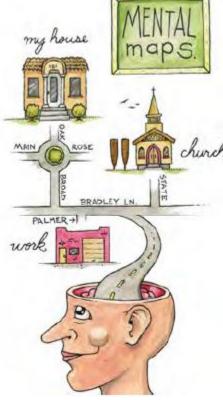
GIS introduction

Mental maps

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



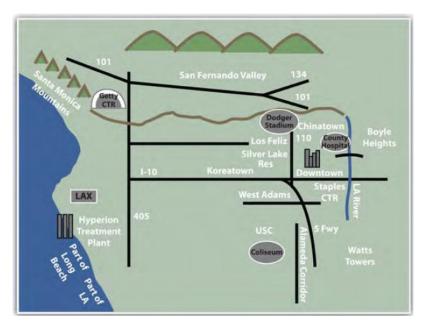
 reflects the amount and extent of geographic knowledge and spatial awareness

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?

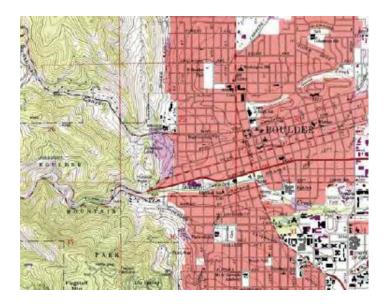
Questions about geographic interaction:

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

Questions about geographic change:

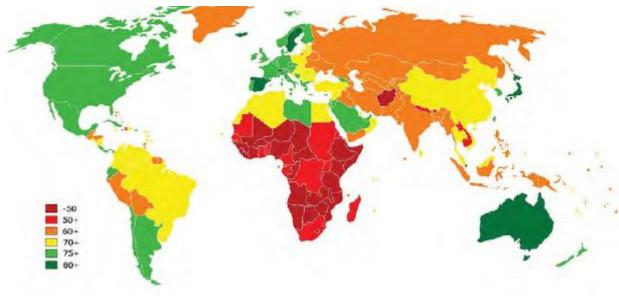
- Has it always been here?
- How has it changed over time and space?

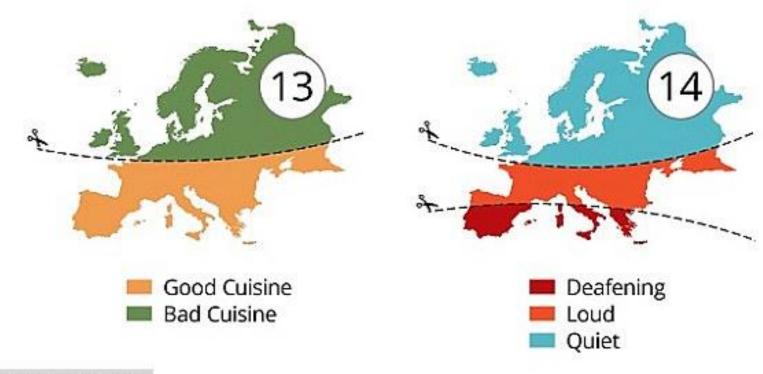
- Reference map:
 - to provide location information,
 - represent geographic reality accurately,
 - topographic or image





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

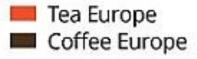


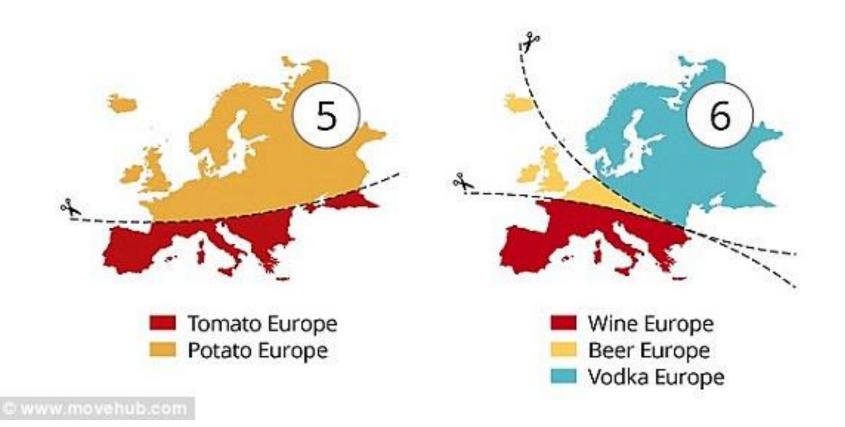


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11

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

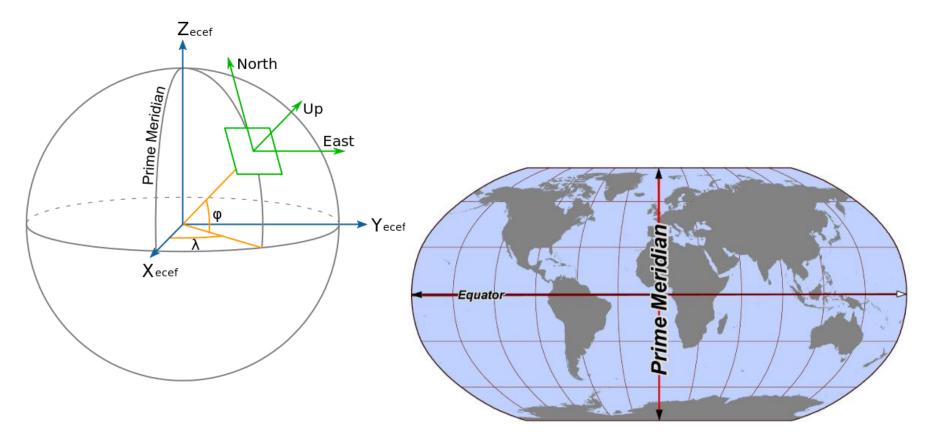


Map measures

- 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):



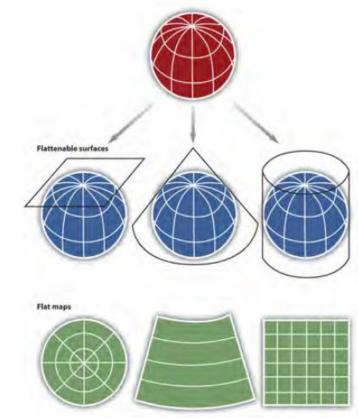
Map measures

• 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

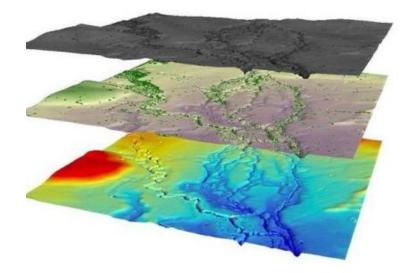


Geographic Information System

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



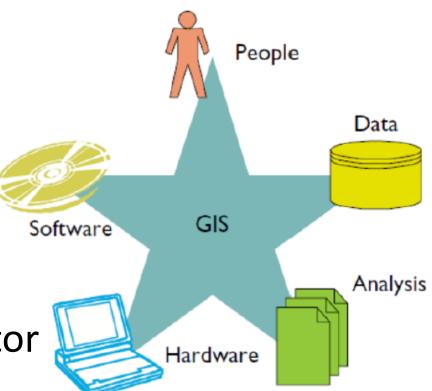


History

- 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

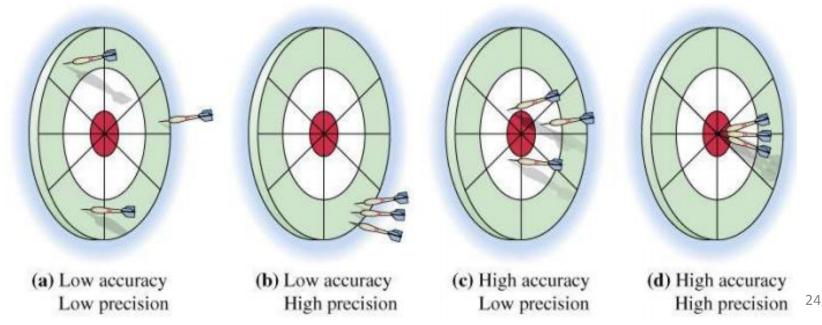
Data sources

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

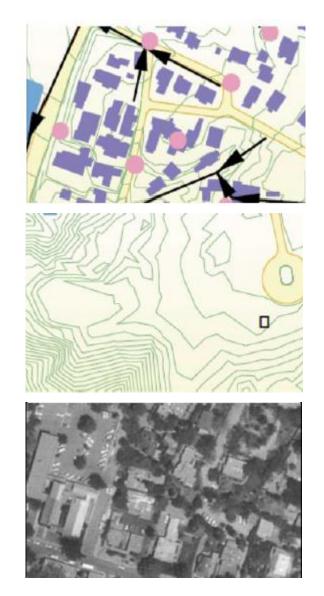


Data quality

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

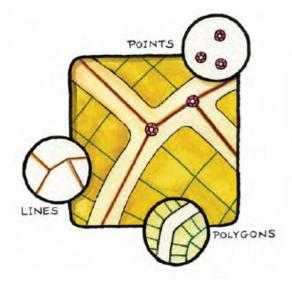
Representation of data

- 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



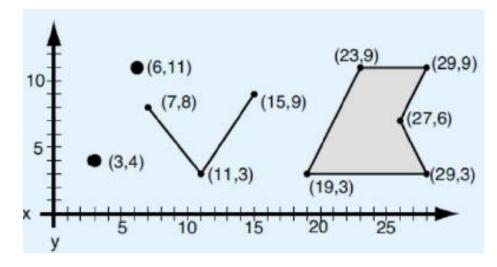
- Vector:
 - focused on modeling discrete features with precise shapes and boundaries,
 - represents features as points, lines, and polygons



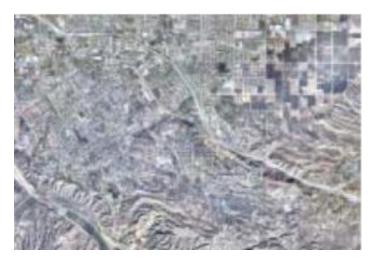


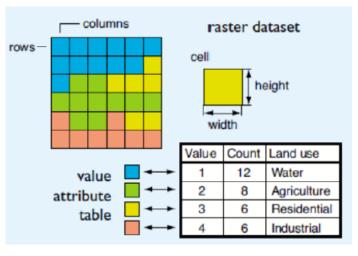
- Vector:
 - points are recorded as a single coordinate,
 - lines are recorded as a series of x,y coordinates,
 - polygons are recorded as a series of x,y
 coordinates defining line segments that enclose

an area

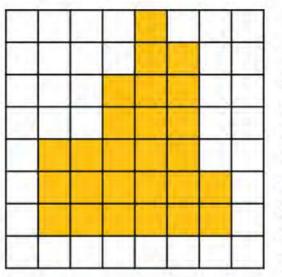


- Raster:
 - represents imaged or continuous data,
 - each cell or pixel in a raster is a measured quantity
 - best applied to feature extraction, grid surface models

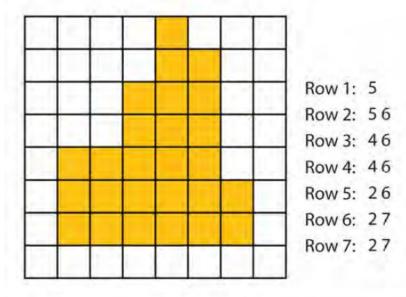




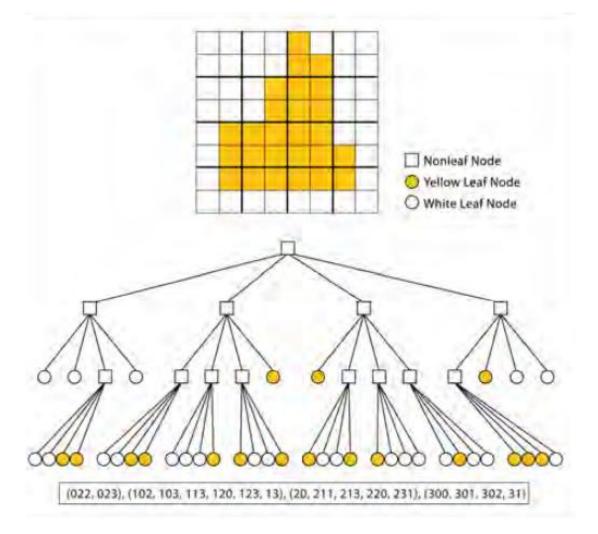
- Raster:
 - Cell-by-cell raster encoding
 - Run-length raster encoding
 - Quad-tree raster encoding



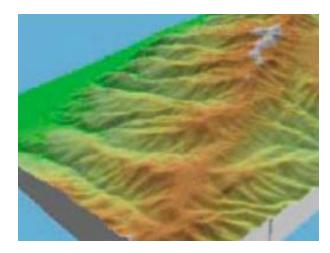
Row 1: 00001000 Row 2: 00001100 Row 3: 00011100 Row 4: 00011100 Row 5: 01111100 Row 6: 01111110 Row 7: 01111110 Row 8: 0000000



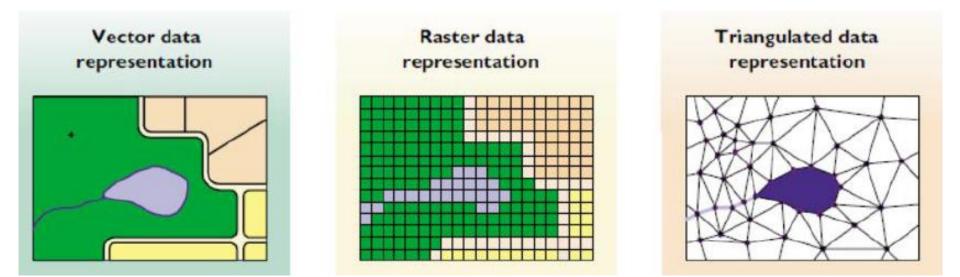
- Raster:
 - Cell-by-cell
 - Run-length
 - Quad-tree



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

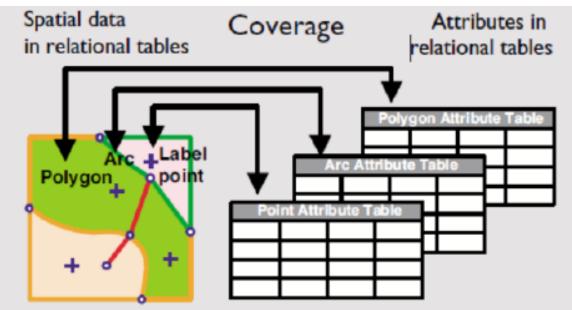


• Comparison:



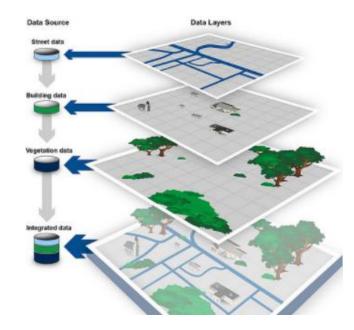
Data storage

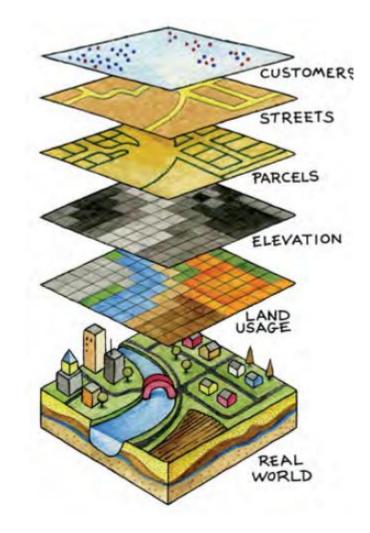
- Location:
 - spatial data: stored in indexed files
 - attribute data: stored in tables
 - database relations can be build



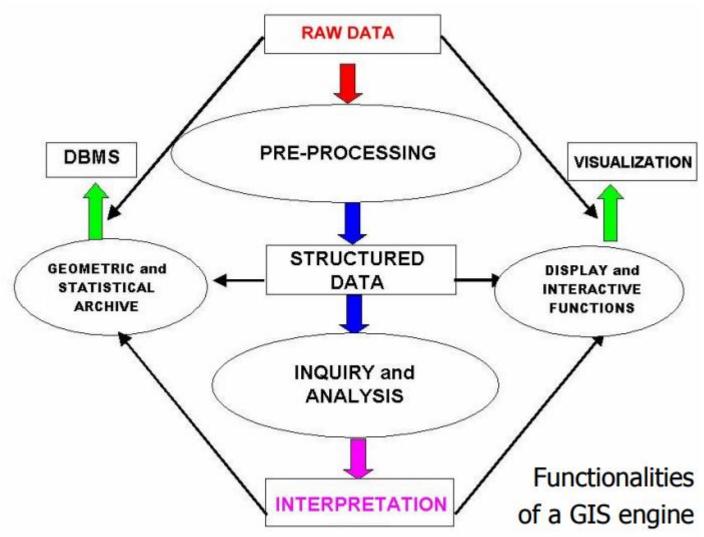
Layers

 Represent different geographic themes, combines spatial and attribute data

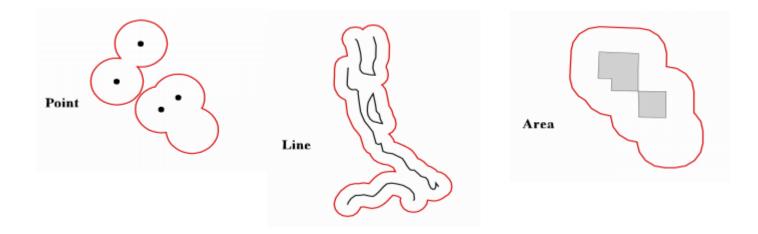




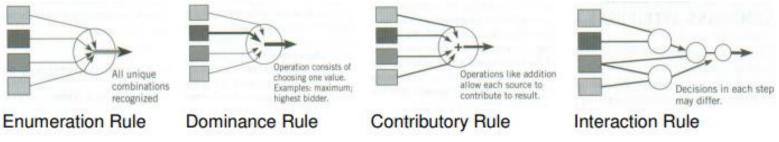
Functionalities



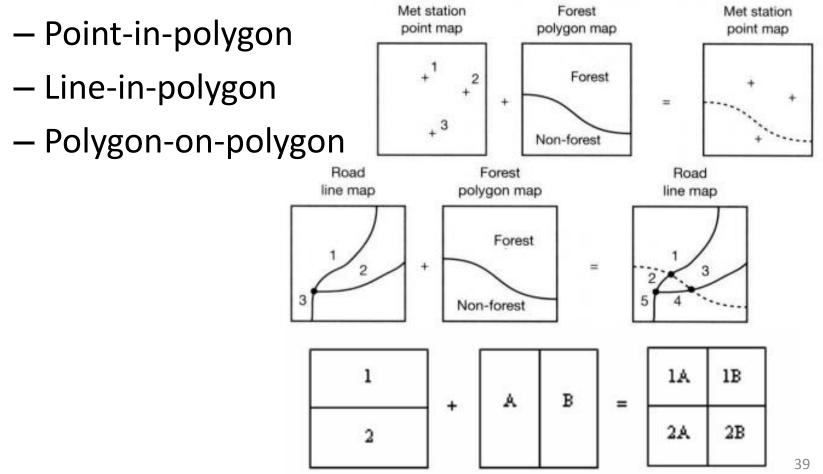
 Buffering: creates new polygons by expanding or shrinking existing polygons or by creating polygons from points and lines



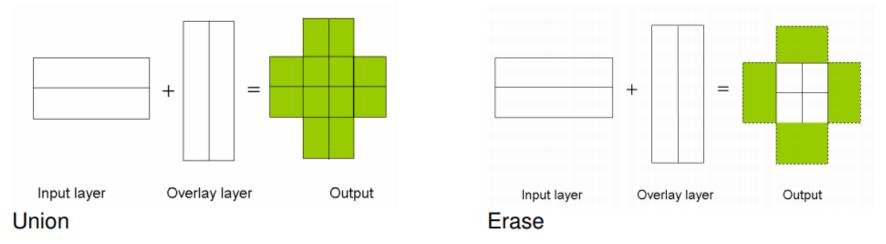
- Overlay: creates new shapes implementing arithmetic and logical mathematical operations
 - Enumeration Rule: each attribute preserved in output and all unique combinations recognized
 - Dominance Rule: one value wins, means that the only one value should be chosen
 - Contributory Rule: each attribute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



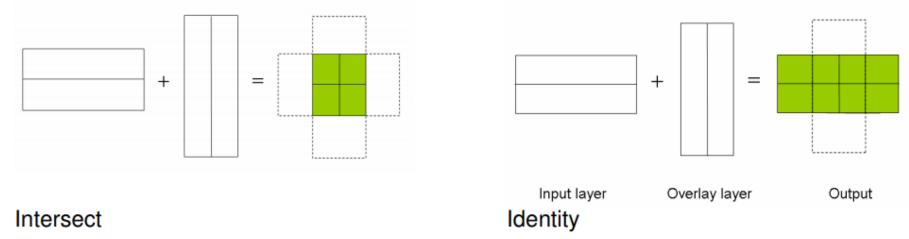
• Overlay:



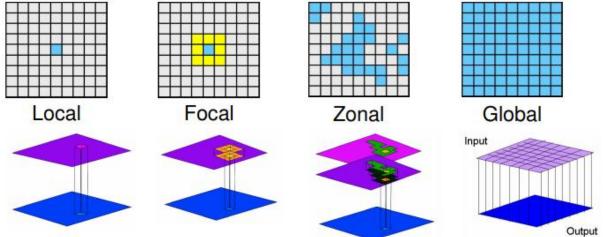
- Map manipulation:
 - Union: preserves and combines all features from both input and overlay layers
 - Erase: discards areas of the input layer that fall inside the overlay layer



- 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

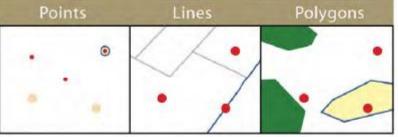


- Raster analysis: mathematical structure consisting of operands and operations
 - Local: only those pixels that overlap a particular pixel
 - Focal: all pixels in a predetermined neighbourhood
 - Zonal: calculation with set of cells with common value
 - Global : all cells used to calculate the value

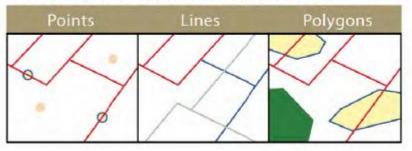


Intersect:
 selects all features
 in the target layer
 that share
 a common area
 with source layer

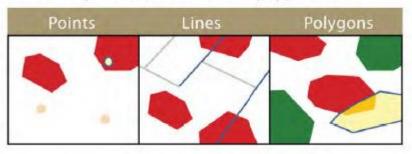
When finding features that intersect with point features



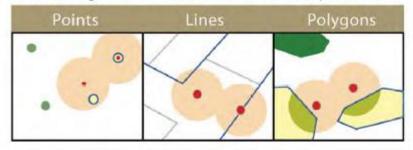
When finding features that intersect with line features



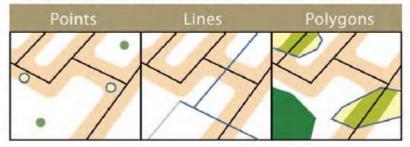
When finding features that intersect with polygon features



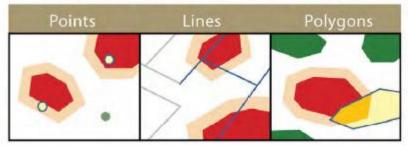
 Within a distance: all features that intersect within a predefined value with source layer When finding features that are within a distance of point features



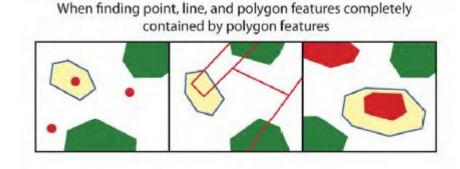
When finding features that are within a distance of line features



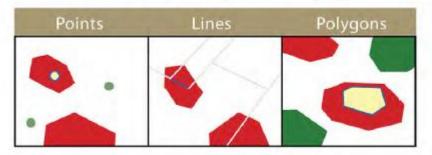
When finding features that are within a distance of polygon features



- 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

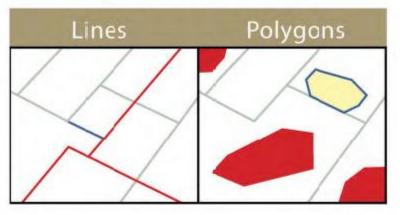


When finding features that are completely within polygon features

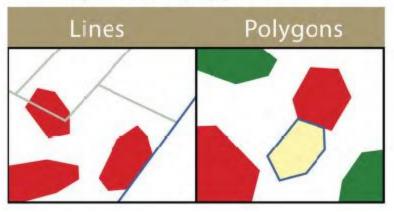


• Share a line segment: selects target features whose boundary geometries share a minimum of two adjacent vertices with the source layer

When finding features that share a line segment with line features



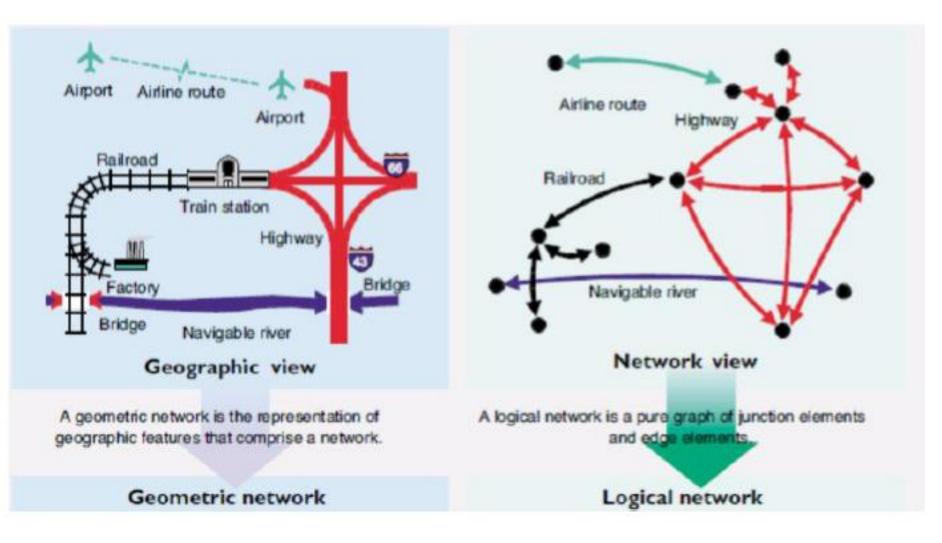
When finding features that share a line segment with polygon features

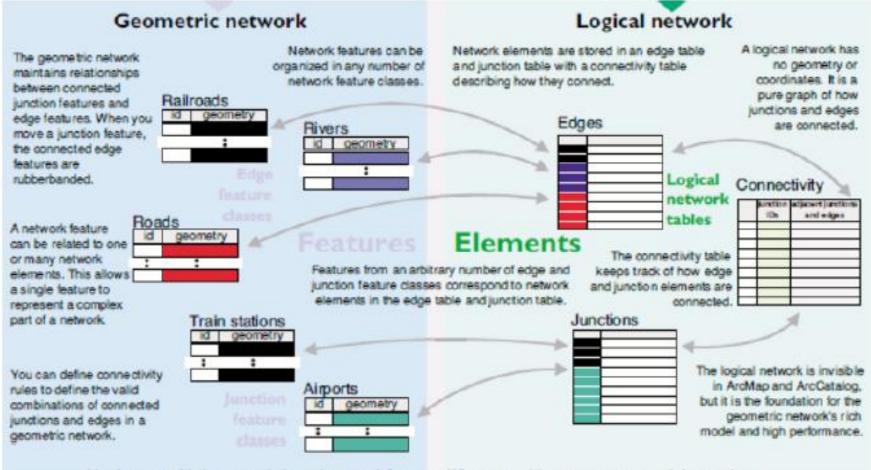


- Network models:
 - Geometric network:

set of features that participate in a linear system, matches a view of a network as a collection of features,

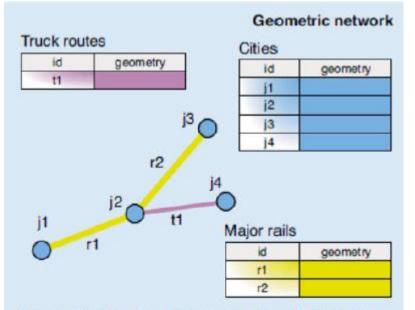
 Logical network: associated to the geometric network, which is network graph consisting of edges and junction elements





You interact with the network through network features. When you add or remove a network feature in a geometric network, Arcinfo adds or removes the matching network elements. When you perform network analysis, ArcInfo submits a solver to the logical network.

The geometric network and logical network are always synchronized.



A geometric network can have any number of participating feature classes. In this example, there is one junction feature class (Cities) and two edge feature classes that connect the junctions (Major rails and Truck routes).

Logical network

Junction element table

Feature Class	Feature ID	Element ID
1	jt	0
1	12	1
1	ß	2
1	j4	3

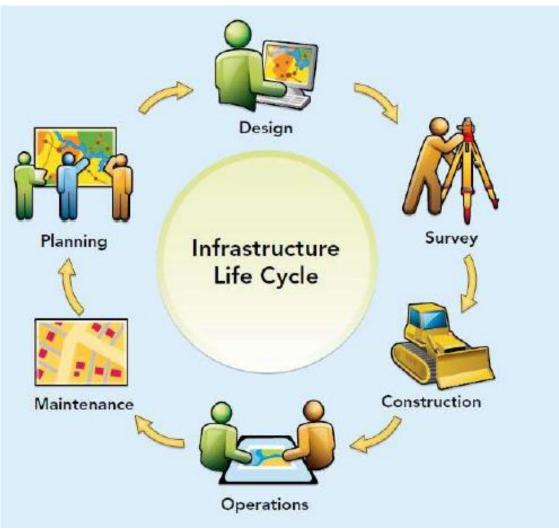
Edge element table

Feature dass	Feature ID	Element ID
2	rt	10
2	r2	11
3	t1	12

Connectivity table

Junction	Adj	acent junc	tion and ed	dge elements
0	1,10			
1	0,10	2, 11	3, 12	1
2	1,11			50
3	1,12			

The logical network tracks feature IDs by feature class. For each feature class and feature ID combination, the logical network creates its own internal element ID.



- 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





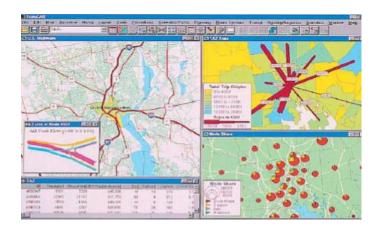
- Construction: organize relevant project information and different types of layers
- Operation: support developing traffic management strategies, viewing comprehensive picture of traffic situation





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





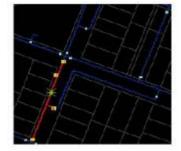
Transportation applications

- 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



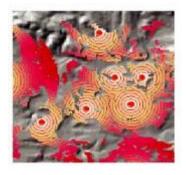


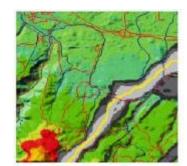




Applications

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









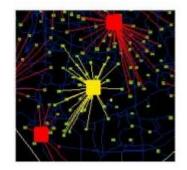
Applications

Business locations

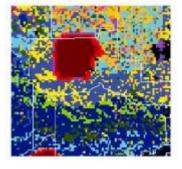
• Fastest route search

Forest fire speading

• Accessibility management







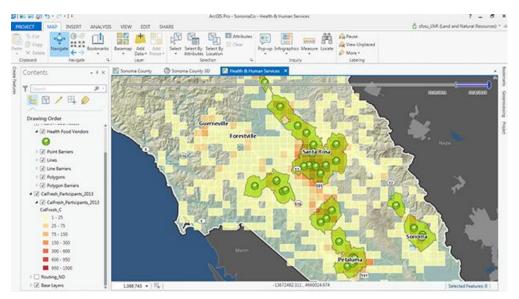


Software



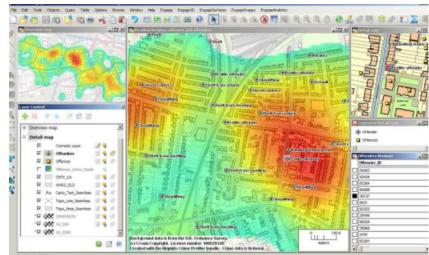
Software – ESRI ArcGIS

- 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

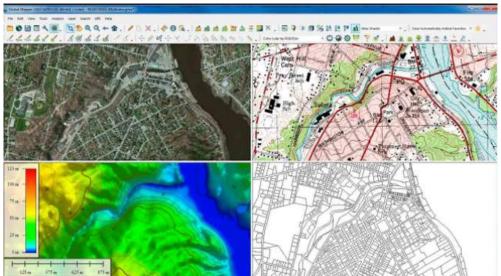
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Software – Global Mapper

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

Free software comparison

Software	Query	Store Extent	Create .shp	Edit .shp	Edit attributes	Hotlink	Join table	GP S import	Add Event Theme
ACCUG 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
B IG	ADVANCED	YES	YES	YES	YES	YES	YES		YES
	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				