Spatial Data Analyses

Introduction

• GIS capabilities to use the spatial and non-spatial data in a spatial database to answer questions and solve problems.

• For planning: e.g. What is the best location for a new dam?

• For prediction: e.g. What will be the size of the lake behind the dam?

Overview

Overview of functions:

- Measurement, retrieval and classification functions
- Overlay functions
- Neighborhood functions
- Network connectivity functions

Analytic functions

- Measurement, retrieval and classification functions:

✓ Measurement: Computing distance, length, area, counting features

✓ Retrieval: Data retrieval by selection on both geometric and attribute data

✓ Classification: (re)Assignment of a thematic value to features in a data layer

Analytic functions

- Overlay functions:
Two or more Data layers are combined and new information is derived by creating features in a new layer

- Neighborhood functions:
Evaluate the characteristics of an area surrounding a features' location

- Network connectivity functions:
Evaluate how feature are connected in a network (road network, water courses, communication lines, etc.

Measurement

Geometric measurement calculation is one of the fundamental operations provided in any GIS software packages. In vector data, geographic features are represented by points, lines or polygons. Therefore, different measurements are provided for different feature types.

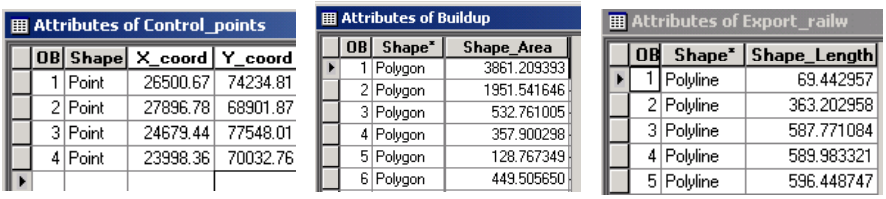
ArcMap provides functions to calculate most of the measurements. In this exercise, you will practice several ways of deriving these measurements.

Measurement

• Vector measurements include Location, length, area size and distance between

• Location is always stored by GIS

• Area and length can be computed but is usually stored by GIS



Attributes of Control_points

OB	Shape	X_coord	Y_coord
1	Point	26500.67	74234.81
2	Point	27896.78	68901.87
3	Point	24679.44	77548.01
4	Point	23998.36	70032.76

Attributes of Buildup

OB	Shape*	Shape_Area
1	Polygon	3861.209393
2	Polygon	1951.541646
3	Polygon	532.761005
4	Polygon	357.900298
5	Polygon	128.767349
6	Polygon	449.505650

Attributes of Export_railw

OB	Shape*	Shape_Length
1	Polyline	69.442957
2	Polyline	363.202958
3	Polyline	587.771084
4	Polyline	589.983321
5	Polyline	596.448747

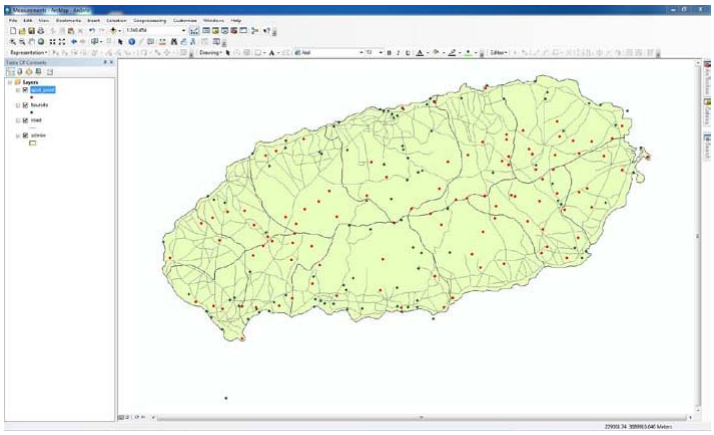
Measurement

Point measurement

The most important measurement of point features is by their position in x,y coordinates. On the right hand bottom of the desktop, ArcMap displays the x,y co- ordinates of any mouse point location within a view (see Fig. 1.1). When you move the mouse pointer, the values of the x,y coordinates also change. The x,y coordinates are measured in the Map units and the Display units as defined in the Data Frame Properties (meters).

Measurement

Point measurement



Measurement

Point measurement

The XY values are stored with your data layers but are not visible in the layers attribute table. You may want to include the XY values of the features in the attribute table of the feature class.

In order to do it you have to create new attributes in the attribute table of the feature class and populate it with the values of the co-ordinates.

Measurement

Line measurement

The most important measurement on line features is length. For a straight line, only one length is measured, the distance from the beginning to the end of that line. However, for a non-straight line, two types of length measurement are offered – segment length and total length. The segment length is the distance between any two vertices along the line and the total length is the sum of all the segment length along the line. ArcMap provides both measurement data.

Measurement

Line measurement

The length of a line segment in a feature class is always displayed in the associated attribute table. (Check this!)
For shape files, the length of the line is not displayed in the attrib-ute table. You can convert the shape file to a feature class. In the attribute table of the feature class the length will subsequently be displayed. For shape files, you can create new fields in the attrib-ute table of the shape file and calculate the length of the lines by using the field calculator. (ArcGis Help: Field calculator)

Measurement

Line measurement

Measurement tool 

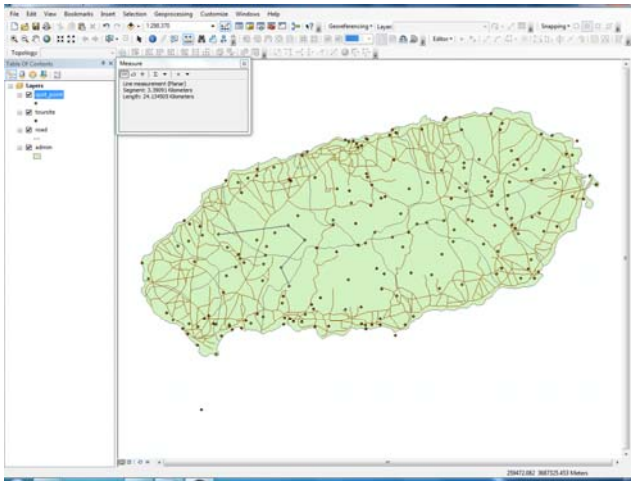
Use the Measurement tool and use the mouse (notice the change of the cursor from arrow to rulers) to draw a line defining the distance you want to measure. The measurements are dis-played in the Measure window.

If you are using global data in decimal degrees, and you've defined your map and distance units, the Measure tool will return the shortest spherical distance between the two points you click on the mapped area.

The Measure window shows the segment length of the last segment you have drawn and next to it, the total length of the line drawn on the map.

Measurement

Line measurement



Measurement

Polygon measurement

The most important measurements on polygon features are the perimeter and the area size of polygons.

The perimeter and area size of polygons in feature classes are always displayed in the attribute table. (Check this!).
For shape files, the perimeter and area size of polygons are not displayed in the attribute table. You can convert the shape file to a feature class or create new fields in the attribute table of the shape file and calculate the area and perimeter of the polygons by using the field calculator. (ArcGis Help: Field calculator)

Measurement

Polygon measurement

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Retrieval

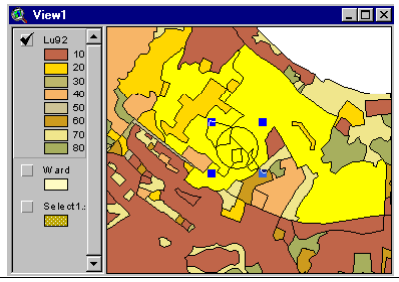
Kinds of retrieval:

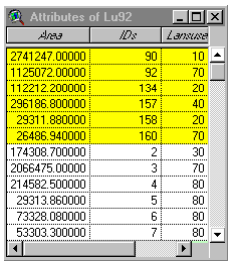
- Interactive (manual) spatial selection
- Spatial selection by attributes conditions
- Spatial selection by using spatial relationships

Retrieval

Interactive (manual) spatial selection:

- Define the selection by pointing or drawing (selection tool).
- Features within the selection (object area) are selected and highlighted.
- Display the attributes of the selected features

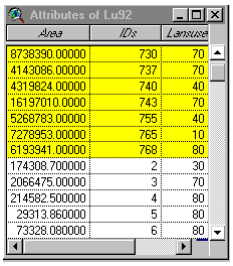


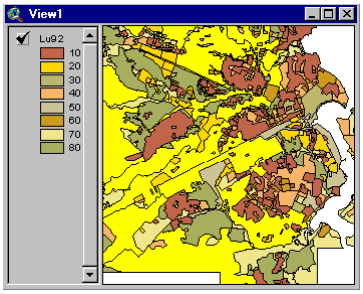


Retrieval

Spatial selection by attributes conditions:

- Define a query expression (such as SQL) to select data in the attribute table (select by attributes)
- The resulted selection will be displayed graphically and in the attribute table



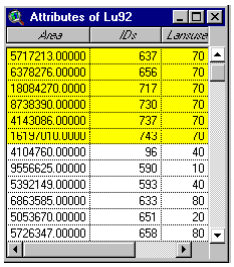


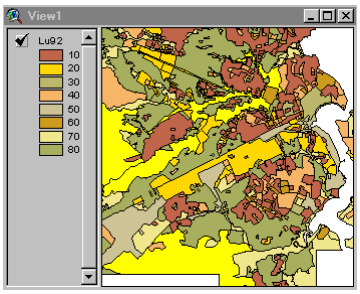
Area > 4000000

Retrieval

Spatial selection by attributes conditions:

- Define a query expression (such as SQL) to select data in the attribute table by combining attribute conditions
- The resulted selection will be displayed graphically and in the attribute table





Area > 4000000 and Landuse = 70

Retrieval

Spatial selection by attributes conditions:

• Define a query expression (such as SQL) to select data in the attribute table from a joined table (one to one, or many to one relationship)

Attributes of land

FID	Shape *	Id	Laduse
0	Polygon	0	1
1	Polygon	0	1
2	Polygon	0	3
3	Polygon	0	4
4	Polygon	0	2
5	Polygon	0	2
6	Polygon	0	2
7	Polygon	0	3
8	Polygon	0	2
9	Polygon	0	2

join

Attributes of table

OID	FIELD1	LANDUSE_NA	LANDUSE_ID
0	0	agriculture	1
1	0	buildup	2
2	0	forest	3
3	0	other	4

Attributes of land

FID	Shape *	Id	Laduse	OID	FIELD1	LANDUSE_NA	LANDUSE_ID
0	Polygon	0	1	0	0	agriculture	1
1	Polygon	0	1	0	0	agriculture	1
2	Polygon	0	3	2	0	forest	3
3	Polygon	0	4	3	0	other	4
4	Polygon	0	2	1	0	buildup	2
5	Polygon	0	2	1	0	buildup	2
6	Polygon	0	2	1	0	buildup	2
7	Polygon	0	3	2	0	forest	3
8	Polygon	0	2	1	0	buildup	2
9	Polygon	0	2	1	0	buildup	2

Retrieval

Spatial selection by attributes conditions:

• Define a query expression to select data in the attribute table and a related table (in Arcgis only) (many to many, or one to many relationship)

Attributes of parcels

FID	Shape *	Id
0	Polygon	1
1	Polygon	2
2	Polygon	3
3	Polygon	4
4	Polygon	5
5	Polygon	6
6	Polygon	7
7	Polygon	8

relate

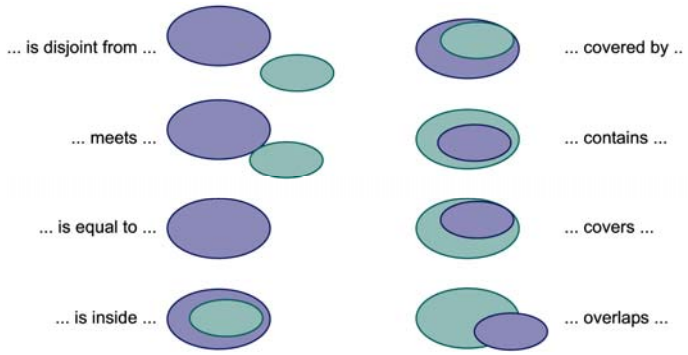
Attributes of owner

OID	owner_id	owner_name	parcel
0	1	Jansen	1
1	2	Smith	1
2	3	Klaassen	0
3	4	Manik	0
4	5	Kock	5
5	6	Knippers	12
6	7	Worm	7
7	8	Feringa	2
8	9	Blok	6
9	10	Braake	6
10	11	Kooistra	8
11	12	Bean	9

Retrieval

Spatial selection by using spatial relationships:

• Examples of spatial relationships:



Retrieval

Spatial selection by using spatial relationships:

• Overview :

✓ Select features that are inside other selected features

✓ Select features that intersect with other features

✓ Select features adjacent to other features

Retrieval

Spatial selection by using spatial relationships:

➢ Select features that are inside other selected features:

• Polygons can contain polygons, lines and points
• Lines can contain lines and points
• No other containment relation are possible

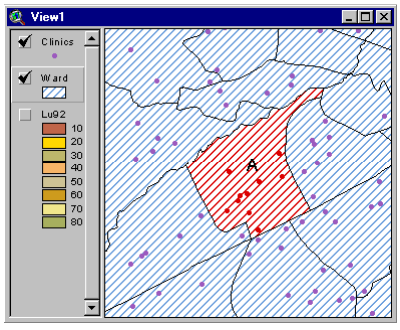
Retrieval

Spatial selection by using spatial relationships:

➢ Select features that are inside other selected features:

• Example: Select all clinics in district A:

1 Select by attributes: district A
2 Select clinics inside selected polygon: (district A)



Retrieval

Spatial selection by using spatial relationships:

➢ Select features that intersect with other features:

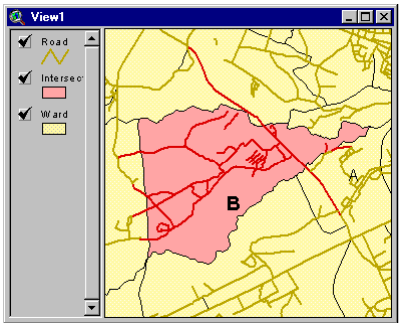
• Two polygons intersect when their boundaries cross each other
• Two lines intersect when the share a common part of the line segment and when they cross each other
• A line and a polygon intersect when line is partially or completely inside the polygon

Retrieval

Spatial selection by using spatial relationships:

➢ Select features that intersect with other features:

• Example: Select all the roads that are partially or completely located in (intersect with) district B



Retrieval

Spatial selection by using spatial relationships:

➢ Select features adjacent to other features:

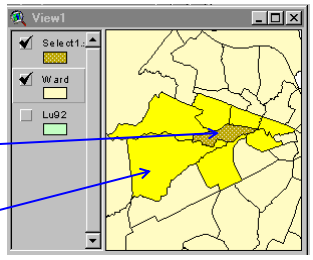
• Also called MEET relationship
• Share common boundaries
• Apply only to line and polygon features

Retrieval

Spatial selection by using spatial relationships:

➢ Select features adjacent to other features:

- Example: Select all polygons that are neighbors of the selected polygon



Original selection Polygon

Features adjacent to the original selection polygon

(re)Classification

Properties:

• Remove details from an input data set to divide it in different classes
• Assign codes based on specific attributes
• Reduce the number of classes and eliminate details
• If the input data set itself is the result of a classification, we call it reclassification
• Reclassify data in different systems or for different purposes.

(re)Classification

Procedure:

• Specify input data source
• Apply one of the classification methods
• Specify the output data: new classification

Examples:
Soil types reclassified into soil suitability for agriculture.
House hold income classification: low, below average, average, above Average, high.

(re)Classification

Two kinds of classification:

- User controlled classification
- Automatic classification

(re)Classification

User controlled classification:

- User specifies the classification attributes:

✓ What will be classified

- User specifies the classification method:

✓ The number of output classes

✓ The relation between the original attribute values and the new attribute value is called: Classification table

CODE	OLD TYPE	NEW TYPE
10	Planned Residential	Residential
20	Industry	Commercial
30	Commercial	Commercial
40	Institutional	Public
50	Transport	Public
60	Recreational	Public
70	Non Built-up	Non Built-up
80	Unplanned Residential	Residential

(re)Classification

Automatic classification:

- User specifies the number of output classes
- Computer decides the class break points:

✓ Equal interval: the constant interval size determined by the minimum and maximum values.

✓ Equal frequency (quantile): maintain equal or nearly equal numbers of features in each class in the output.

OBJECTID*	people	Age_classes
6	100	0-20
7	300	21-40
8	350	41-60
9	150	61-80
10	100	81-100

OBJECTID*	people	Age_classes
6	200	0-28
7	200	29-43
8	200	44-51
9	200	51-70
10	200	71-100

(re)Classification

Raster classification:

Pixel values can represent classes
New cell values are calculated

1.1	1.2	1.4	2.8	8.2
4.1	4.5	5.6	4.3	9.0
4.5	3.5	3.2	2.1	1.3
4.3	5.2	6.0	8.5	8.9
4.3	4.4	1.2	1.1	1.9

(a)

1	1	1	2	8
4	4	5	4	9
4	3	3	2	1
4	5	6	8	8
4	4	1	1	1

(b)

Lower limit	Upper limit	New category
1.0	1.9	1
2.0	2.9	2
3.0	3.9	3
4.0	4.9	4
5.0	5.9	5
6.0	6.9	6
7.0	7.9	7
8.0	8.9	8
9.0	9.9	9

Overlay

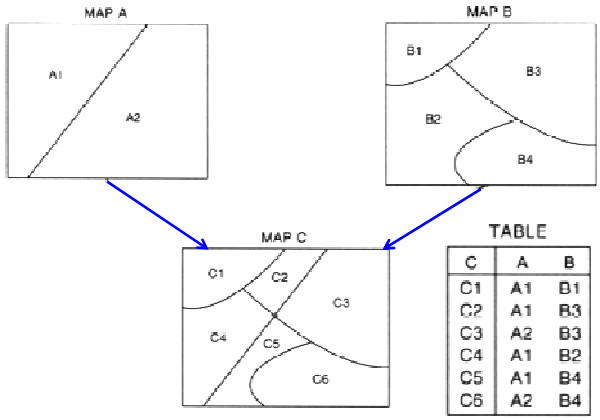
Properties:

- Two input data layers can be overlaid when they are projected in the same coordinate system and overlap in the study area.

- The principle of spatial overlay is to compare the characteristics of the same location on both data layers and to produce a new output value for each location.

Overlay

Overlay general principle: Spatial Join



C	A	B
C1	A1	B1
C2	A1	B3
C3	A2	B3
C4	A1	B2
C5	A1	B4
C6	A2	B4

Overlay

Overlay operations (vector data) Overview:

- Intersect
- Clip
- Overwrite (update)
- Erase
- Union
- Identity

Overlay

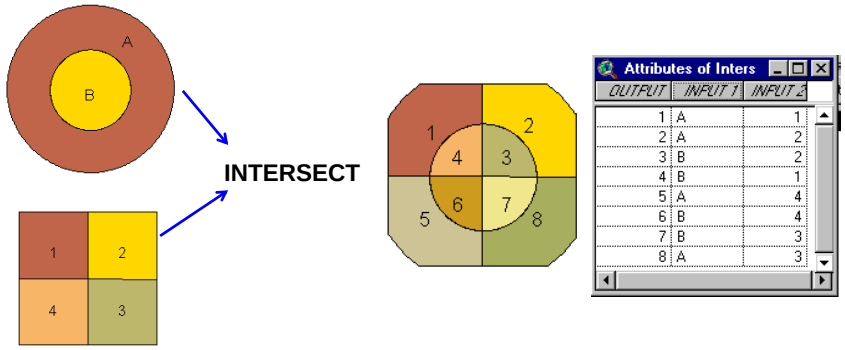
Overlay operations (vector data) Overview:

INTERSECT:
We use Intersect when we want to overlay a layer with the polygons in another layer so that the resulting output layer has the combined attribute data of the features in the two inputs, and only contains features that fall within the spatial extent of the overlay polygons.
In this way, we can find just those features that overlap and 'stamp' the attributes of the overlay polygons in the second layer onto the features in the first layer. We can intersect polygons with polygons and lines with polygons.

Overlay

Overlay operations: Intersect:

• Only the features inside the common area of the two input data layers are kept in the output.



Overlay

Overlay operations (vector data) Overview:

CLIP:

We use Clip when we want to cut out a piece of one layer using one or more of the polygons in another layer as a 'cookie cutter'.

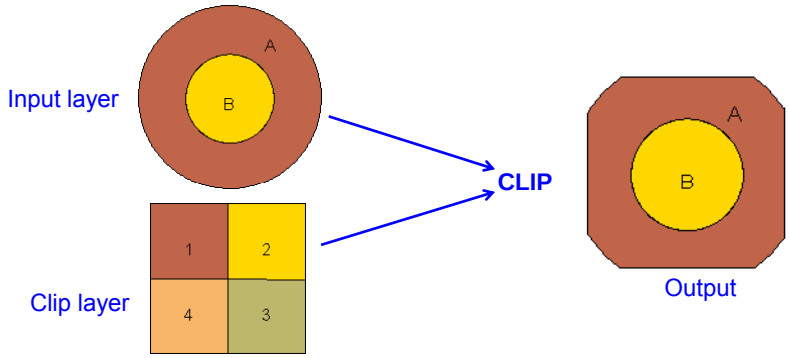
The layer that is having its features clipped can contain points, lines, or polygons.

The attributes of the features in the output layer are the same as those of the features in the layer being clipped.

Overlay

Overlay operations: Clip:

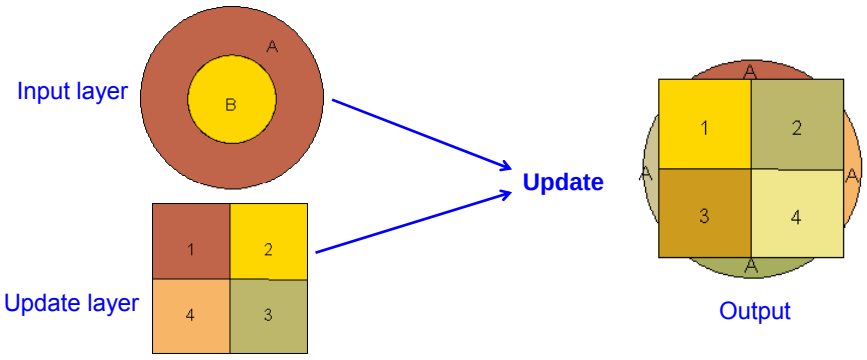
- Extracts those features from an input layer that overlap with a clip layer



Overlay

Overlay operations: Overwrite (update):

- Replaces the features of the input layer with the features of the update layer



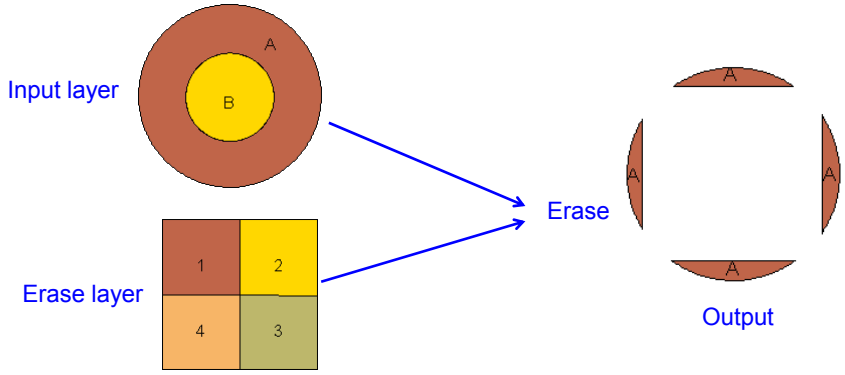
Overlay

Overlay operations (vector data) Overview:

ERASE:
ERASE creates a new feature class by overlaying two sets of features. The **Erase Features polygons define the erasing region. Input Features that are within the erasing region are removed.**
The output feature classes contain only those Input Features that are outside the erasing region. Input Features can be polygons, lines, or points; but Erase Features must be polygons. Output features are of the same class as the Input Features. They are clipped to the outer boundary of the Erase Features polygons. Topology is rebuilt for the output feature class.
The attribute table for the output feature class contains the same items as the Input Features attribute table.
In the final part of this exercise you execute the overlay functional-ities described above to find out how they work and what it results in.
Finally you will apply the overlay functionalities in a systematic way to solve a typical 'planning' problem using GIS techniques.

Overlay

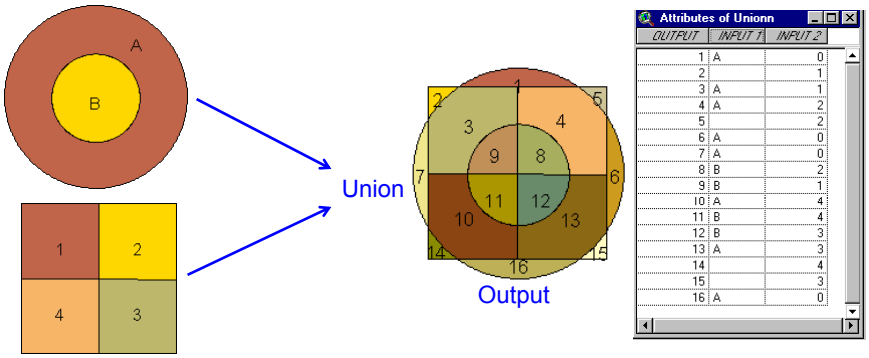
Overlay operations: Erase
• Erases the features of the input layer that overlap with the erase layer



Overlay

Overlay operations: Union

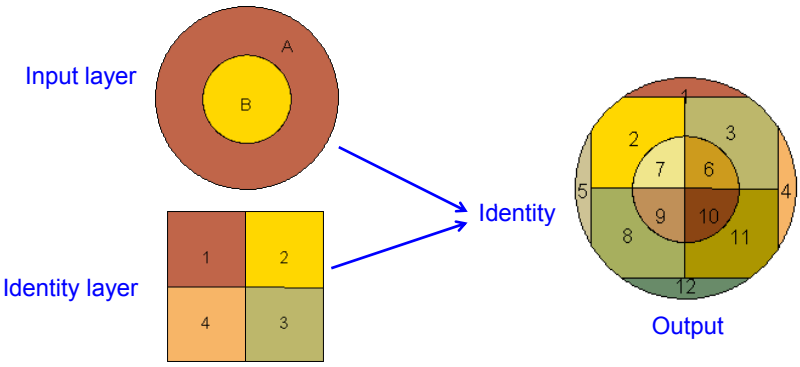
- All features of the two input data layers are kept in the output



Overlay

Overlay operations: Identity

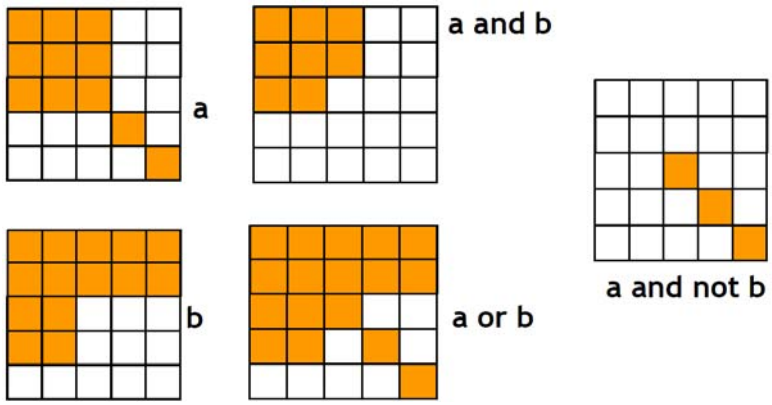
- All features of the input layer, as well as the features of the identity layer that overlap the input layer, will be preserved in the output



Overlay

Raster overlay:

Examples of logical expressions:

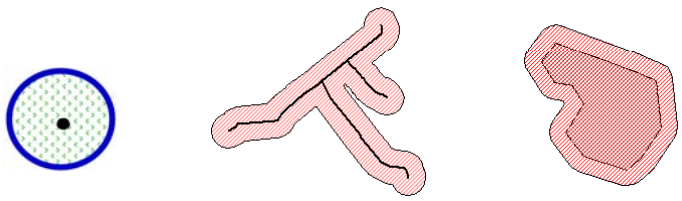


Neighborhood

Buffer generation or proximity analyses:

➢ Select features within or beyond a specified distance

• Generate buffer polygons around (selected) features
• Apply containment relationship operation to select features inside or outside the buffer polygon(s)

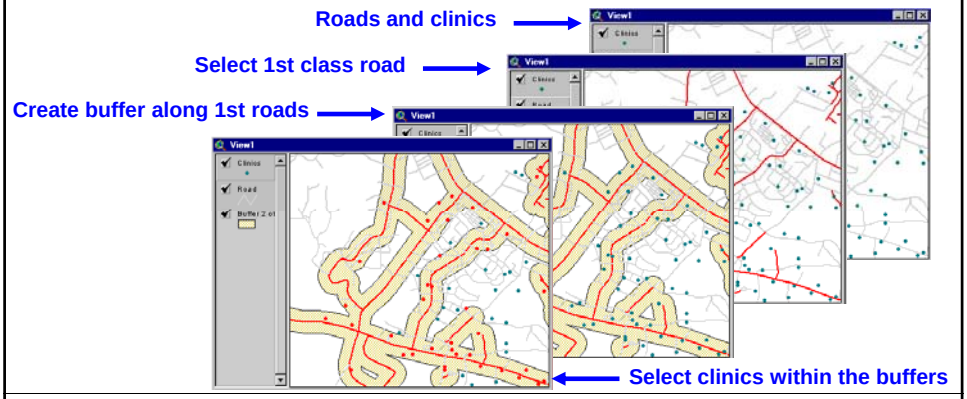


Neighborhood

Buffer generation or proximity analyses:

➢ Select features within or beyond a specified distance

• Example: Select all clinics within 200 m from the 1st class road



Network

Network characteristics:

• Network is created from a set of lines connected by nodes

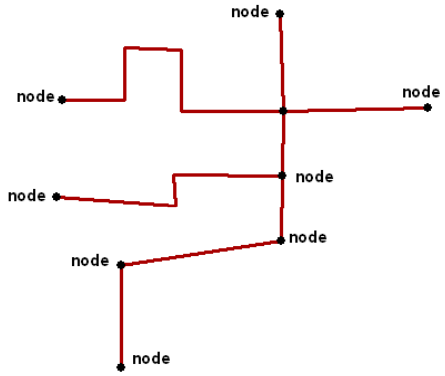
• Network can represent rivers, roads, pipelines, telecommunication lines etc.

• Network can be directed and undirected: Directed: Transportation is in one direction (e.g. water supply). Undirected: Transportation can be in both directions. (e.g.roads)

Network

Network characteristics:

• Network is created from a set of lines connected by nodes



Network

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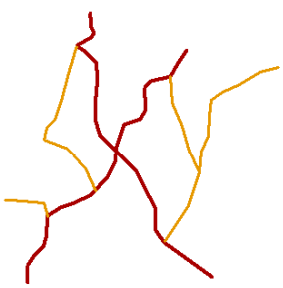
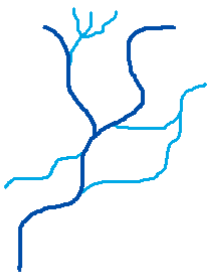
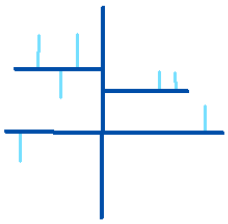


roads



rivers

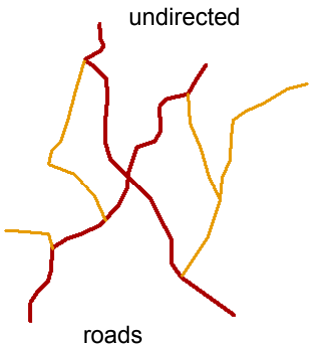


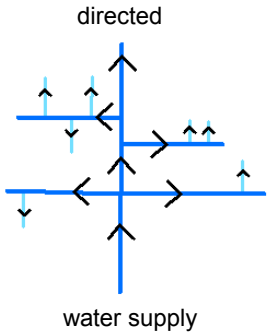
water supply

Network

Network characteristics:

- Network can be directed and undirected:





Network

Network analyses functions:

• Optimal path finding: Generates a least-cost path on a network between a pair of pre-defined locations based on both geometric and attribute data

• Network partitioning: Assigns network elements (nodes or line segments) to different locations using pre-defined criteria

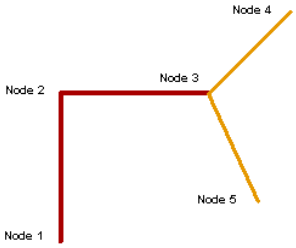
Network

Network analyses: Optimal path finding:

Cost factor characteristics:
• The cost factor is a feature attribute in the attribute table, like length, travel time, etc
• For lines, the cost can be same or different for different directions.

Attributes of lines

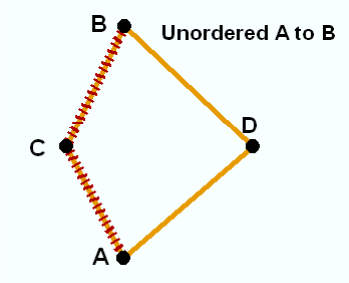
OBJECTID	SHAPE*	From_Node	To_Node	SHAPE_Length	Cost_From_To	Cost_To_From
29	Polyline	1	2	5284.012338	20	20
46	Polyline	2	3	5234.107837	20	25
47	Polyline	3	5	4259.275652	30	30
48	Polyline	3	4	4136.751954	30	35

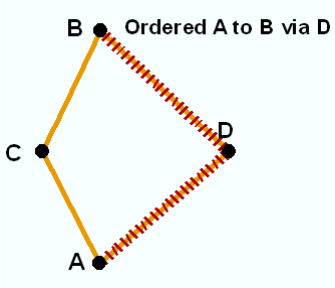


Network

Network analyses: Optimal path finding:

Ordered and unordered:
• Ordered: The sequence in which places have to be visited matters
• Unordered: The sequence does not matter

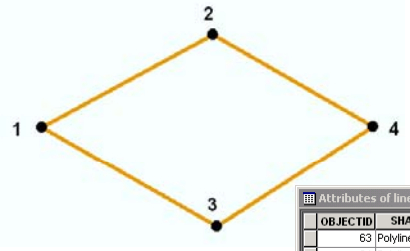




Network

Network analyses: Optimal path finding:

The optimal path is the one that has the least total costs between the source and the destination:
• What is the optimal path from node 1 to node 4 ?



Attributes of lines

OBJECTID	SHAPE*	From_Node	To_Node	SHAPE_Length	Cost_From_To	Cost_To_From
63	Polyline	1	3	5503.016524	20	30
64	Polyline	3	4	5064.559971	20	10
65	Polyline	1	2	5311.352898	30	20
66	Polyline	2	4	5033.388003	20	20

Network

Network analyses: Network partitioning:

Network allocation:
• Purpose is to assign lines and/or nodes of the network to a number of target locations

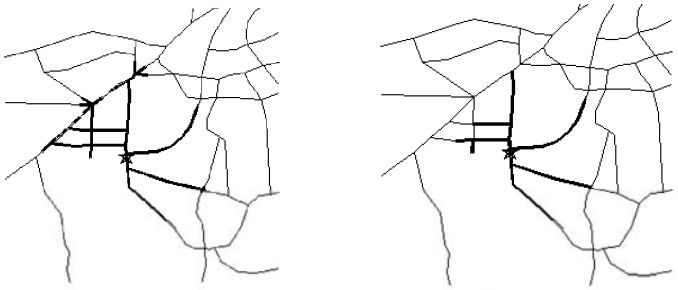
Example: School and service area

• Complications:
✓ The capacity with which a center can produce the resources e.g. only 200 seats are available in the school
✓ The consumption of the resources which may vary amongst lines e.g. some streets have more children than other streets

Network

Network analyses: Network partitioning:

Network allocation:



(a) Travel 2 km from the school

Travel 2 km from the school and only 200 seats are available in the school. (b)

Network

Network analyses: Network partitioning:

Trace analyses :

• Is performed to understand which part of the network is 'conditionally connected' to a chosen node on the network, known as trace origin