

GEOSPATIAL / GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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Chapter – 2

GIS DATA STRUCTURES

Data Structure: Data Structure in GIS - Types of Data (Points, Lines and Polygons) - Data Base Structures (Raster Data Structures and Vector data Structures) - Data Conversion, (Vector to Raster and Raster to Vector).

2. GIS DATA STRUCTURES

2.1 Definition

- Computer based data structure for the representation of real world entities
 - Two types
 - Vector data structure
 - Raster data structure
 - A data structure that uses
 - points, lines and polygons to describe world surface / spatial phenomena – VDS
 - Sets of regular shaped tessellated units to describe world surface / spatial phenomena – RDS
 - Tessellate - cover a surface by repeated use of a single shape without gaps or overlapping.

2.2 File and Data access

- Essential features of any data storage system are that they should allow data to be accessed and cross-referenced quickly.
- Simple lists
- Ordered sequential files – Nos. in Telephone directory
- Indexed files – Word search in a dictionary
 - Direct files
 - Indirect files
 - Index inverted files

Inverted files

Soil Profile No.	Series	pH	Depth	Drainage	Texture	Erosion
1	A	4	Deep	Good	Sandy	---
2	B	5	Shallow	Good	Clay	Yes
3	C	6	Shallow	Poor	Sandy	No
4	D	7	Deep	Good	Clay	Yes
5	E	4	Deep	Poor	Clay	No
6	F	5	Shallow	Poor	Clay	No

Index (Inverted file)

Topic	Soil Profiles (sequential numbers in original file)					
	1	2	3	4	5	6
Deep						
Shallow						
Good Dr.						
Poor Dr.						
Sandy						
Clay						
Eroded						

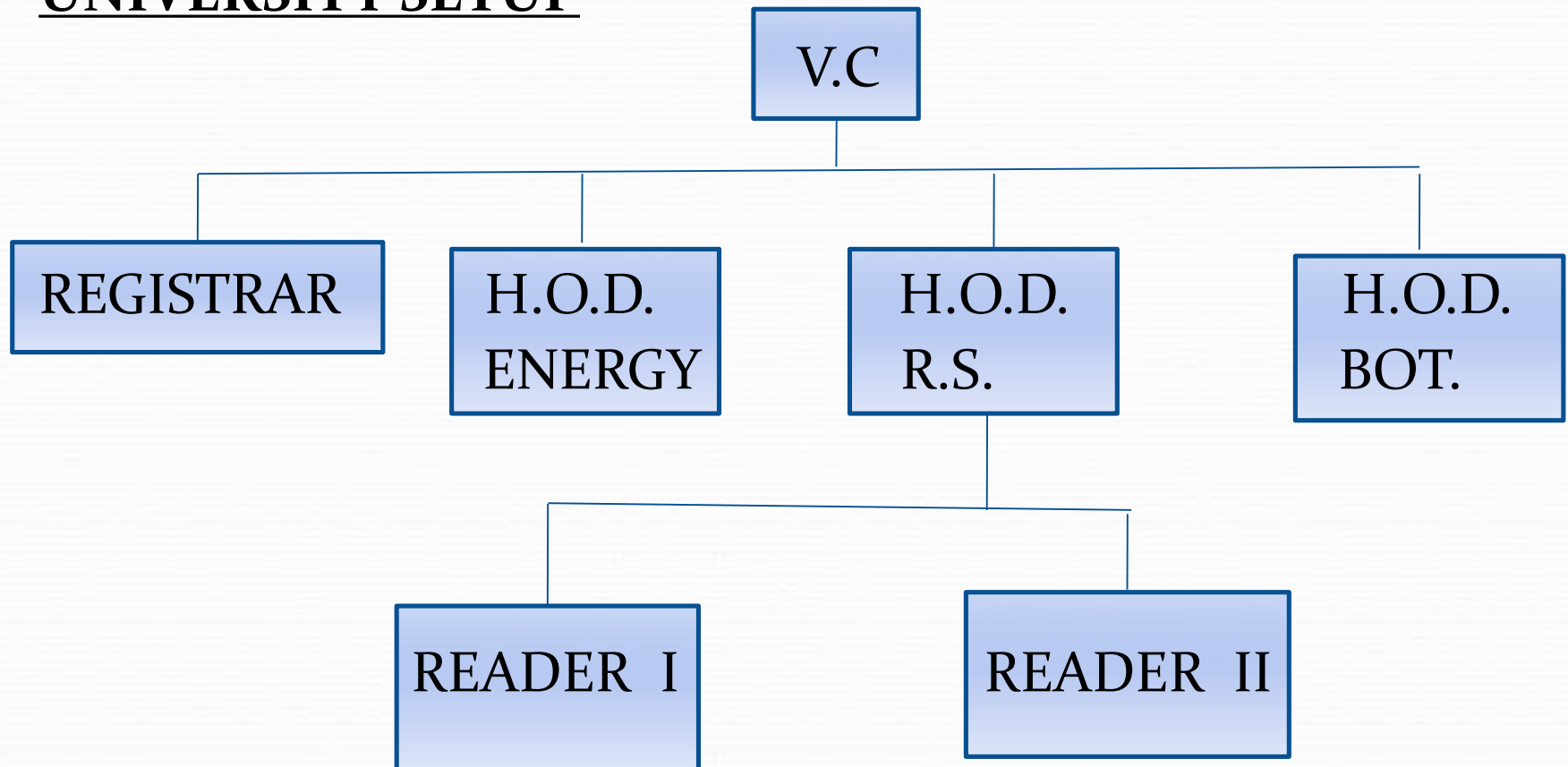
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2.3 Database structures and management

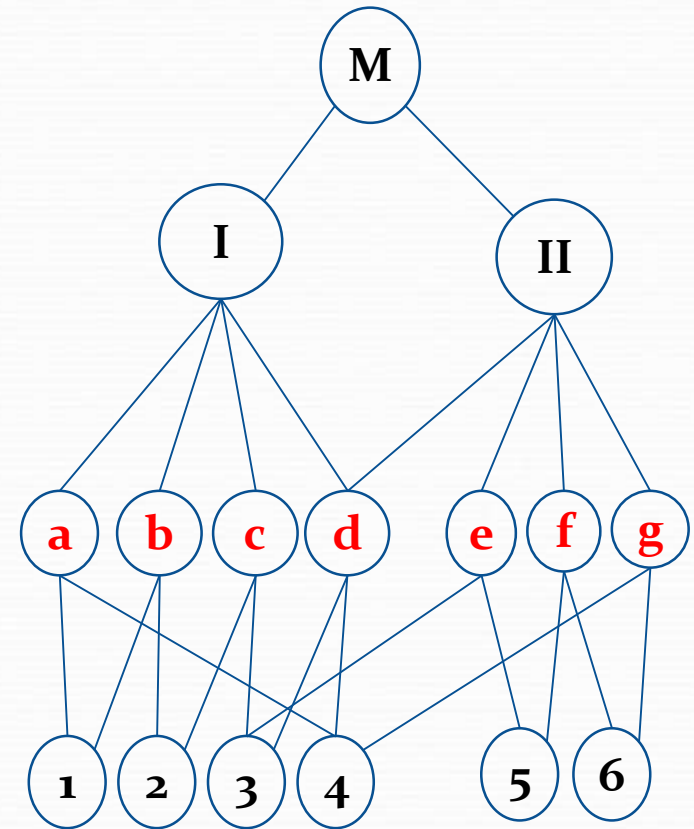
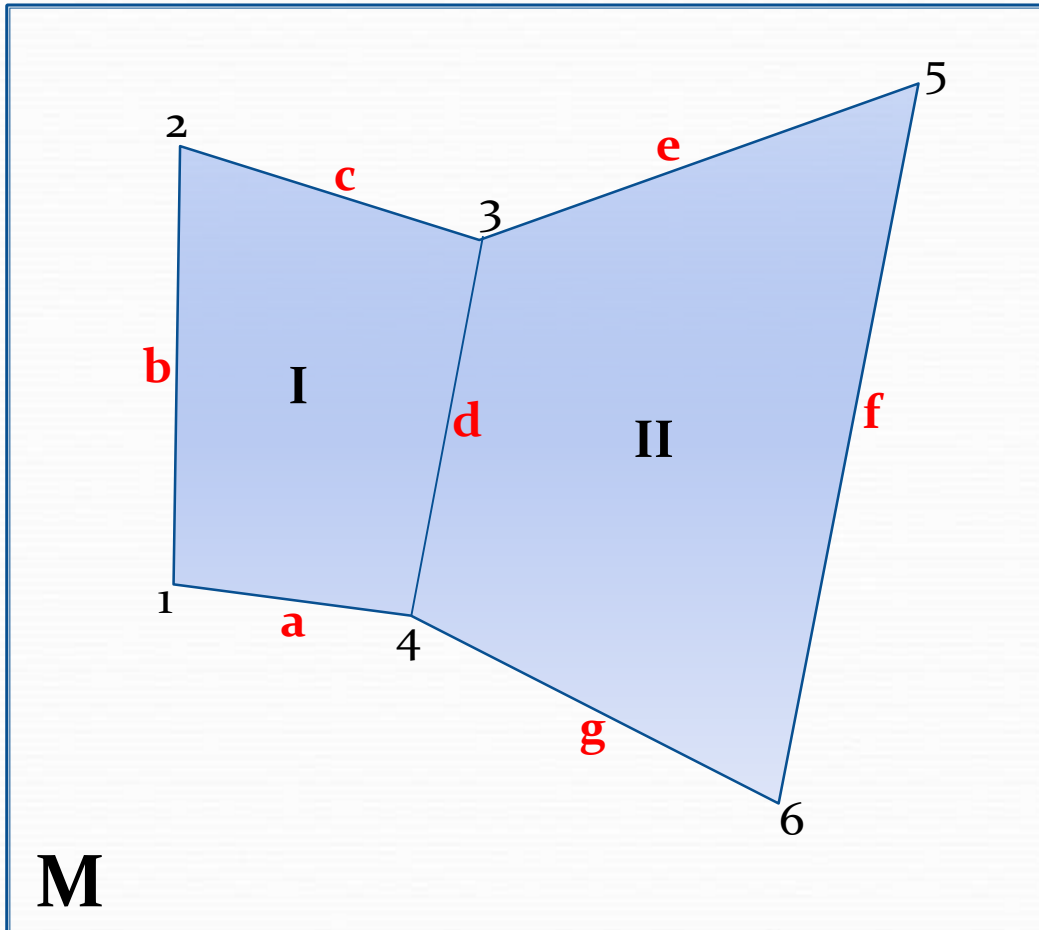
- Hierarchical database structure
- Network database structure
- Relational database structure
- Object-oriented database structure
- Full topological polygon network structure
- TIGER
- Other developments in database structures

HIERARCHICAL DATA STRUCTURE

UNIVERSITY SETUP



NETWORK DATA STRUCTURE

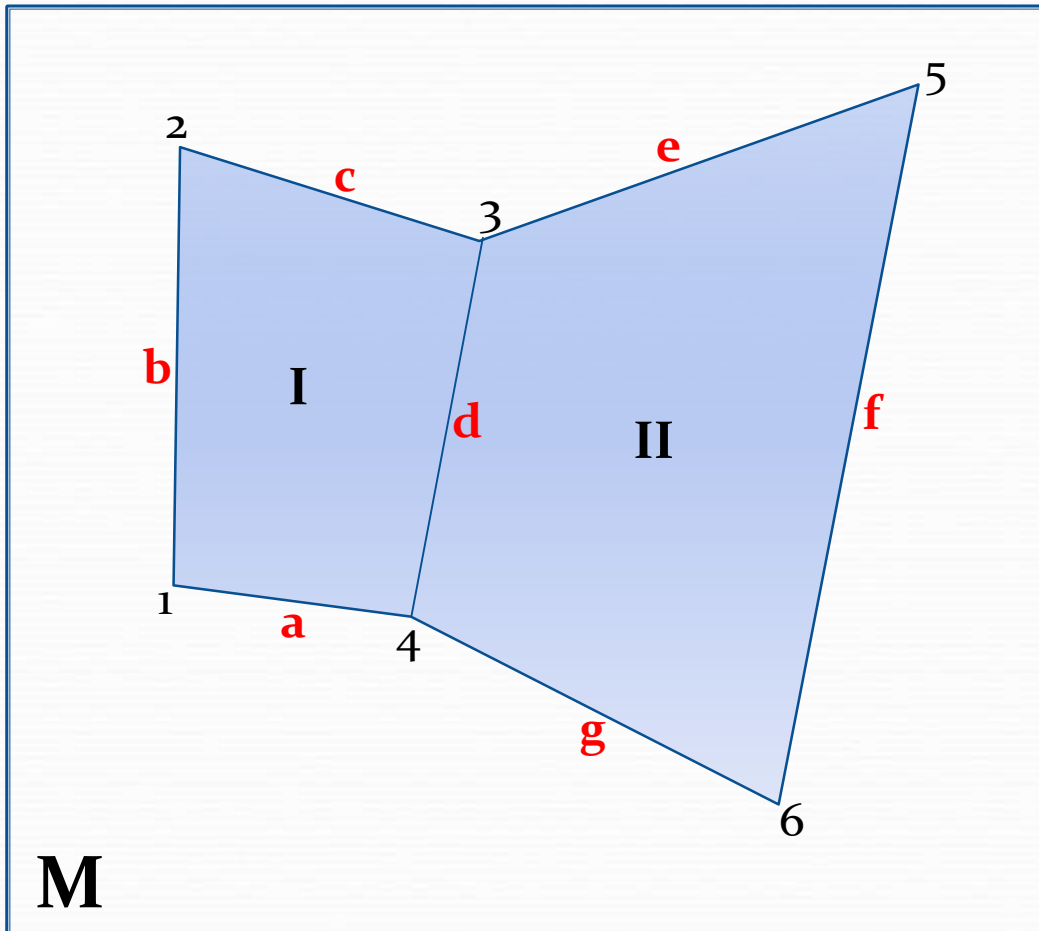


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Map M consists of 2 polygons, 7 lines (6+1 shared) and 6 nodes,

RELATIONAL DATA STRUCTURE



Map:

M	I	II
---	---	----

Polygons:

I	a	b	c	d
II	d	e	f	g

Lines:

I	a	4	1
I	b	1	2
I	c	2	3
I	d	3	4
II	e	3	5
II	f	5	6
II	g	6	4
II	d	3	4

Co-ordinates:

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OBJECT-ORIENTED GIS

Object-oriented data model is one application of object-oriented technology.

- it uses objects to organize spatial data.
- Unlike a geometric object of a point, line or area, an **OBJECT** is defined here as something that has a set of properties and can perform operations upon requests.
- That means, almost everything one uses in a GIS is an object.
- For e.g., a land use map is an object, which has properties, such as its coordinate system and feature type and can respond to requests such as zoom in, zoom out and a query.

Structural aspects

Principles: To group objects : association, aggregation, generalization, instantiation and specialization aspects are required.

Association: Describes the relationships between objects of two types.

If owner and land parcel represent two types of objects, the relationships between them can follow the rules that

- an owner can own one or more parcels and
- a parcel can be owned by one or more owners.

Aggregation: Asymmetric association in a whole-part relationship.

For e.g., block groups are connected to form a census tract and census tracts are connected to form a county.

Generalization: Identifies the commonality among objects, and groups objects of similar types into a higher-order type.

For e.g., parcel, zoning and census tract maps may be grouped into a higher-order class called boundary.

Grouping of objects forms a hierarchical structure, which organizes objects into classes and classes into superclasses and subclasses.

Instantiation: An object of a class can be created from an object of another class.

For e.g., a high-density residential area object may be created from a residential area object.

Specialization: Differentiates objects of a given class by a set of rules.

For e.g., roads may be separated by average daily traffic volume.

Behavioural aspects of objects:

Application of object oriented data model is to GIS.

- it is the behavioural aspects of objects.

Inheritance: It is the basic principle in explaining the behaviours of objects:

- subclasses inherit properties and operations from a superclass, and
- objects inherit properties and operations from a subclass.

For e.g., the residential area is a superclass and low-density area and high-density area are the subclasses.

- All properties of the class residential area are inherited by its own subclasses.
- Through inheritance, properties need only be defined once in the class hierarchy.

Encapsulation and polymorphism: Encapsulation refers to the mechanism to hide the properties and operations of an object so that the object can perform an operation by responding to a predefined message or request.

For e.g., a polygon object can respond to a request called ReturnCenter (return the center of) by returning the physical center of the polygon.

Polymorphism: It allows the same operation to be implemented in different ways in different objects.

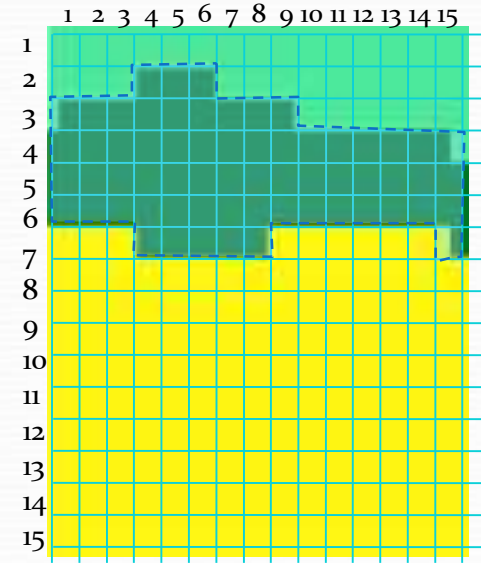
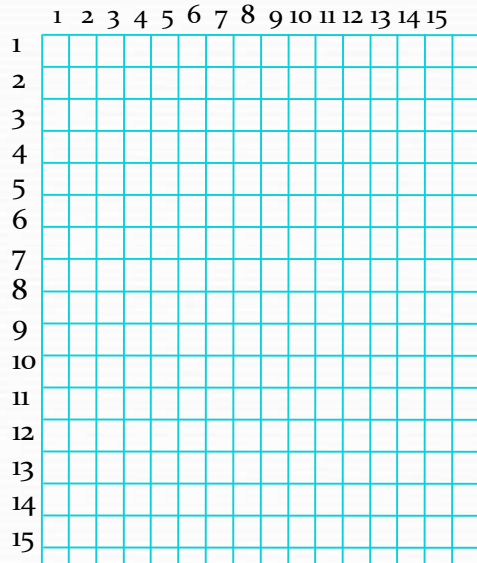
For e.g., the same request called GetDimension (get the dimension of) can be sent to a point, a line, or a polygon but the result differs depending on the feature type.

The number 0 is returned if the object is point,
1 if the object is a line, and
2 if the object is a polygon.

2.4 Data structures for Raster data

- Simple raster database structure
- Hierarchical database structure
- Compact methods of storing raster data
 - Chain encoding
 - Run length encoding
 - Block encoding
 - Quadtree and binary tree encoding

Chain encoding



$0^3, 1^1, 0^3, 3^1, 0^3, 3^1, 0^5, 3^1, 0^1, 3^3, 2^1, 1^1, 2^6, 3^1, 2^5, 1^1, 2^3, 1^4$

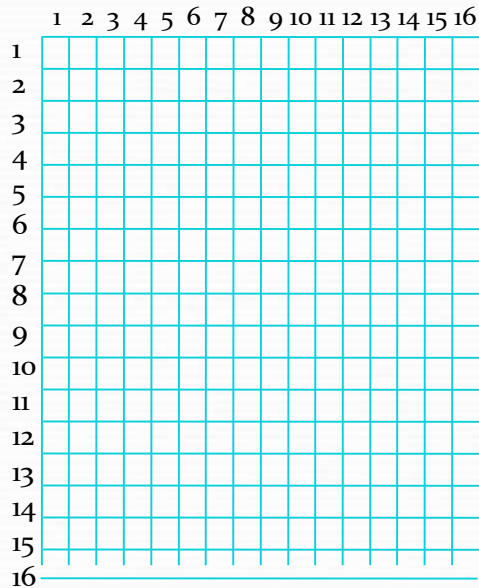
Conditions:

1. Define Origin: X & Y of starting cell
2. Sequence of unit vectors / cells along the outer boundary of the region in cardinal directions
3. Directions can be numbered (East = 0
North = 1
West = 2
South = 3)
4. Boundary of the region is coded clockwise.

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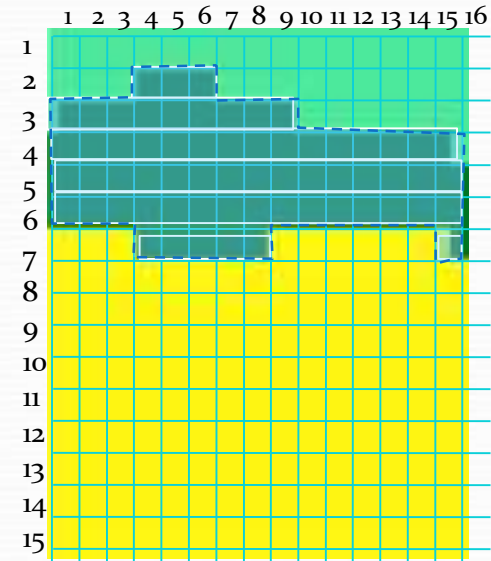


Run length encoding



Row wise from
left to right –
begin cell, end
cell of a particular
class

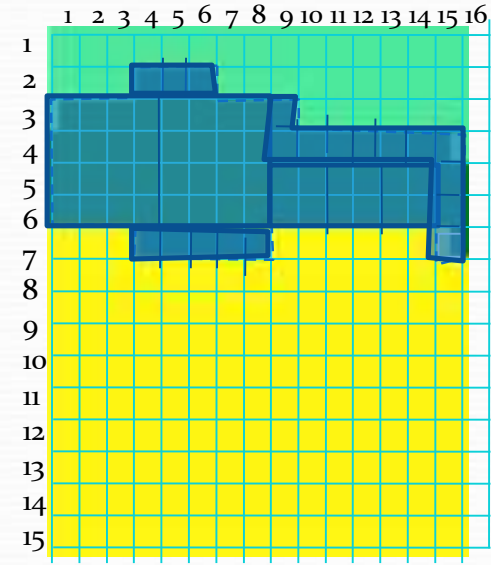
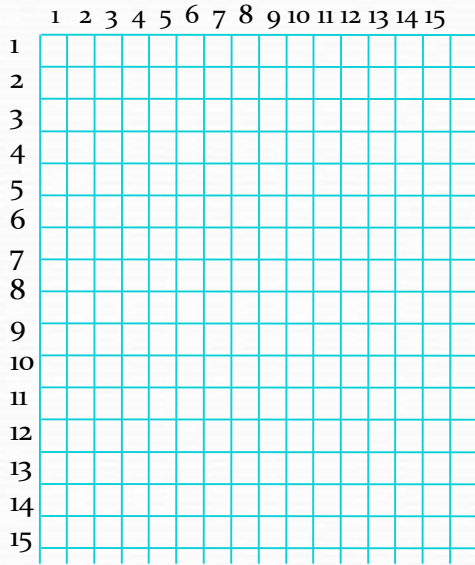
Row 1	
Row 2	4,6
Row 3	1,9
Row 4	1,15
Row 5	1,15
Row 6	1,15
Row 7	4,8 15,15



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Block encoding



Illr to RLE, but 2 dimensionally, using square blocks

Data structure consists of 3 nos.

1. The origin – X, Y (centre or bottom left)
2. Radius of each square – single unit squares, 4-square blocks, 16-square blocks, etc.

For Green Region 'B',

2 16-squares

3 4-squares

16 unit squares

2 coordinates for each square (42)

3 for cell sizes,

Total=45 nos.

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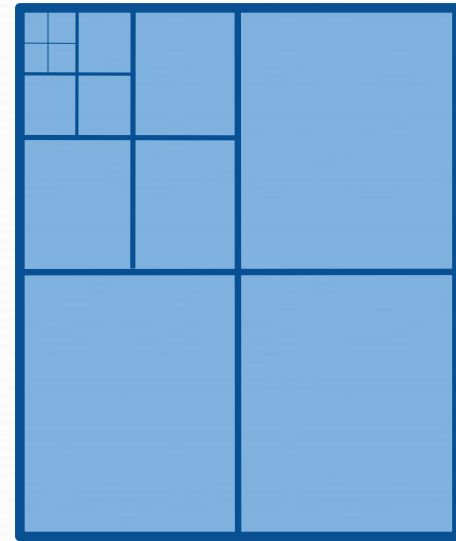
Quadtree encoding

Successive, hierarchical division
of $2^n \times 2^n$ array

If the region is divided into half
each time – binary

If the region is tiled into
quadrants – quadtree

Lowest limit of the division is -
single cell.



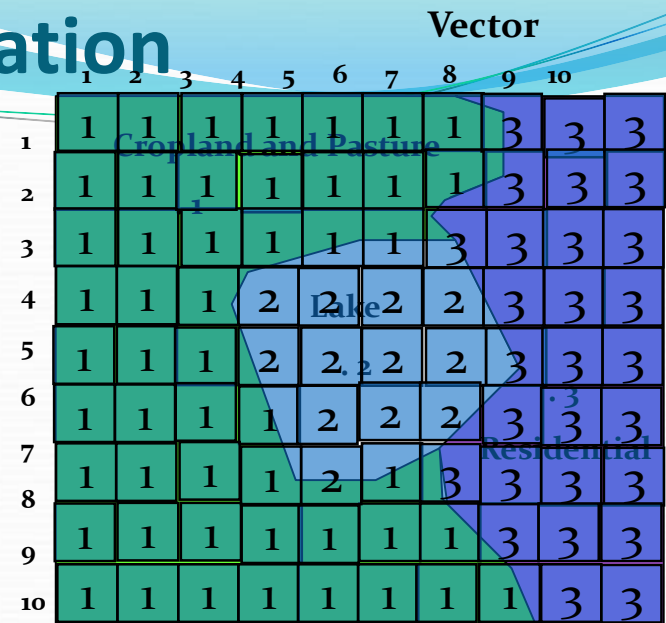
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16



GIS Data Representation



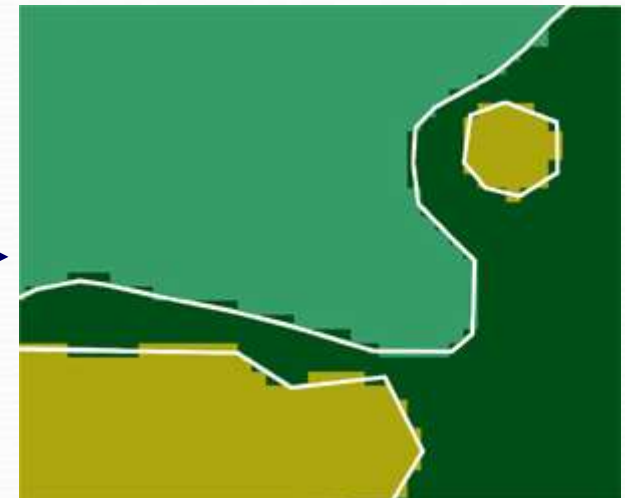
Consist arrays of cells in a grid pattern



Raster (Pixel size = 5mm x 5mm)



Vectorization



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Consist vector elements – points, lines & polygons

2.5 Vector – Raster comparison

ADVANTAGES AND DISADVANTAGES OF RASTER DATA BASE

SL. NO.	<u>ADVANTAGES</u>	<u>DISADVANTAGES</u>
1.	DATA STRUCTURE IS SIMPLE	IF THE PIXEL SIZE IS LARGER TO REDUCE THE THEN DETAILS ARE LOST
2.	OVERLAYING OF THEMATIC DATA WITH REMOTELY SENSED DATA IS EASY	NETWORK LINKAGE IS DIFFICULT
3.	SPATIAL ANALYSIS IS EASY	PROJECTION & TRANSFORMATION IS TIME CONSUMING
4.	SIMULATION IS EASY	OUTPUT LOOKS CLUMSY

2.5 Vector – Raster comparison...CONTD...

ADVANTAGES AND DISADVANTAGES OF VECTOR DATA BASE

SL. NO.	<u>ADVANTAGES</u>	<u>DISADVANTAGES</u>
1.	COMPACT DATA STRUCTURE	COMPLEX DATA STRUCTURE
2.	TOPOLOGY WITH CLEAR NETWORK	COMBINATION OF SEVERAL THEMES CREATE PROBLEMS
3.	ACCURATE GRAPHICS	SIMULATION AND PROGNOSTIGATION IS DIFFICULT
4.	RETRIVAL AND UPDATING IS POSSIBLE	SPATIAL ANALYSIS IS DIFFICULT