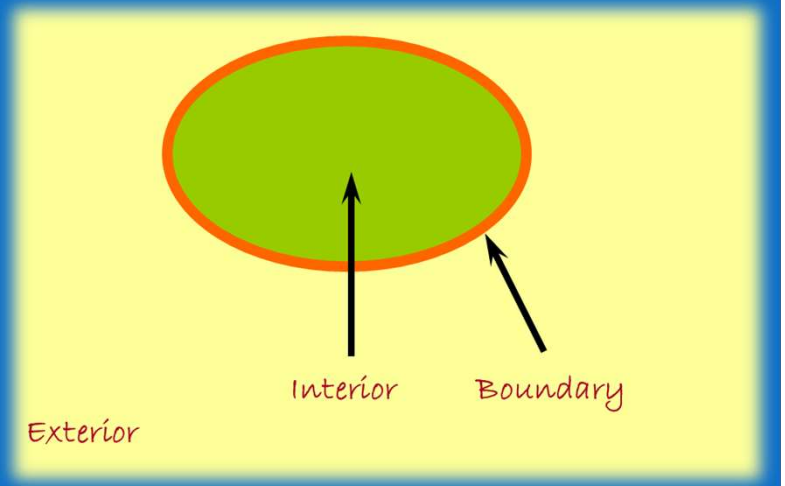
TOPOLOGICAL MODEL

Topology is the branch of mathematics that deals with geometric properties that remain invariable under certain transformations, such as stretching and bending.

The Topology model describes the connections and relationships between objects independent of their coordinates. These relationships remain fixed as geometry is stretched and bent.

Hence topology model overcomes the major weaknesses of Spaghetti Model, which lacks relationship required for many GIS manipulations and presentations



TOPOLOGICAL MODEL

For spatial analysis in GIS, only the geometry with the position, shape and size in a coordinate system is not enough but the topology is also required.

Topological models explicitly stores spatial relations between graphical elements.

In GIS, Topology is the science which represents the spatial relationships between geographic data or coverage features (e.g., arcs, nodes, polygons and points), which do not change with any transformation

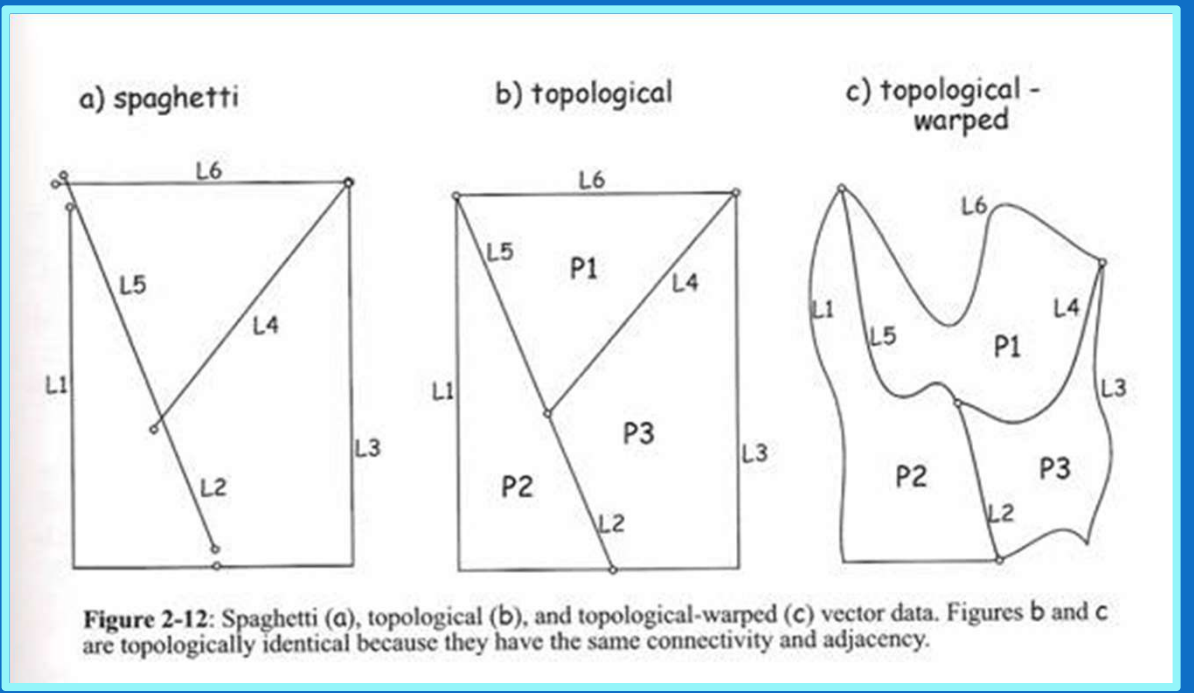


Figure 2-12: Spaghetti (a), topological (b), and topological-warped (c) vector data. Figures b and c are topologically identical because they have the same connectivity and adjacency.

Possible topological relationships between spatial objects

a. Point-Point Relationship

"**is within**" : within a certain distance

"**is nearest to**" : nearest to a certain point

b. Point-Line Relationships

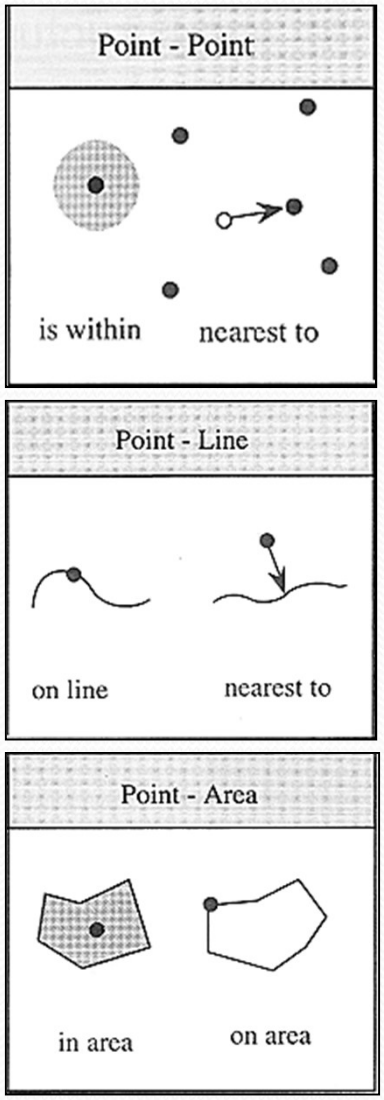
"**on line**" : a point on a line

"**is nearest to**" : a point nearest to a line

c. Point-area Relationships

"**is contained in**" : a point in an area

"**on border of area**" : a point on border of an area



d. Line-Line Relationships

"intersects" : two lines intersect

"crosses" : two lines cross without an intersect

"flow into" : a stream flows into the river

e. Line-Area Relationship

"intersects" : a line intersects an area

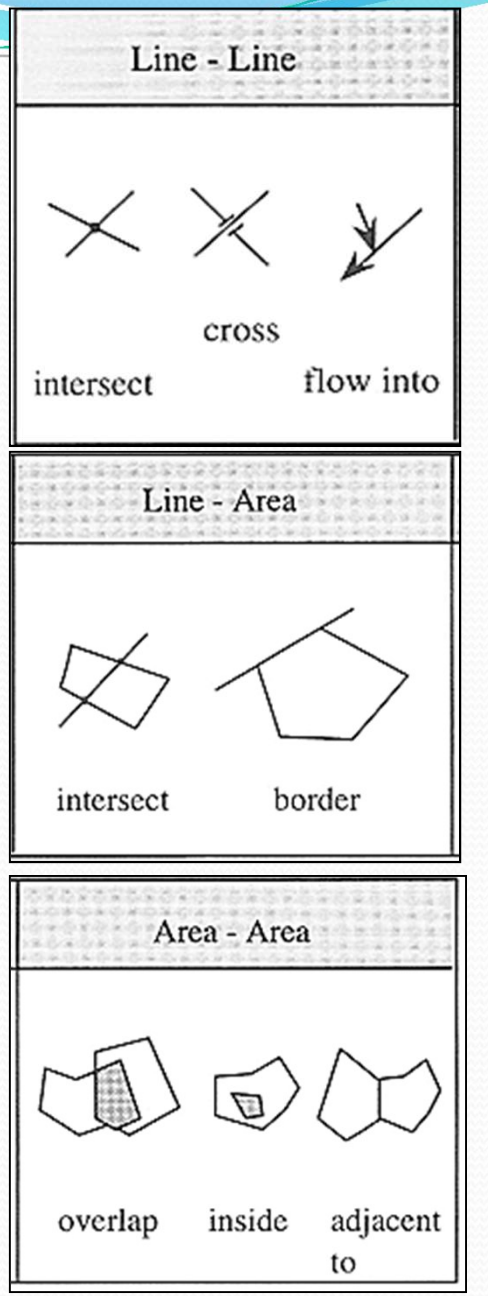
"borders" : a line is a part of border of an area

f. Area-Area Relationships

"overlaps" : two areas overlap

"is within" : an island within an area

"is adjacent to" : two area share a common boundary

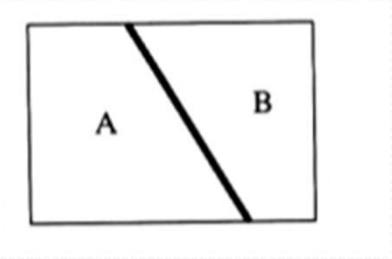


TOPOLOGICAL RELATIONSHIPS

Associations between geographic data based on their relative locations to one another.

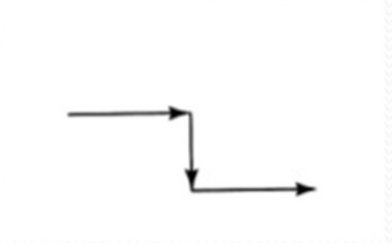
Topological relationships include three basic elements

Adjacency : Information about neighborhood among spatial objects



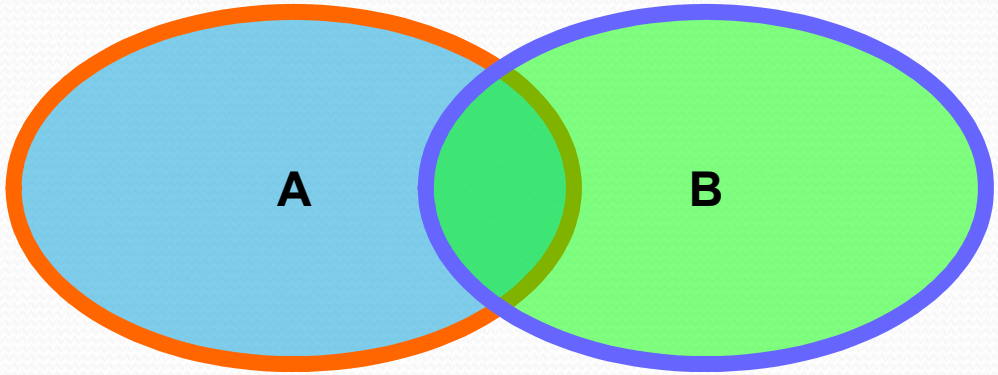
Containment : Information about inclusion of one spatial object within another spatial object

Connectivity : Information about linkages among spatial objects

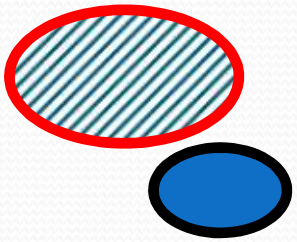


Topological Relationships

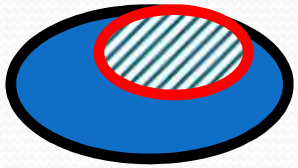
Relationships between two regions can be determined based on the intersection of their boundaries and interiors.



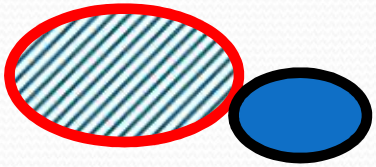
Spatial Relationships



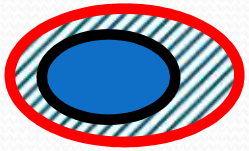
disjoint



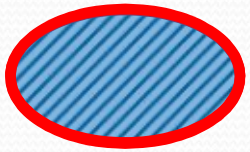
covered by



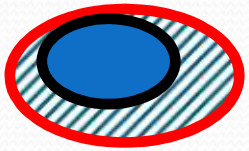
meet



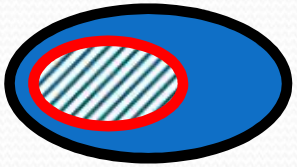
contains



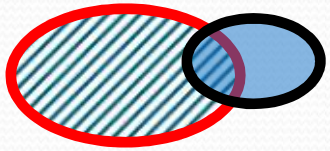
equal



covers



inside



overlap

TOPOLOGICAL MODEL

Topological information is explicitly stored along with geometric information expressed in coordinates

- Employs nodes and links
- A node can be a point where two lines intersect, an end point on a line or a given point on a line
- A link (edge/ arc/ chain) is a segment of line between two nodes. Links have a start node and an end node, therefore have a direction in topology model.
- Several links can share a node, a collection of such links and nodes can is known as a network.
- A closed polygon consisting of alternating nodes and links forms an area (face). A closed polygon is also called as a ring.

TOPOLOGY MODEL

Unique identities are automatically assigned to all links, nodes and polygons and **attribute data describing connections** are associated with all identities

Point entity is identified by a unique FID

Line entity (or Arc) is identified by the **line itself** as well as its **nodes**. Topological relationship among the line entities are computed and stored by using identifiers of nodes.

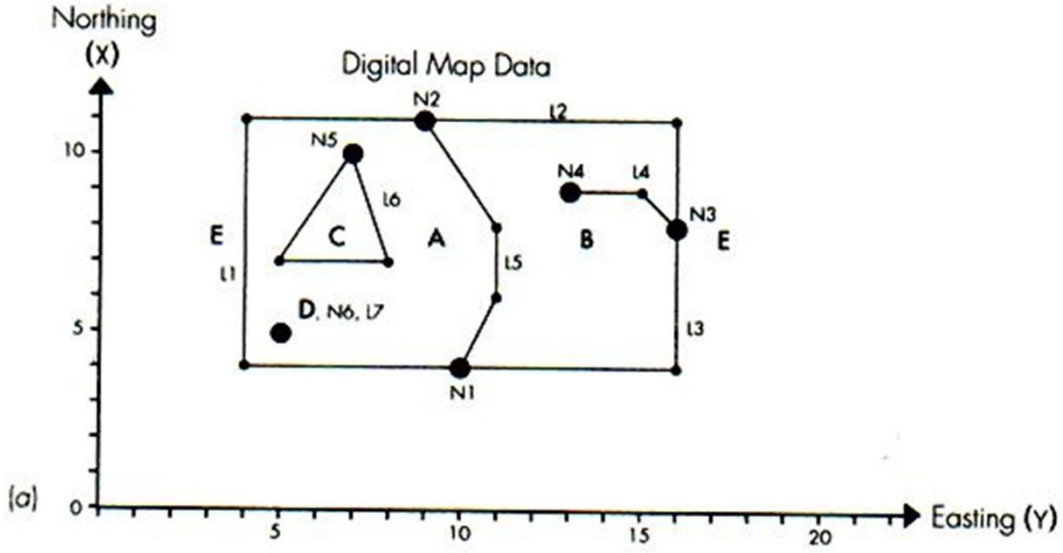
Polygon entities are formed by using line entities and their respective nodes. Individually polygon entities are identified by unique ID number. Topological relationships are computed by and stored by using the adjacency information stored with the line entities. Adjacency information includes the nodes of the line (***from node & to node***) as well as the **identifiers of polygons to the left and right of the line.**

Topology can be described in three tables. The system creates these tables automatically

Basic idea is that all geometric objects can be represented by nodes and links. The objects attributes and relationships can be described by storing nodes and links logically and systematically

1. The polygon topology table : List of links comprising all polygons, each of which is identified by a number
2. The node topology table : Lists the links that meet at each node
3. The link topology table : Lists the nodes on which each link terminates and the polygons on right and left of each link. Right and left are defined in the direction from a designated start node to a finish node.
4. An additional table gives the objects geographical coordinates. This table ties these features to the real world and permits computations of distances, area, intersections etc.

Vector Model: Topological



(a)

(b)

POLYGON TOPOLOGY

Polygon	Links
A	L1, L5
B	L2, L3, L5
C	L6
D	L7
E	L1, L2, L3

(c)

NODE TOPOLOGY

Node	Links
N1	L1, L3, L5
N2	L1, L2, L5
N3	L2, L3, L4
N4	L4
N5	L6
N6	L7

(d)

LINK TOPOLOGY

Links	Start node	End node	Left polygon	Right polygon
L1	N1	N2	E	A
L2	N2	N3	E	B
L3	N3	N1	E	B
L4	N3	N4	B	B
L5	N2	N1	B	A
L6	N5	N5	A	C
L7	N6	N6	A	A

(e)

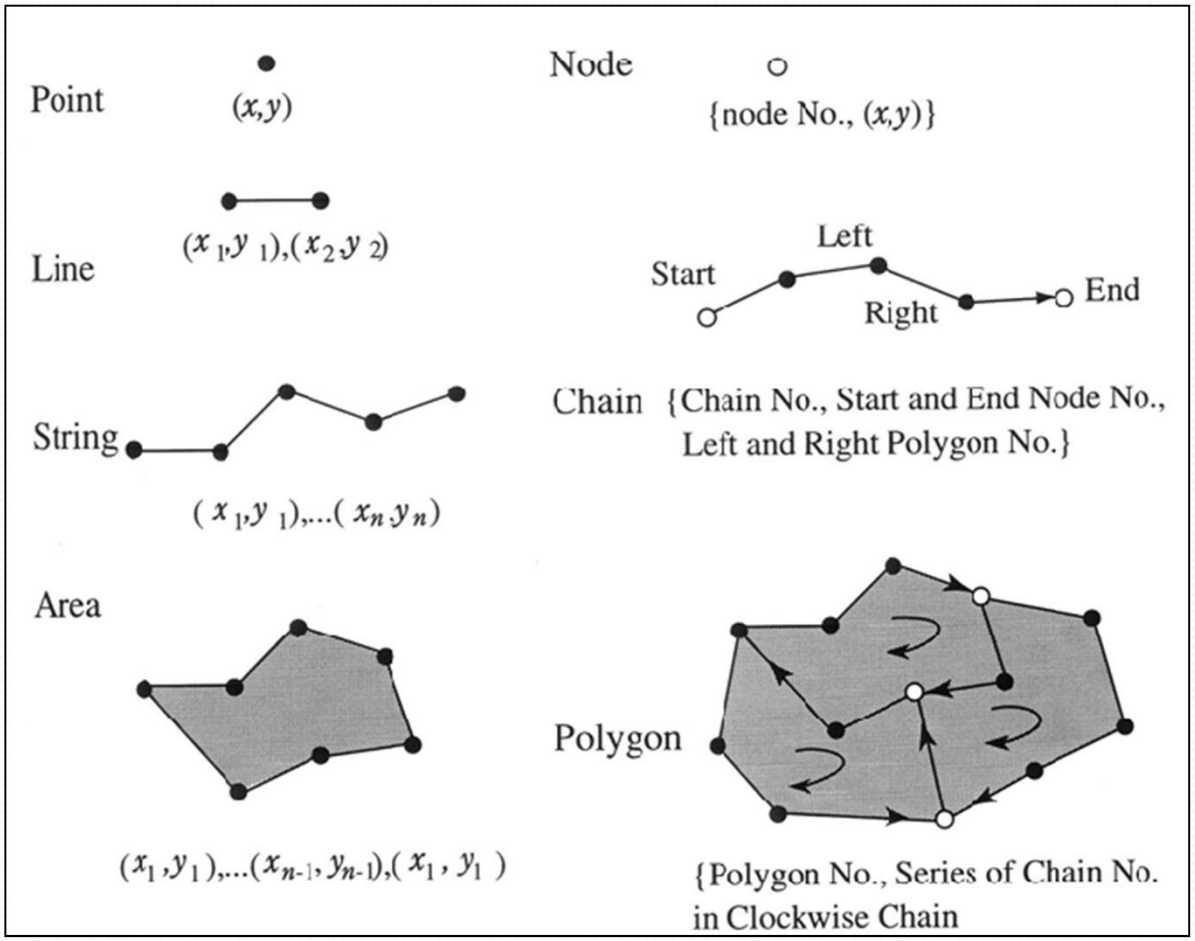
LINK COORDINATES

Link	Coordinates			
L1	4,10	4,4	11,4	11,9
L2	11,9	11,16	8,16	
L3	8,16	4,16	4,10	
L4	8,16	9,15	9,13	
L5	11,9	8,11	6,11	4,10
L6	10,7	7,8	7,5	10,7
L7	5,5			

Bernhardsen, Tor. (1999). 2nd Ed. *Geographic Information Systems: An Introduction.* p. 62. fig. 4.12.

Geometry

Topology



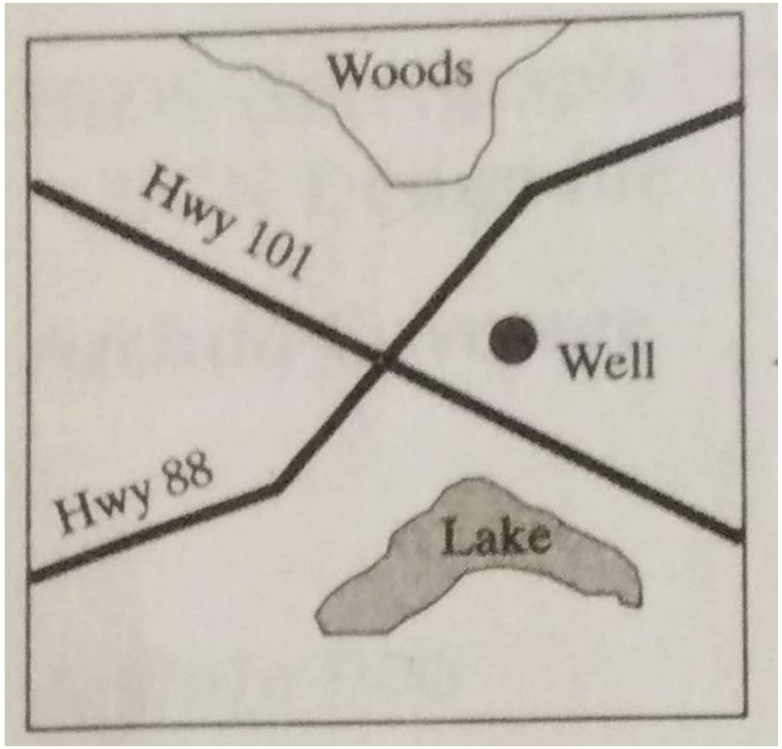
The GEOMETRY of a point is given by 2D coordinates (x, y), while line, string and area are given by a series of point coordinates

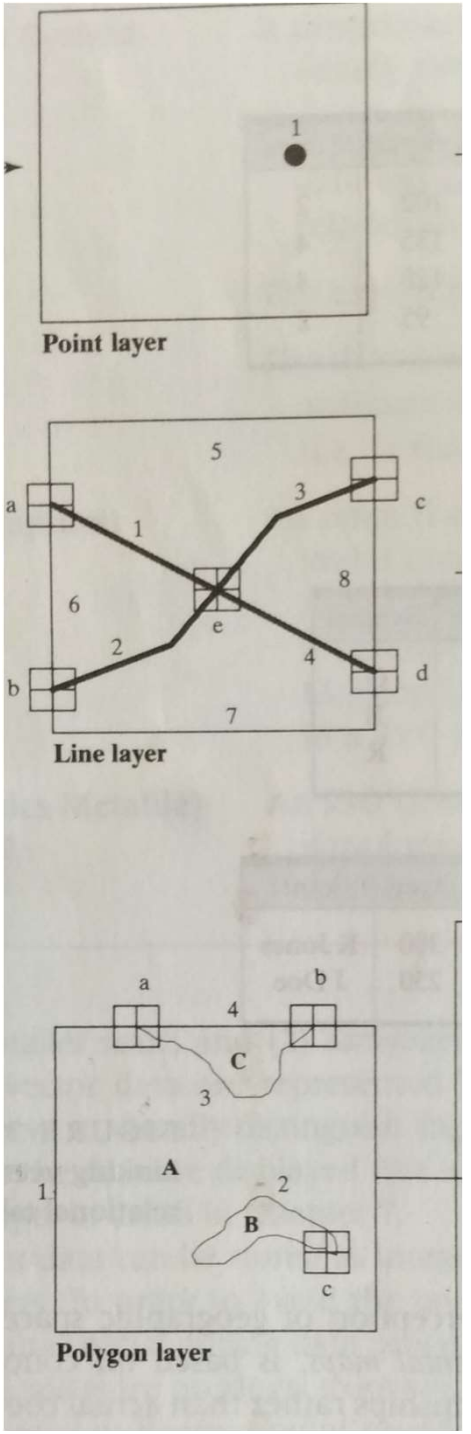
TOPOLOGY defines additional structure

- **Node : an intersect of more than two lines or strings, or start and end point of string with node number .**
- **Chain : a line or a string with chain number, start and end node number, left and right neighboured polygons**
- **Polygon : an area with polygon number, series of chains that form the area in clockwise order (minus sign is assigned in case of anti-clockwise order).**

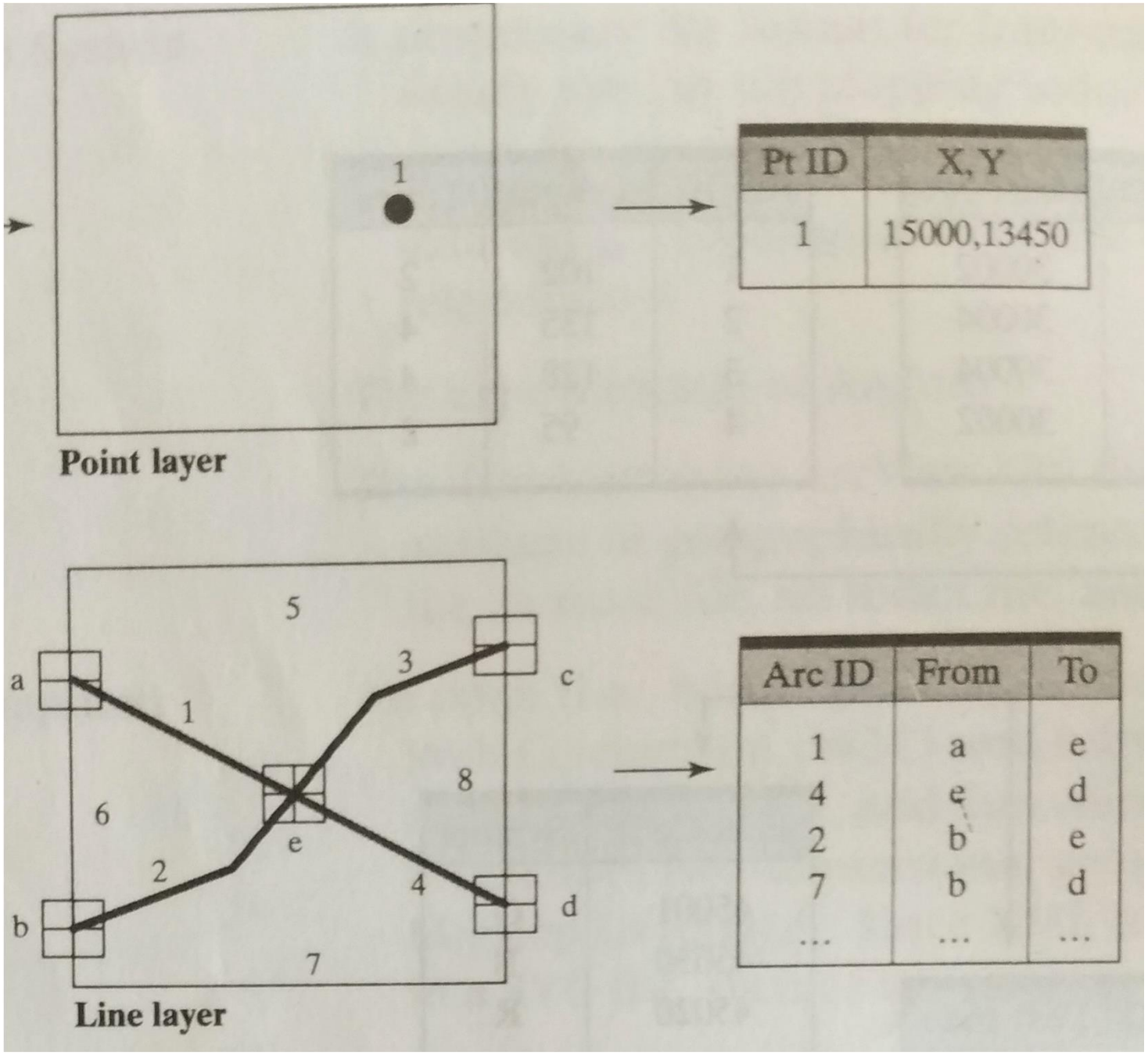
Layers of topographical map

A cartographic map



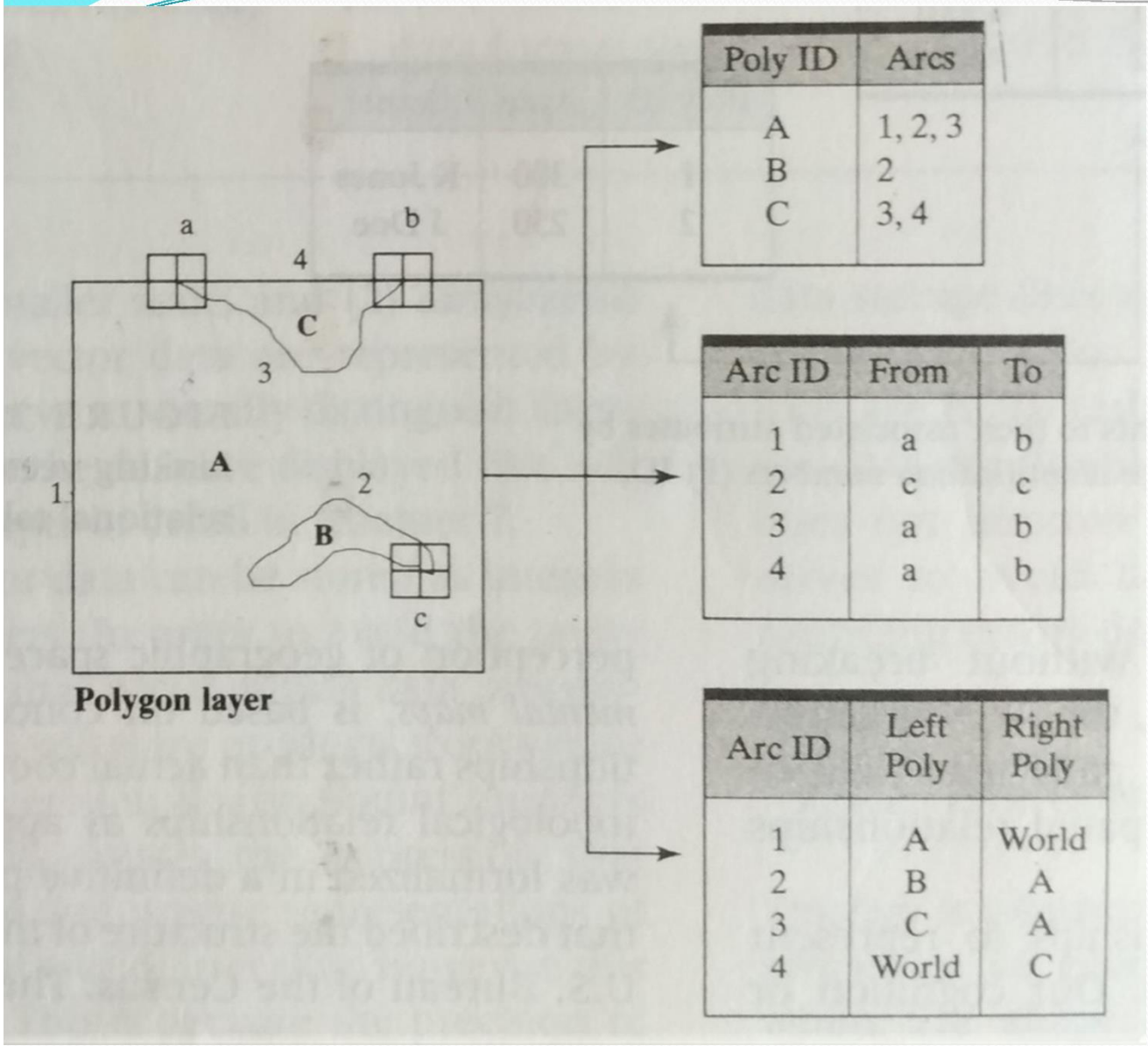


Source:Lo & Yeung, 2009



Point and line layers and associated tables in a topographical map

Source: Lo & Yeung, 2009



Poly ID	Arcs
A	1, 2, 3
B	2
C	3, 4

Arc ID	From	To
1	a	b
2	c	c
3	a	b
4	a	b

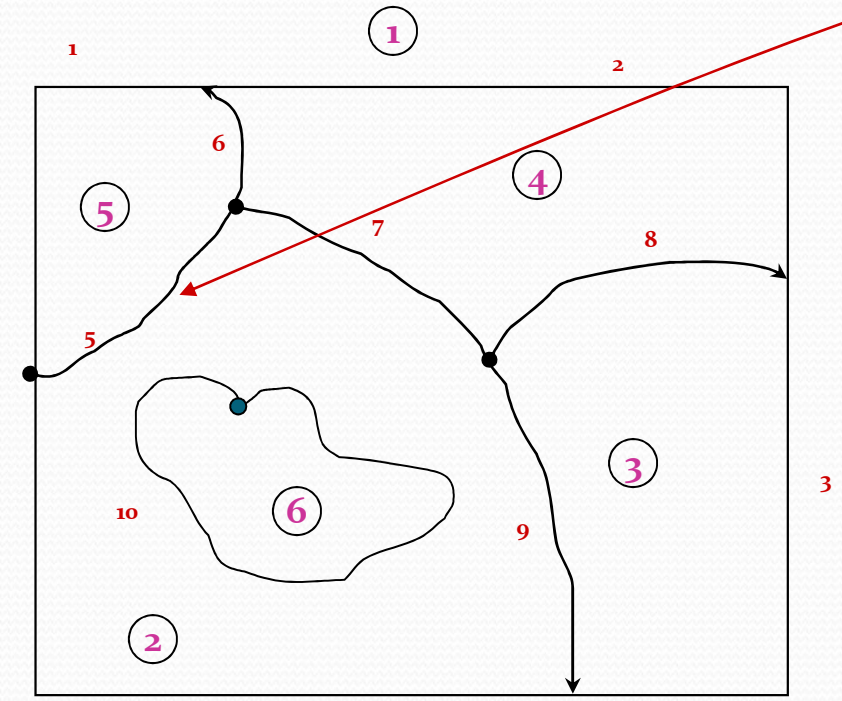
Arc ID	Left Poly	Right Poly
1	A	World
2	B	A
3	C	A
4	World	C

Polygon layer and associated tables in a topographic al map

Source: Lo & Yeung, 2009

ADJACENCY

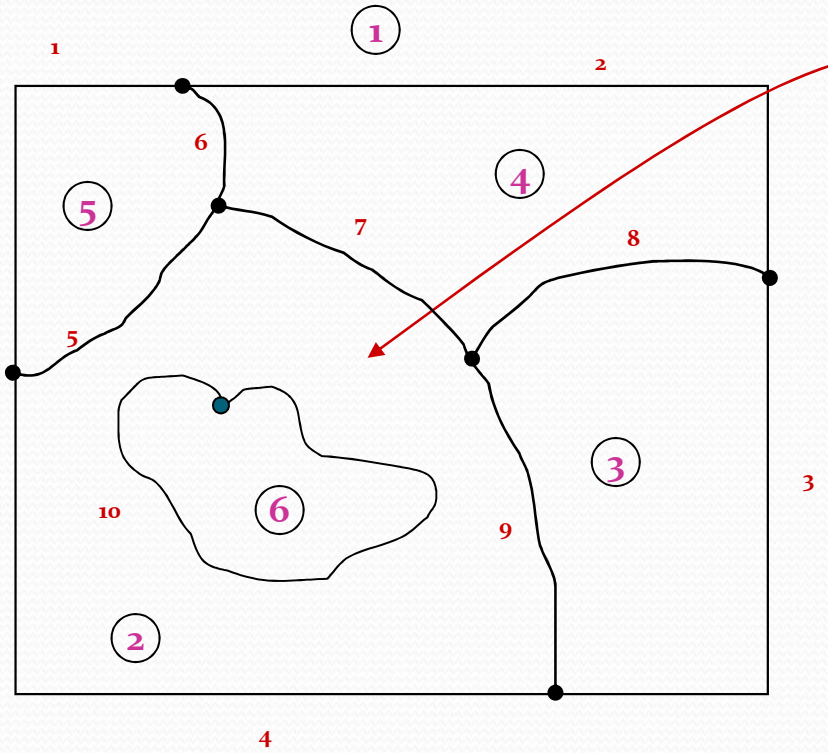
- Defines the direction of each arc and its neighbourhoodness
- Each arc has a direction (From-node ….. to-node)
- A list of the polygons on the left and right side of each arc is maintained by GIS.



Polygon 5 is on the left side of arc 5 and polygon 2 is on its right.

CONTAINMENT

- Polygons are represented as series of x, y co-ordinates connecting to enclose an area.



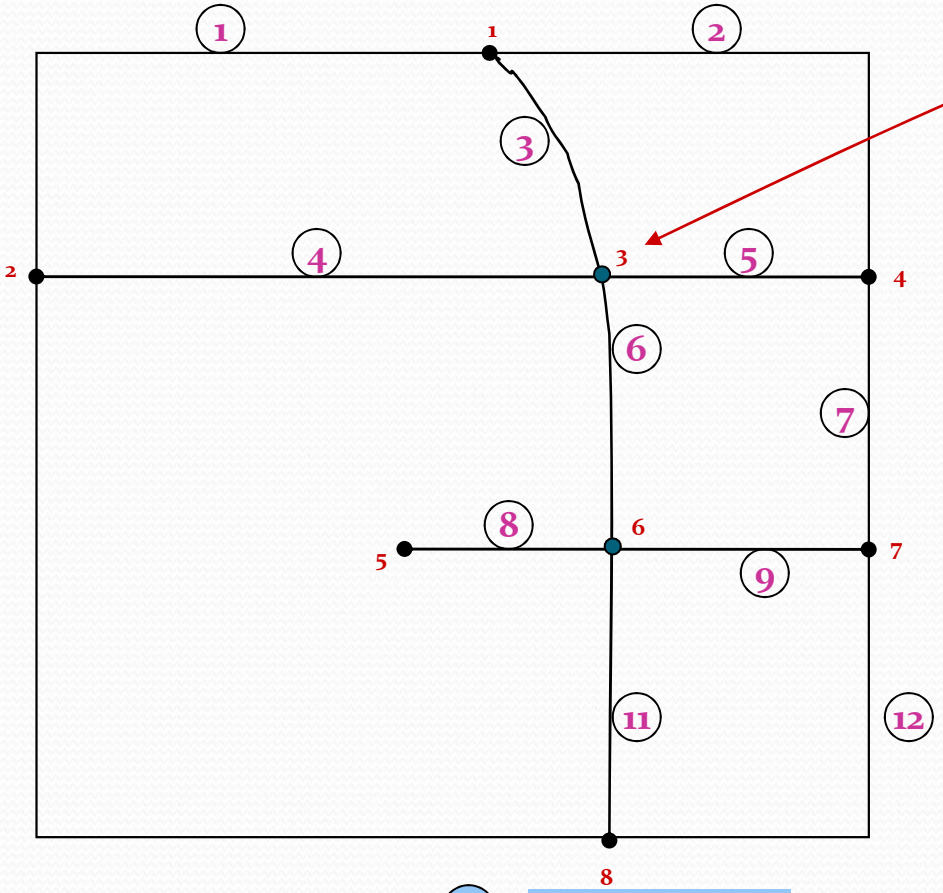
Arcs 4,5,7,9 comprise of polygon 2, which in turn contains an island polygon 6 inside it (made of arc 10).

(12) Polygon Number

8 Arc number

CONNECTIVITY

- Vertices define the shape of an arc, Nodes are the endpoints of an arc.
- By tracking all the arcs that meet at any node, GIS understands that which arcs connect to each other.



Arcs 3,4,5 and 6 join at node 3.

So it is possible to travel along arc 5 and turn onto arc 3 since they share a common node (3).

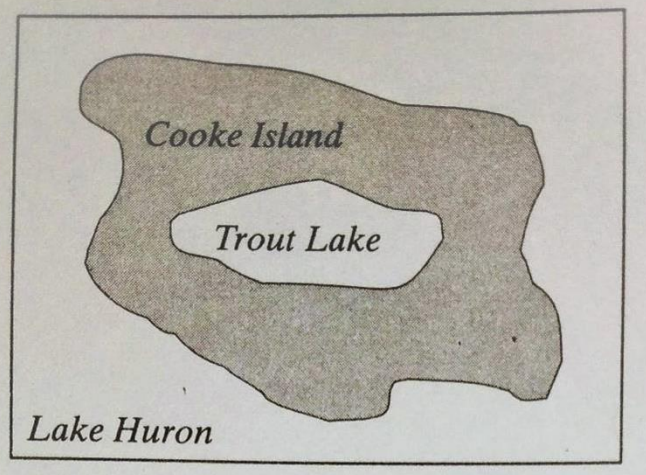
This is not the case with arc 5 and arc 9 as they don't share a common node.

8 Node number

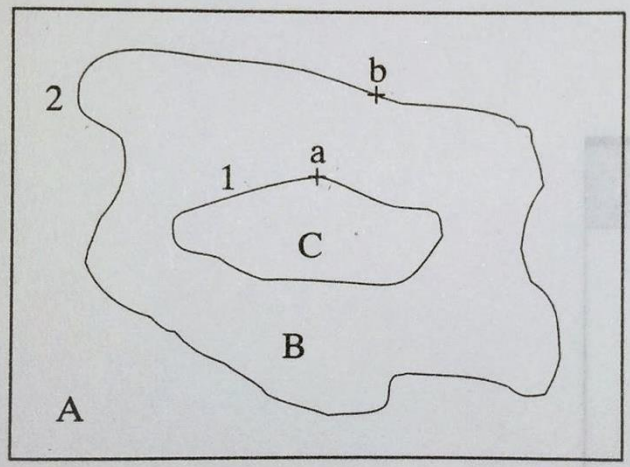
12 Arc number

WHY TOPOLOGICAL MAPPING?

1. Data input and representation
2. Spatial search
3. Construction of complex spatial objects from basic graphical elements – islands and multipart polygons
4. Integrity checks in database creation



(a) Cartographic map

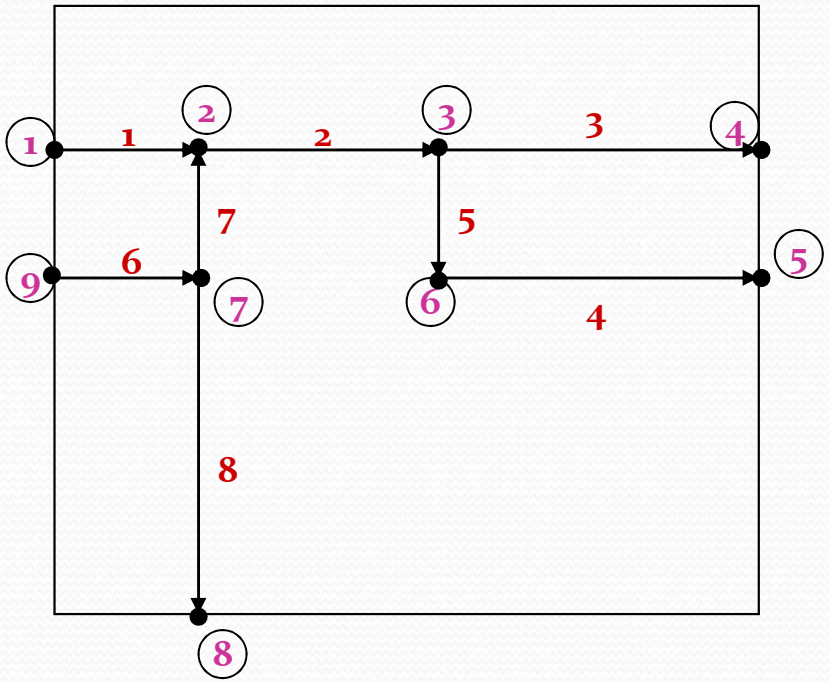


(b) Topologic map

Arc ID	From_node	To_node	Left_Poly	Right_Poly
1	a	a	B	C
2	b	b	A	B

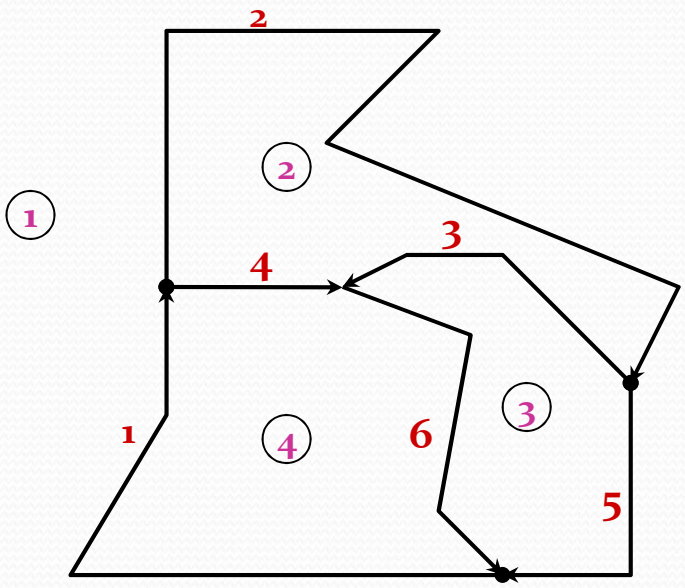
(c) Arc attribute table

Hands on



Arc	*From-node*	*To-node*
1		
2		
3		
4		
5		
6		
7		
8		

Hands on



Polygons	*Arcs (list)*
1	
2	
3	
4	

Arcs	*Left Polygon*	*Right Polygon*
1		
2		
3		
4		
5		
6		