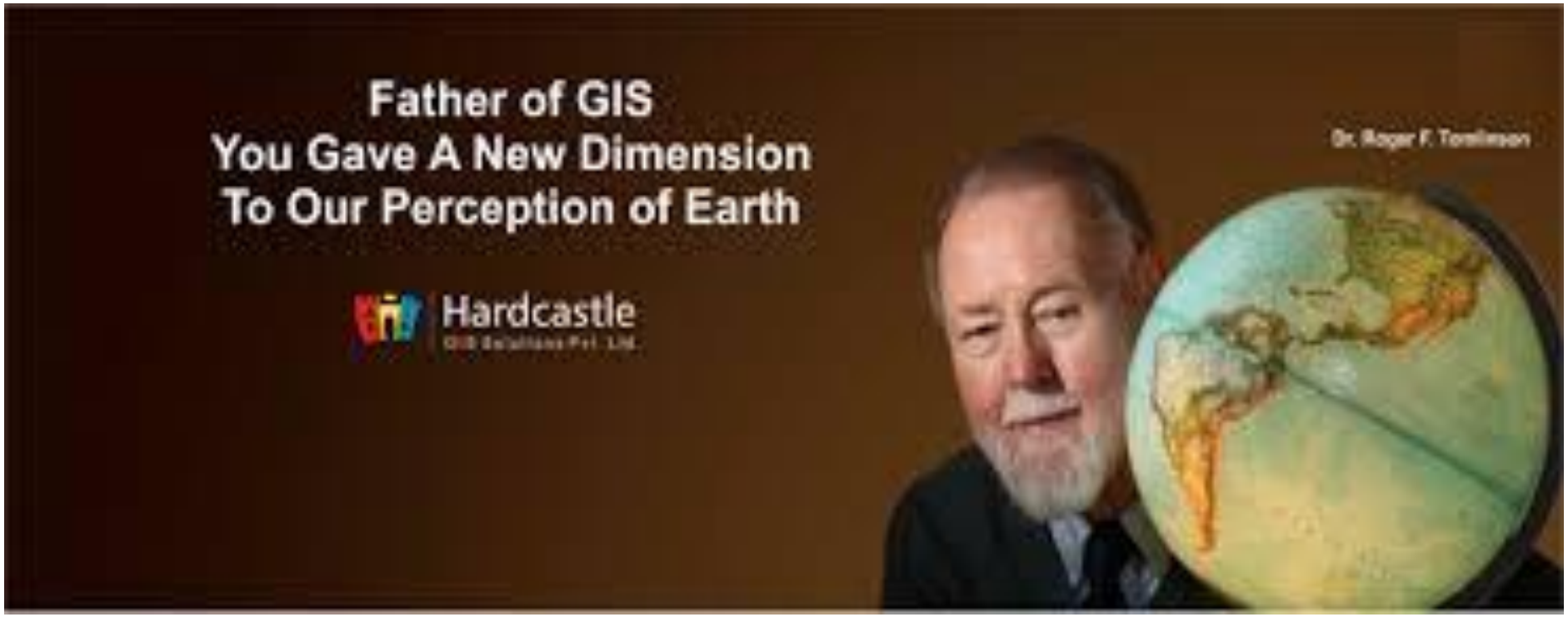
Geographic Information System

Lecture -1



Roger Tomlinson

INTRODUCTION TO GIS

GIS stands for **Geographical Information System**

It is defined as an integrated tool, capable of mapping, analyzing, manipulating and storing geographical data in order to provide solutions to real world problems and help in planning for the future.

GIS deals with ***what*** and ***where*** components of occurrences. For example, to regulate rapid transportation, government decides *to build fly-over* (what component) in those areas of the city ***where traffic jams are common*** (where component).

Burrough (1998) defined GIS as " a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes"

Objectives of GIS

Some of the major objectives of GIS are to

- Maximizing the efficiency of planning and decision making
- Integrating information from multiple sources
- Facilitating complex querying and analysis
- Eliminating redundant data and minimizing duplication

Components of a GIS

A GIS has following components:

Hardware : It consists of the equipment and support devices that are required to *capture, store process and visualize the geographic information*. These include computer with hard disk, digitizers, scanners, printers and plotters etc.

Software : Software is at the heart of a GIS system. The GIS software must have the basic capabilities of *data input, storage, transfosrmation, analysis and providing desired outputs*. The interfaces could be different for different softwares. The GIS softwares being used today belong to either of the category –proprietary or open source. ArcGIS by ESRI is the widely used proprietary GIS software. Others in the same category are MapInfo, Microstation, Geomedia etc. The development of open source GIS has provided us with freely available desktop GIS such as Quantum, uDIG, GRASS, MapWindow GIS etc., GIS softwares.

Data : The data is captured or collected from ***various sources*** (such as maps, field observations, photography, satellite imagery etc) and is ***processed*** for analysis and presentation.

Procedures : These include the methods or ways by *which data* has to be input in the system, retrieved, processed, transformed and presented.

People : This component of GIS includes all those individuals (such as programmer, database manager, GIS researcher etc.) who are making the GIS work, and also the individuals who are at the user end using the GIS services, applications and tools.

History of GIS

Mapmaking (representation of geographical information): The direct evidence of mapping comes from Middle East in the form of Babylonian Clay Tablets as early as 1000 B.C which depicted earth as a flat circular disk.

- Eratosthenes (200 B.C): calculated the circumference of earth accurately.
- Ptolemy and Al-Idrisi : contributions in the field of cartography.
- Mercator and Newton: Inspired cartographers and geographers to better understand the earth and the geographical phenomenon.

Putting layers of data on series of base maps to analyze things geographically has been into existence much longer than the introduction of computers to the geographical world.

The French cartographer Louis-Alexandre Berthier had drawn the maps of the Battle of Yorktown (1781) that contained hinged overlays to show troop movements.

L. A. Berthier

Berthier's map of Battle of Yorktown (1781)

Dr. John Snow showed the locations of death by cholera on a map to track the source of outbreak of cholera in Central London in September, 1854.

- Introduction of computers in the field of geography was a positive step towards understanding and learning the subject better.

- Change in cartographic analysis due to improved graphics, development of theories of spatial processes in economic and social geography, anthropology and regional science, increased social awareness and improvement in education.

- Integrated transportation plans of Detroit, Chicago during the period of 1950s and 1960s used information on routes, origin, destination, and time to produce the maps of traffic flow and volume is an example of integration of computer technology with geographical data.

Early Developments in GIS

Canada Geographic Information System (CGIS)

Roger Tomlinson and colleagues (1960s) for Canadian Land Inventory.
It was developed as a measuring tool (to measure area), a producer of tabular information rather than a mapping tool.

Harvard Laboratory

The Harvard laboratory for Computer Graphics and Spatial Analysis (1964) by Howard Fisher.
The GIS packages developed were SYMAP, CALFORM, SYMVU, GRID, POLYVRT, ODYSSEY

Dual Independent Map Encoding (DIME)

US Bureau of Census in 1967 to conduct the 1970 census of population.
Digital records of all US streets were created to support census records.

Environmental Systems Research Institute (ESRI)

Jack Dangermond (1969) to undertake GIS projects.
In 1981, ESRI launched ArcInfo (major commercial GIS software system) based on vector & relational database data model.

Longley et al (2001) have described the period from1980 to 2000 as the era of commercialization in the field of GIS.
(commercial GIS industries, research centers, GPS, OpenGIS Consortium, Internet GIS products along with publications on GIS and allied fields)

The period after 2000 is referred to as the era of exploitation. In 2000, it was estimated that GIS was being used by one million core users and five million casual users.

Importance of GIS

GIS informs not only about the activities and the events but also where they exist. The solutions to problems often require access to several types of information that can only be linked by geography. GIS allows to store and manipulate information using geography and to analyze patterns, relationships, and trends in that information to help in making better decisions.

Application of GIS

Tax Mapping: Raising revenue from property taxes is one of the important functions of the government agencies. The amount of tax payable depends on the value of the land and the property. The correct assessment of value of land and property determines the equitable distribution of the community tax. A tax assessor has to evaluate new properties and respond to the existing property valuation. To evaluate taxes the assessor uses details on current market rents, sale, maintenance, insurance and other expenses. Managing as well as analyzing all this information simultaneously is time consuming and hence comes the need of GIS. Information about property with its geographical location and boundary is managed by GIS. Land units stored in parcel database can be linked to their properties. Querying the GIS database can locate similar type of properties in an area. The characteristics of these properties can then be compared and valuation can be easily done .

Business: Approximately 80 percent of all business data are related to location. Businesses manage a world of information about sales, customers, inventory, demographic profiles etc. Demographic analysis is the basis for many other business functions: customer service, site analysis, and marketing. Understanding your customers and their socioeconomic and purchasing behavior is essential for making good business decisions. A GIS with relevant data such as number of consumers, brands and sites they go for shopping can give any business unit a fair idea whether their unit if set up is going to work at a particular location the way they want it to run.

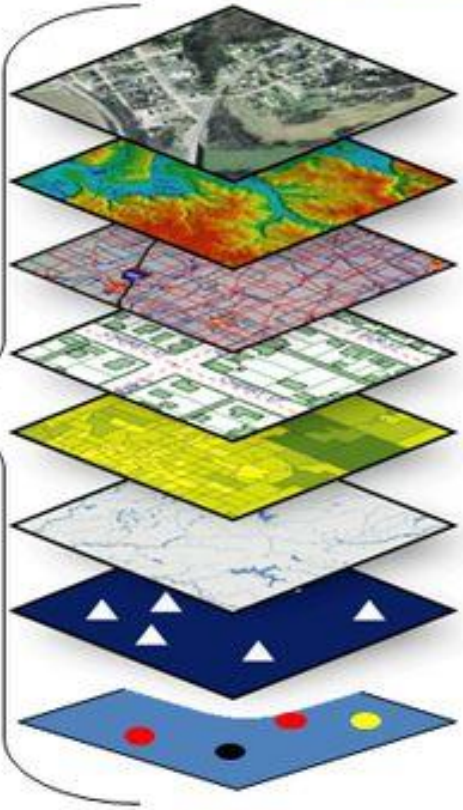
Logistics: Logistics is a field that takes care of transporting goods from one place to another and finally delivering them to their destinations. It is necessary for the shipping companies to know where their warehouses should be located, which routes should the transport follow that ensures minimum time and expenditures to deliver the parcels to their destinations. All such logistics decisions need GIS support.

Emergency evacuation: The occurrence of disasters is unpredictable. We as humans are unable to tell when, where and what magnitude of disaster is going to emerge and therefore solely depend on disaster preparedness as safety measures. It is important to know in which area the risk is higher, the number of individuals inhabiting that place, the routes by which the vehicles would move to help in evacuating the individuals. Thus preparing an evacuation plan needs GIS implementation.

Environment: GIS is being increasingly involved in mapping the habitat loss, urban sprawl, land-use change etc. Mapping such phenomena need historical landuse data, anthropogenic effects which greatly affect these phenomena are also brought into GIS domain. GIS models are then run to make predictions for the future.

The Real World

GIS World Model



Imagery

Elevation

Transportation

Addresses

Boundaries

Water Features

Survey Control

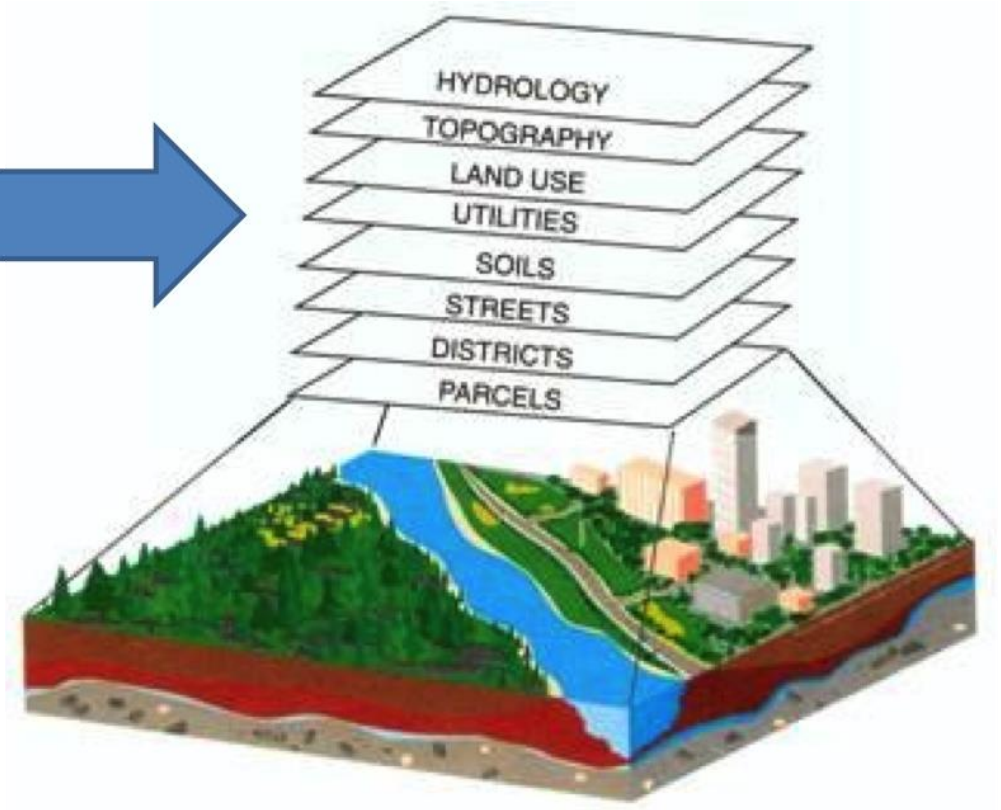
Your Data

Types of data

- 1. Spatial data:
  - Says ***where*** the feature is
  - Co-ordinate based
  - Vector data – discrete features:
    - Points
    - Lines
    - Polygons (zones or areas)
  - Raster data:
    - A continuous surface
- 2. Attribute data:
  - Says ***what*** a feature is
    - Eg. statistics, text, images, sound, etc.

Layers
(Vector Data)

Basemap
(Raster Data)



Vector and raster

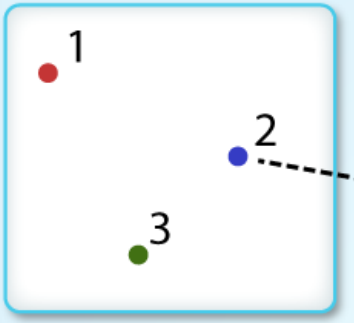
Vector

- Features with discrete shapes and boundaries (e.g., street, land ownership parcel, well)
- Database management
- Database query and reporting
- Network analysis
- High quality maps

Raster

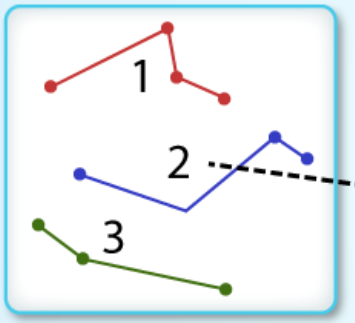
- Continuous surfaces with fuzzy boundaries or with qualities that change gradually over space (e.g., soil, land cover, vegetation, pollution)
- Spatial analysis and modeling (e.g., agricultural suitability)

Example Attributes for Point Data



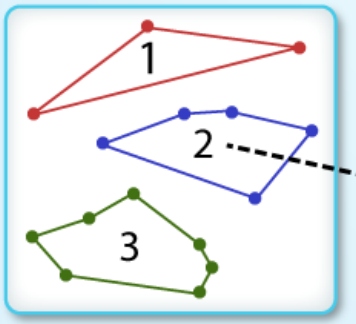
ID	Plot Size	Type	VegClass
1	40	Vegetation	Conifer
2	20	Vegetation	Deciduous
3	40	Vegetation	Conifer

Example Attributes for Line Data



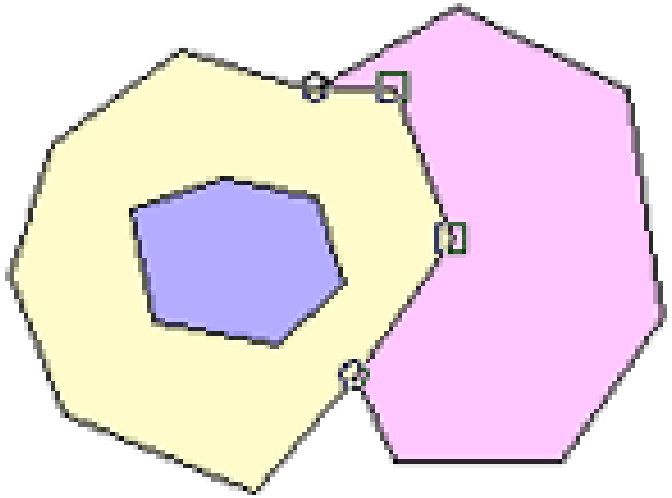
ID	Type	Status	Maintenance
1	Road	Open	Year Round
2	Dirt Trail	Open	Summer
3	Road	Closed	Year Round

Example Attributes for Polygon Data

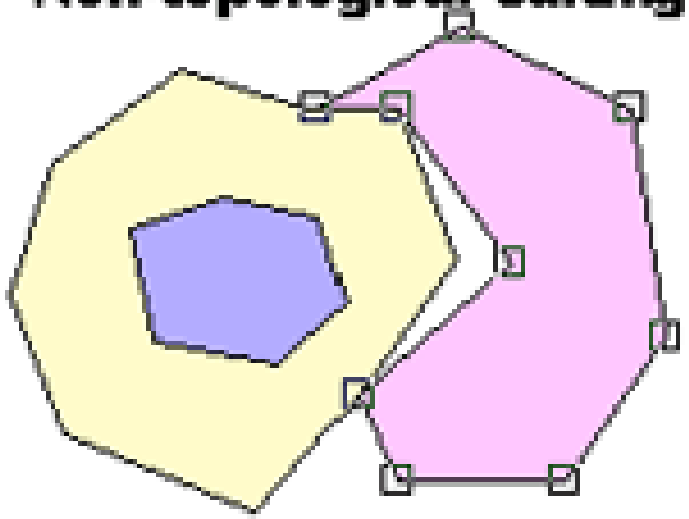


ID	Type	Class	Status
1	Herbaceous	Grassland	Protected
2	Herbaceous	Pasture	Open
3	Herbaceous / Woody	Grassland	Protected

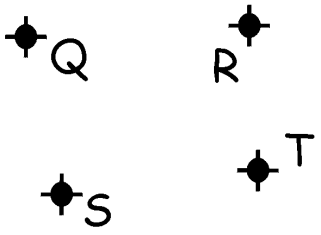
Topological editing



Non-topological editing

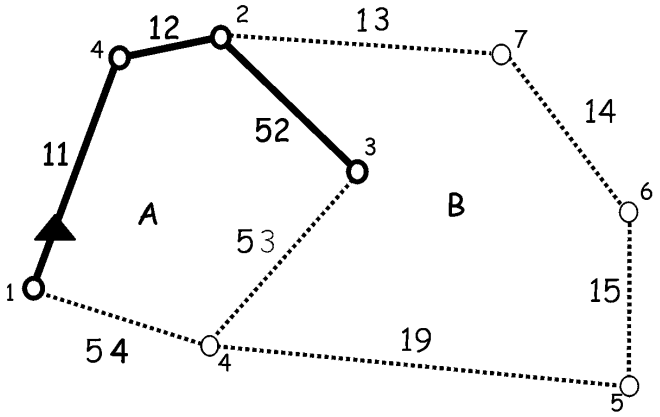


Points



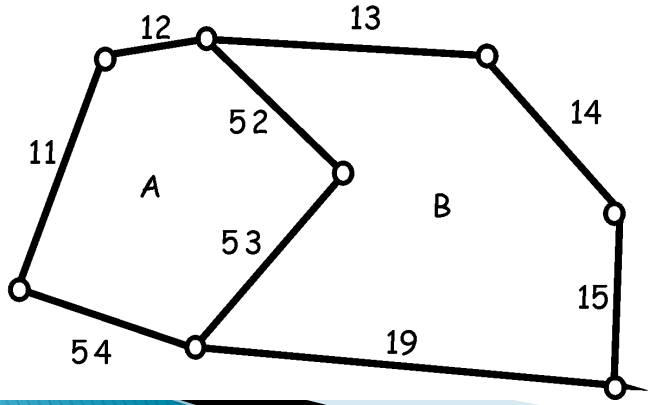
Point ID	X	Y
Q	32.7	45.6
R	76.3	19.5
S	22.7	15.8
etc...		

Lines



Line ID	Begin node	End node	Left poly	Right poly
11	1	4	...	A
12	4	2	...	A
52	2	3	B	A
etc ..				

Polygons



Polygon ID	Lines
A	11,12,52,53,54
B	52,53,19, 15,14,13