pixels that overlap a particular pixel
  - Focal: all pixels in a predetermined neighbourhood
  - Zonal: calculation with set of cells with common value
  - Global : all cells used to calculate the value



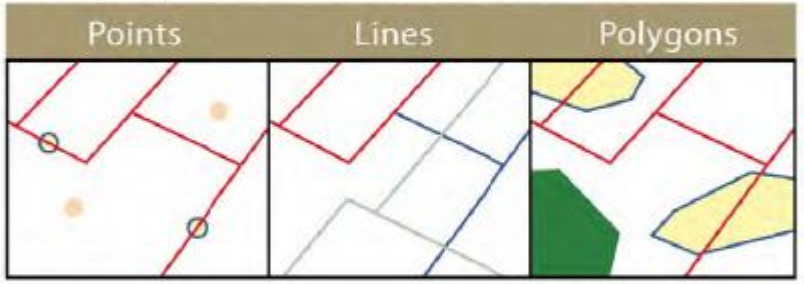
Spatial queries

- Intersect:
  selects all features
  in the target layer
  that share
  a common area
  with source layer

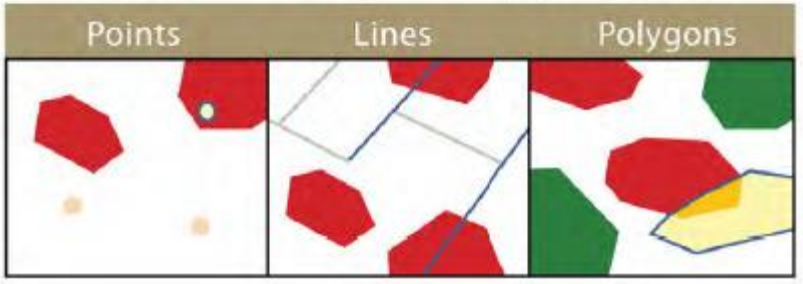
When finding features that intersect with point features



When finding features that intersect with line features



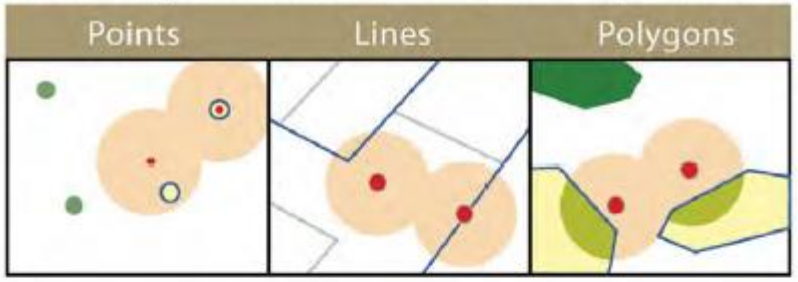
When finding features that intersect with polygon features



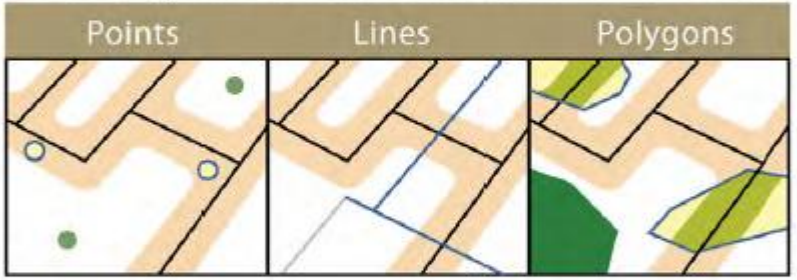
Spatial queries

- Within a distance: all features that intersect within a predefined value with source layer

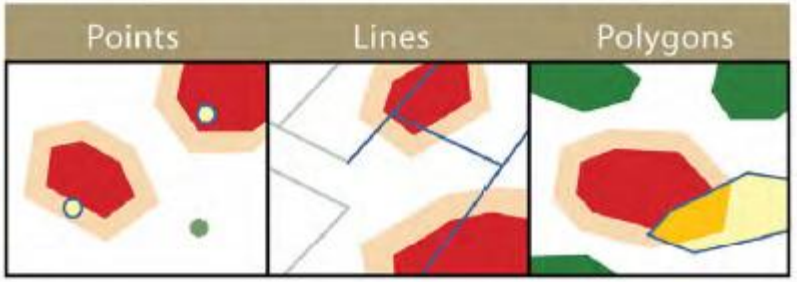
When finding features that are within a distance of point features



When finding features that are within a distance of line features

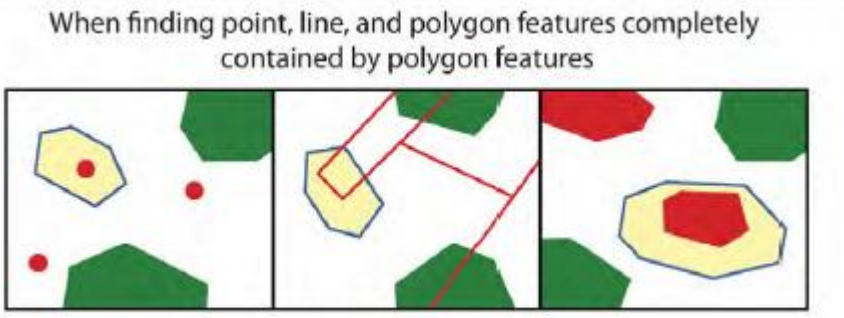


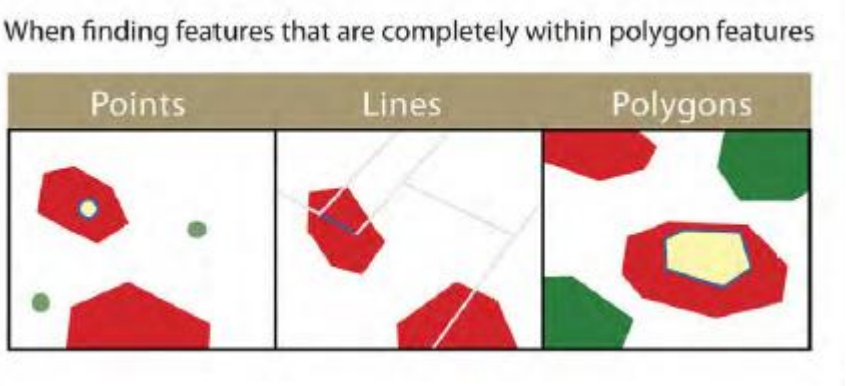
When finding features that are within a distance of polygon features



Spatial queries

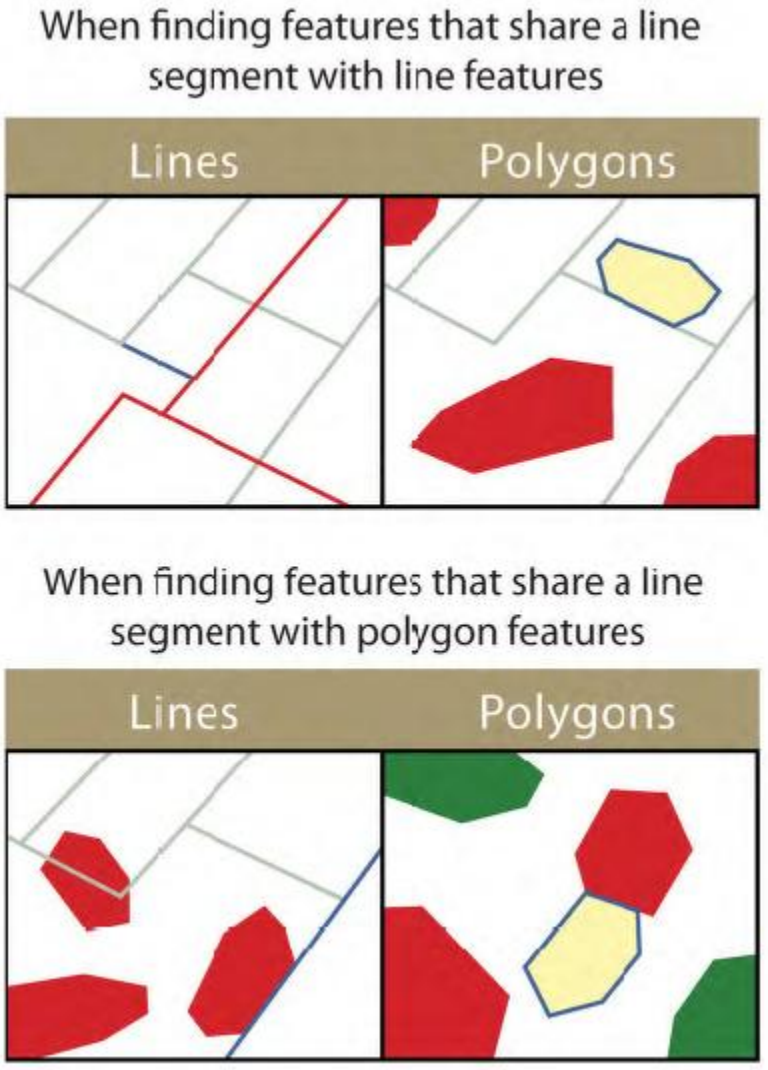
- Contain:
  returns
  those features
  that are entirely
  within source layer
- Completely within:
  selects those features
  whose entire
  spatial extent is
  within the geometry
  of the source layer





Spatial queries

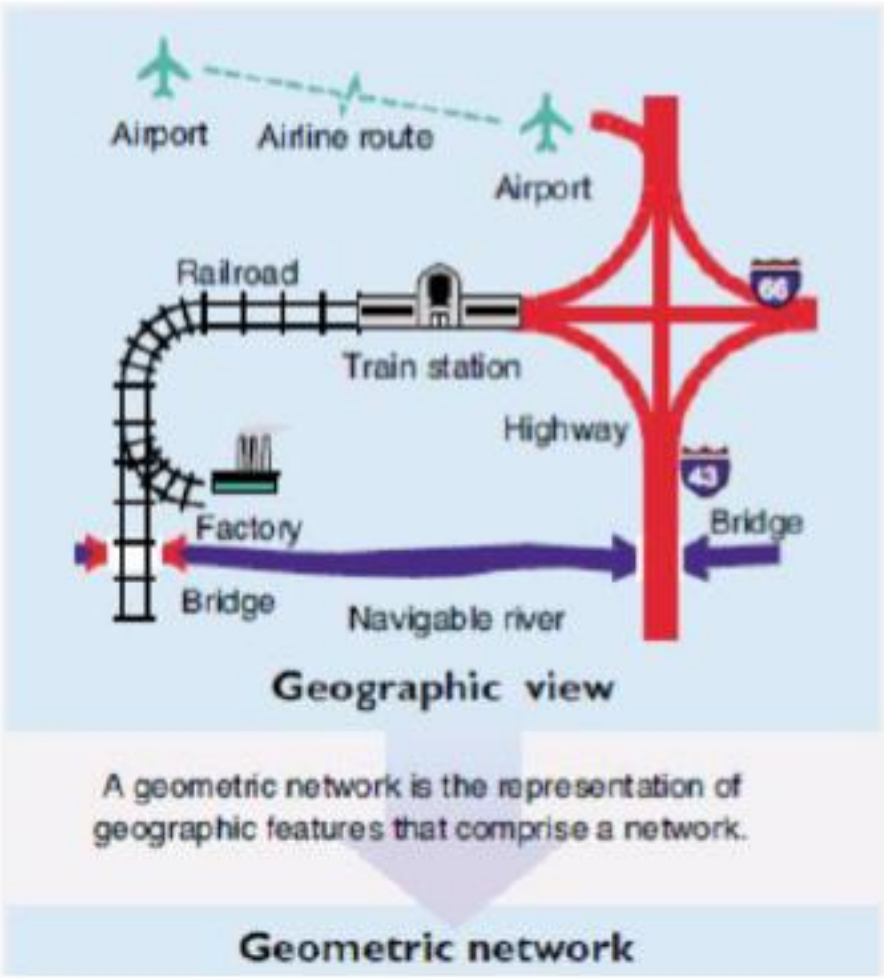
- Share
  a line segment:
  selects target features
  whose boundary
  geometries share
  a minimum of two
  adjacent vertices
  with the source layer

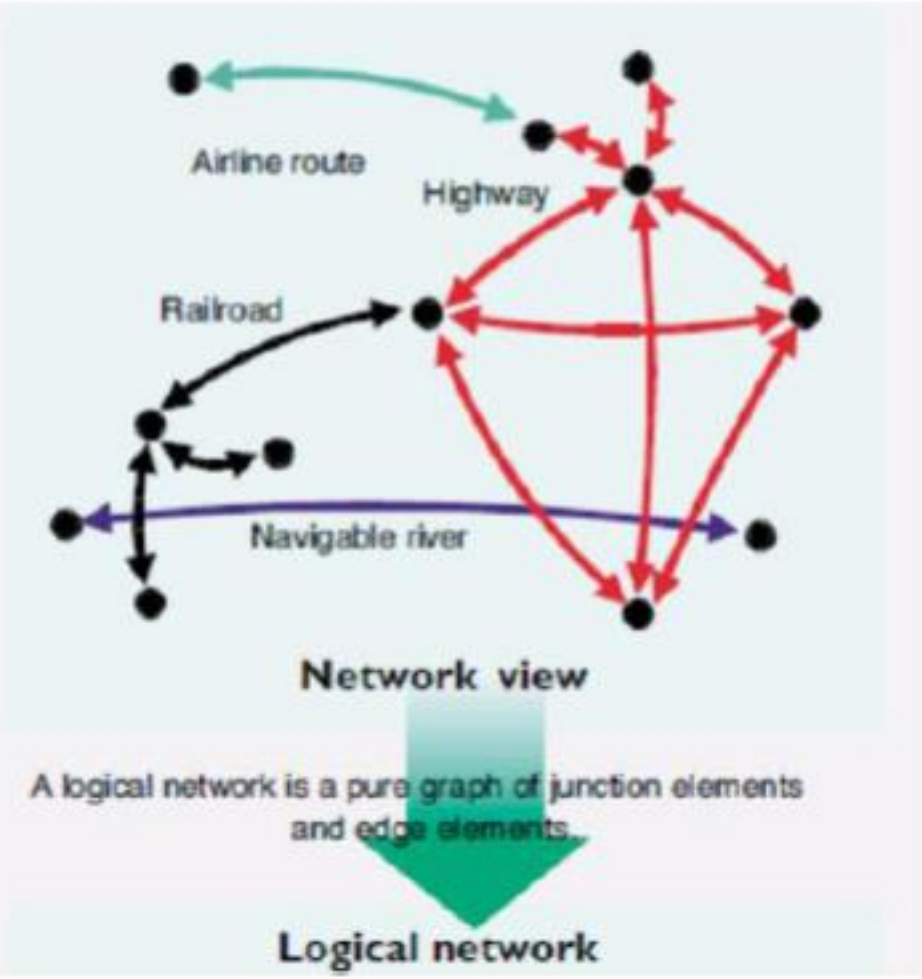


Modeling infrastructure

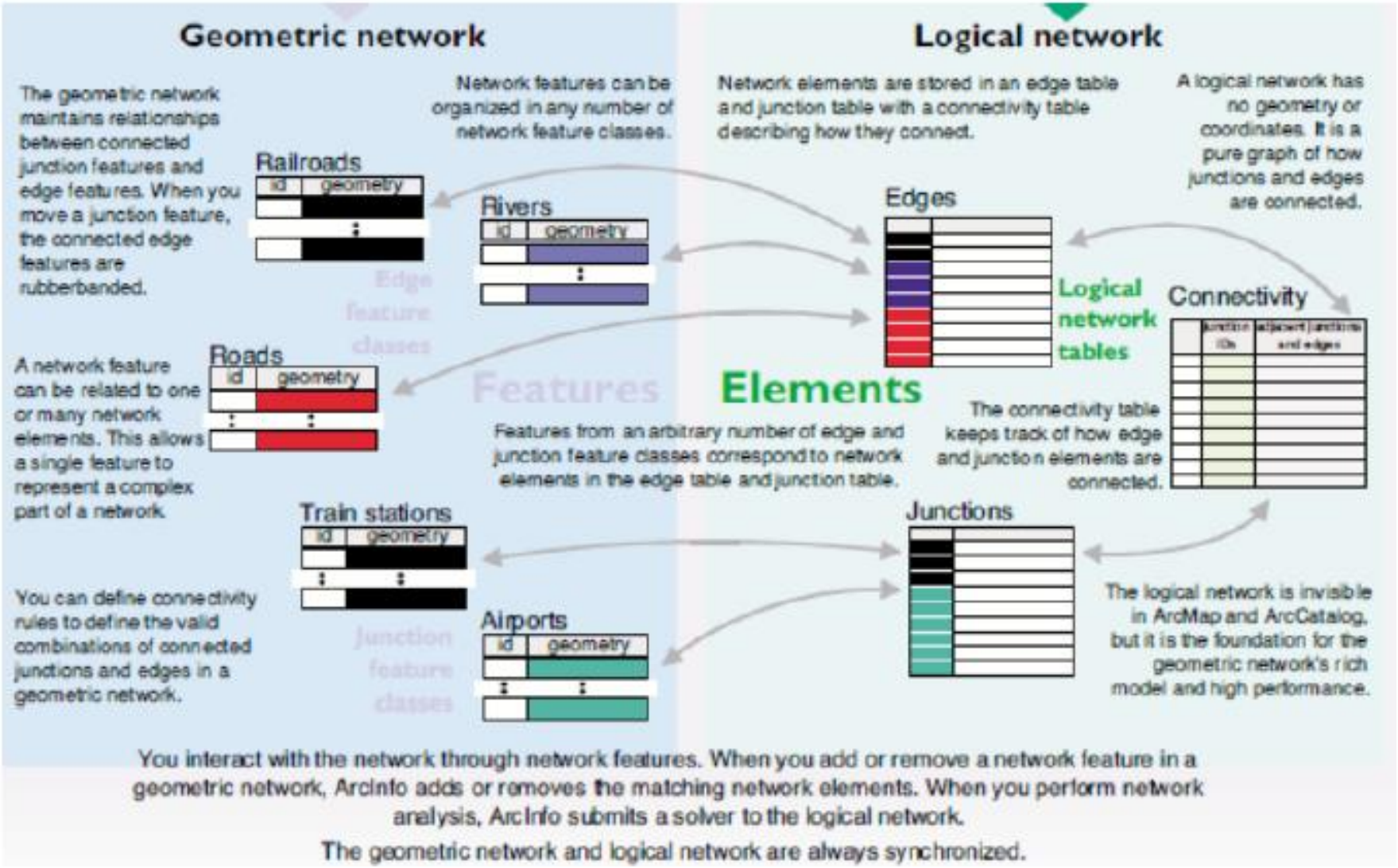
- Network models:
  - Geometric network:
    set of features that participate in a linear system, matches a view of a network as a collection of features,
  - Logical network: associated to the geometric network, which is network graph consisting of edges and junction elements

Modeling infrastructure

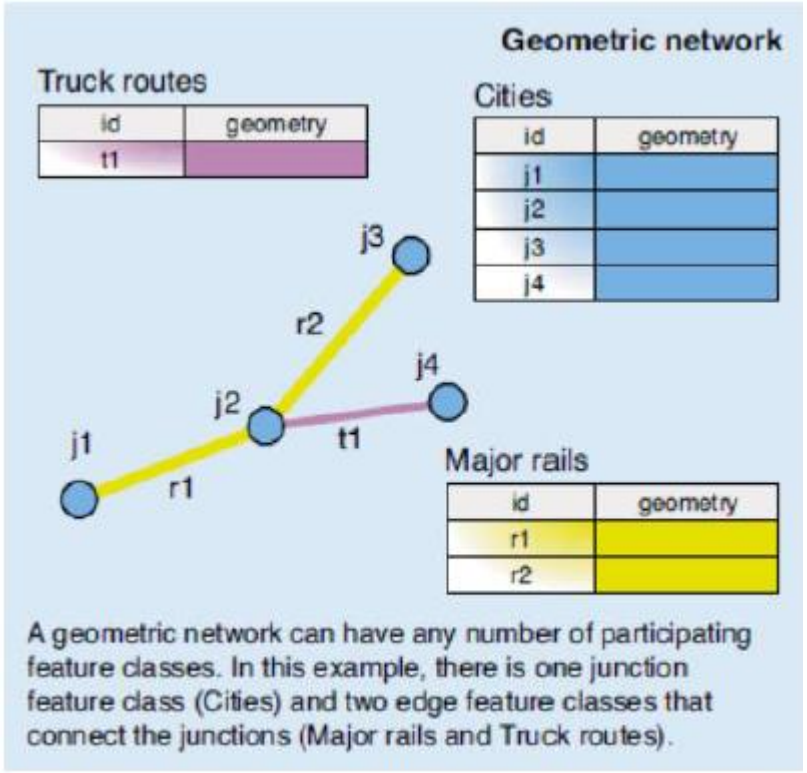


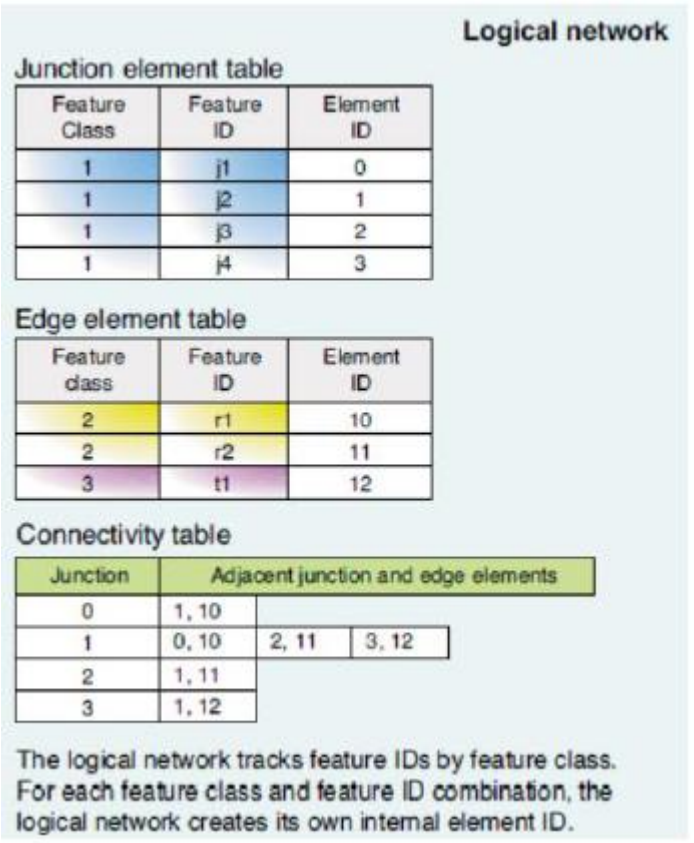


Modeling infrastructure

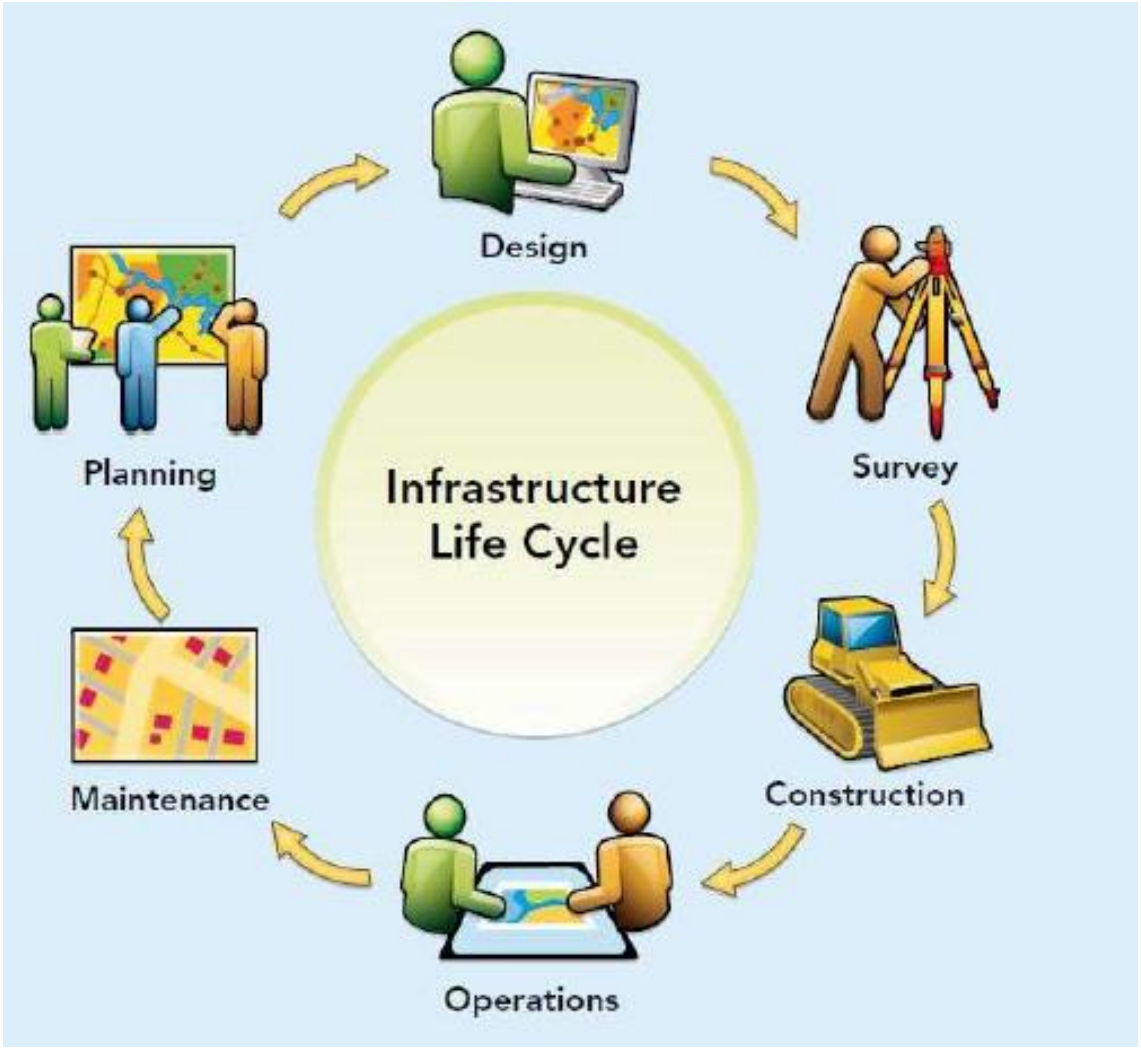


Modeling infrastructure





GIS in transportation



GIS in transportation

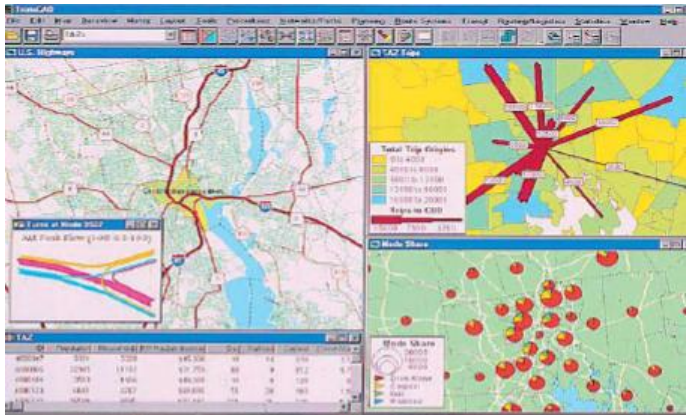
- Design:
  integrate GIS with
  design tools (e.g. CAD)
  to analyse and estimate
  capabilities to
  the infrastructure design
- Survey:
  manage and store
  GPS data and survey
  measurements

GIS in transportation

- Construction:
  organize relevant
  project information and
  different types of layers
- Operation:
  support developing
  traffic management
  strategies,
  viewing comprehensive
  picture of traffic situation

GIS in transportation

- Maintenance:
  support efficient
  scheduling of activities
- Planning:
  pattern analysis,
  problematic
  road segment
  identification

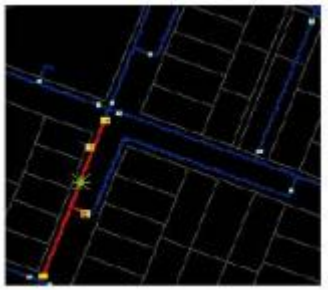


Transportation applications

- Calculating the shortest path between points
- Determining a trade area based on travel time
- Dispatching the closest ambulance
- Finding the best sequence to visit customers
- Routing a garbage truck efficiently

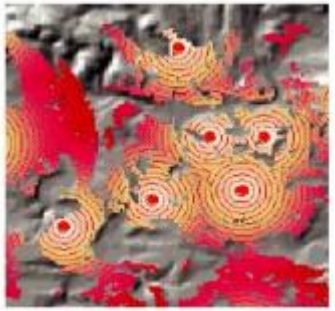
Applications

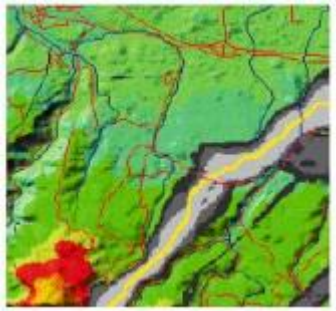
- Land use and housing
- Water management
- Road network and bycicle pathes
- Crime patterns

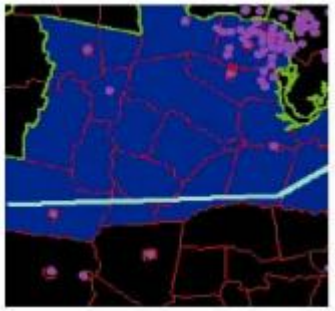


Applications

- Terrarin for telecom networks
- Pipeline pathes
- Electric company device placement
- Meteorology

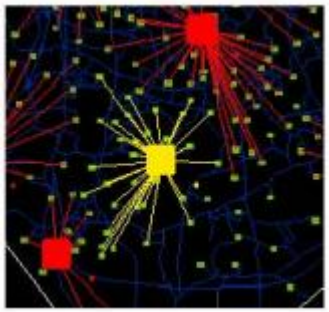






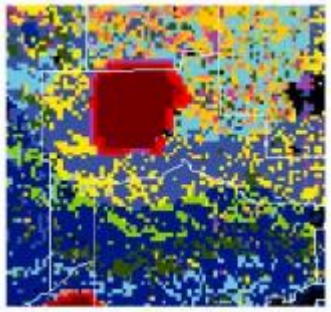
Applications

- Business locations



- Fastest route search

- Forest fire speading

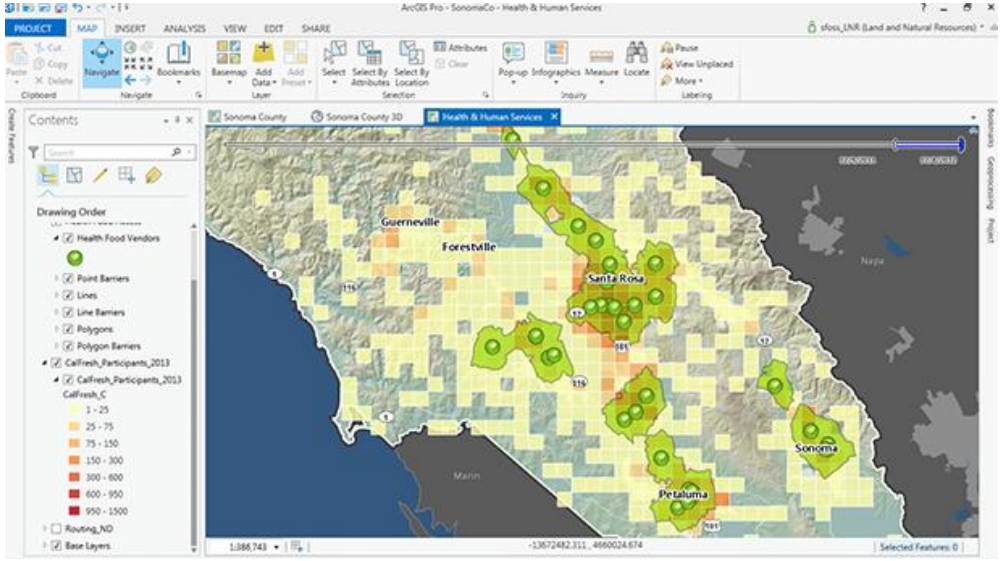


- Accessibility management

Software

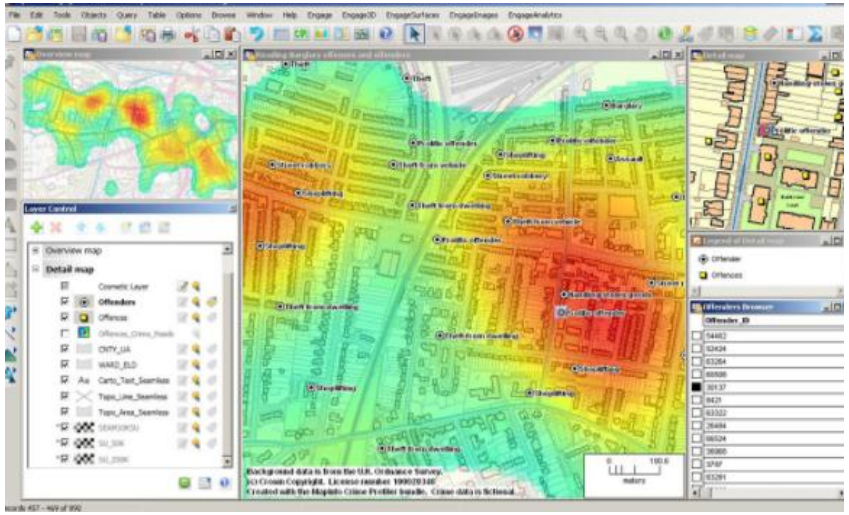
Software – ESRI ArcGIS

- Mapping and printing
- Spatial and attribute data analysis
- Visual data editing
- Extensive data modelling
- Extensive analytical capabilities



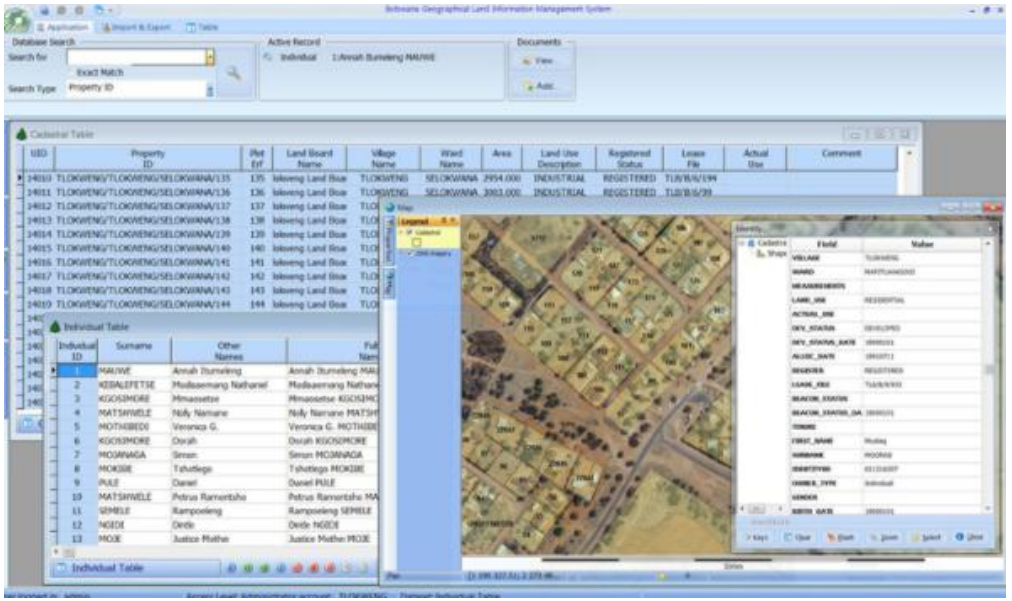
Software – MapInfo

- Mapping and printing
- Spatial and attribute data analysis
- Visual data editing and CAD
- Extensive demographic data modelling
- Enhanced data access
- Programming environment



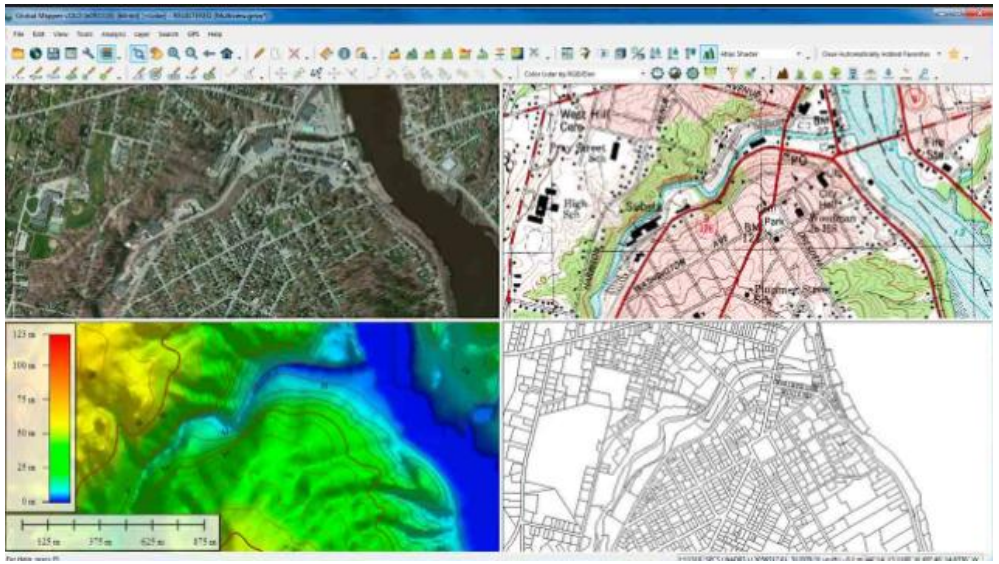
Software – IntelliGIS

- Mapping and printing
- Spatial and attribute data analysis
- Visual data editing
- Report and map templates
- Programming environment



Software – Global Mapper

- Mapping and printing
- Spatial and attribute data analysis
- Visual data editing
- Capable of displaying most popular raster, elevation and vector datasets
- Convert, edit, track GPS



Software comparison

	ArcGIS	MapInfo	IntelliGIS	Global Mapper
Pros	-Extensive analytical functionality -Supports multi-user editing -Provides ready to use datasets and maps -- Extensive product support	- Extensive demographic analysis and editing tools - Supports the latest database formats - Automatic feature options, e.g. labelling - Extensive product support	-Supports several data formats - Store Data in any RDBMS using full database functionality - Script Environment allows users to develop extended functionality - Possibility to create custom maps and reports	- Supports hundreds of the best popular vector, raster and elevation data formats - 3D viewer - Capable of perfoming complex analysis
Cons	- ESRI data format - Complex ESRI Object Model - Version incompatabilities - Price	- MapInfo data format - More attribute data focus than spatial - Price	-High-end analytical tools not included - Relative smaller vendor	- No SQL functionality - Small vendor

Free software comparison

Software	Query	Store Extent	Create .shp	Edit .shp	Edit attributes	Hotlink	Join table	GPS import	Add Event Theme
AccuGlobe Desktop	ADVANCED	YES	YES	YES	YES	YES	YES	With plug-in	YES
ArcExplorer GIS Data Viewer Java Edition for Education	ADVANCED	---	---	---	---	YES, but limited	---	---	YES
DIVA-GIS	ADVANCED	---	---	---	---	---	---	---	YES
fGIS	BASIC	---	YES	YES	YES	YES	YES	---	YES
gvSIG	ADVANCED	YES	YES	YES	YES	YES	YES	---	YES
MapWindow GIS	ADVANCED	YES	YES	YES	YES	---	YES, but limited	YES	YES
Quantum GIS	ADVANCED	YES	YES	YES	YES	---	---	.gpx & through GPSBabel	YES
TatukGIS	ADVANCED	---	---	---	---	YES	---	.gpx	---
uDig	BASIC	YES	YES	YES	YES	---	---	---	---