AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

DEPARTMENT OF COMUTER SCIENCE AND ENGINEERING

R2017 - SEMESTER V

OPEN ELECTIVE I:
OCE552 - GEOGRAPHICAL INFORMATION SYSTEM

UNIT I - FUNDAMENTALS OF GIS

SYLLABUS

UNIT I FUNDAMENTALS OF GIS 9

Introduction to GIS - Basic spatial concepts - Coordinate Systems - GIS and Information Systems – Definitions – History of GIS - Components of a GIS – Hardware, Software, Data, People, Methods – Proprietary and open source Software - Types of data – Spatial, Attribute data- types of attributes – scales/ levels of measurements.

1. INTRODUCTION TO GIS

1.1 Introduction to GIS

What is GIS?

GIS is an integrated system used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes.

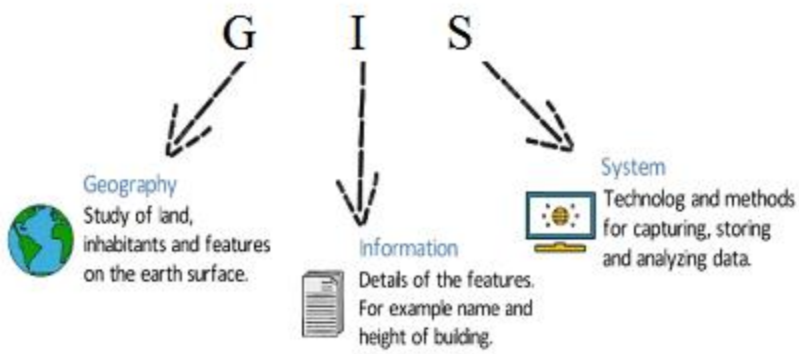
A geographic information system is a conceptualized framework that provides the ability to capture and analyze spatial and geographic data.

- Wikipedia

A GIS is an organized collection of computer hardware, software, geographic data, and personnel to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

A Geographic Information System (GIS) is a system of computer applications that can be used to display, manipulate, and analyze spatially varied information from multiple sources all in one place.

Geographic Information System is nothing but a computer application that captures, stores and displays the various physical and manmade features on the Earth.

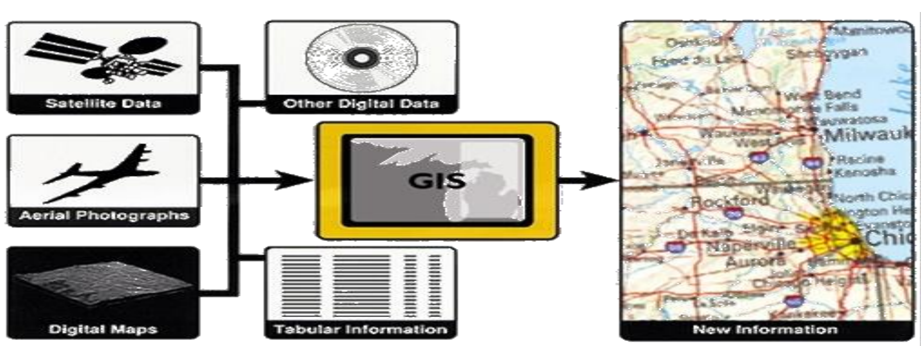


A geographic information system (GIS) is a computer system for capturing, storing, querying, analyzing and displaying geospatial data.

Starting from mountains to buildings, GIS can map everything and store it in a database(DB). One of many applications of GIS is disaster management.

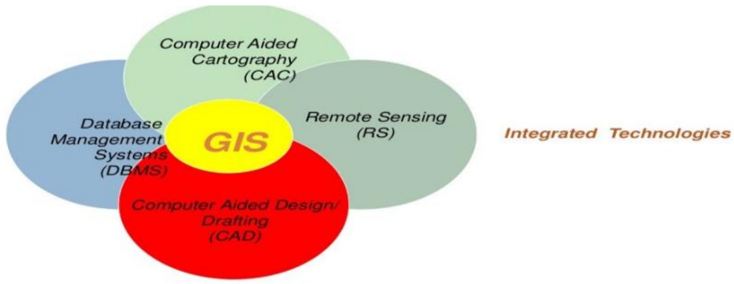
A GIS is a collection of computer hardware, software, and geographic data for digitally capturing, managing, analyzing, and displaying all forms of geographically referenced information.

White House defines GIS as
"the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data."



Maps + Information = GIS

1.2 ORIGIN OF GIS

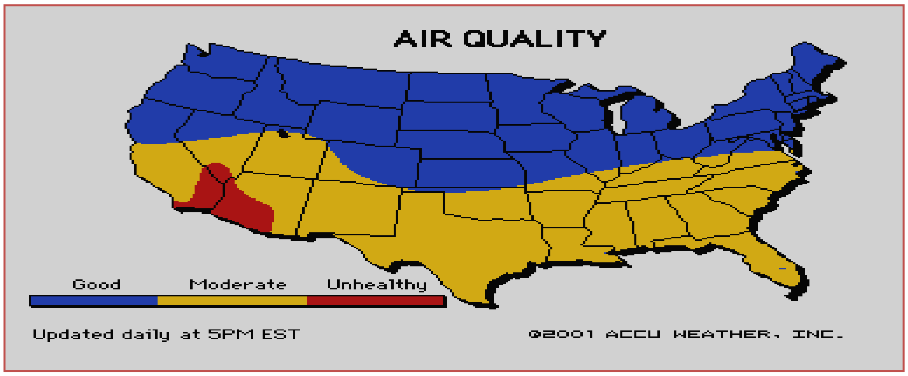


1.3 WHY GIS ?

- Old Records / Maps are poorly maintained.
- Poorly updated.
- Inaccurate
- No sharing
- No data retrieval services for maps.

1.4 WHO USES GIS?

GIS is used to monitor various environmental concerns across the world. Coastal subsidence, deforestation, and pollution are a few environmental concerns that may be addressed using GIS.
The example uses GIS to monitor U.S. air quality. Areas identified as unhealthy are more easily depicted on a map than in stacks of reports.



1.5 PURPOSE OF GIS

a) A GIS makes connections between activities based on geographic proximity.

b) The digital data structure can be conceptualized as a set of "floating electronic maps" with a common registration allowing the used to "look" down (drill down) and across the stack of maps.
c) The spatial relationships can be summarized (data base inquiries).
d) Powerful tools for addressing geographical /environmental issues.
e) Allows us to arrange information about a location as a set of maps.
f) Displaying information about one characteristic of the region.
g) Needs a location reference system (such as latitude and longitude).

1.6 ALTERNATIVE NAMES OF GIS

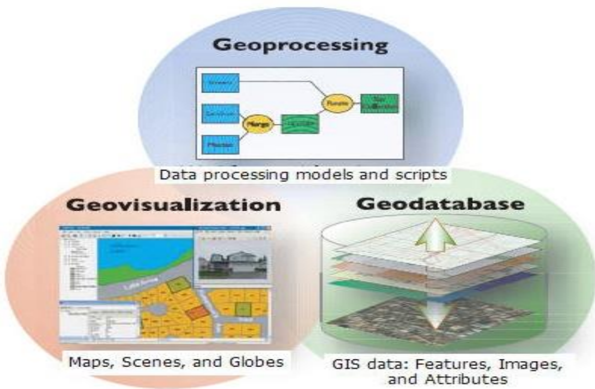
- Multipurpose geographical data system
- Multipurpose input land use system
- Computerized geographical information system
- System for handling natural resources inventory data
- Geo-information system
- Spatial information system
- Land resource information system
- Spatial data management and comprehensive analysis system
- Planning information system
- Resource information system
- Natural resource management information system
- Spatial data handling system
- Geographically referenced information system
- Environment information system
- AGIS - Automated geographical information system
- Multipurpose cadastre
- Land information system
- AM/FM - Automated mapping and facilities management

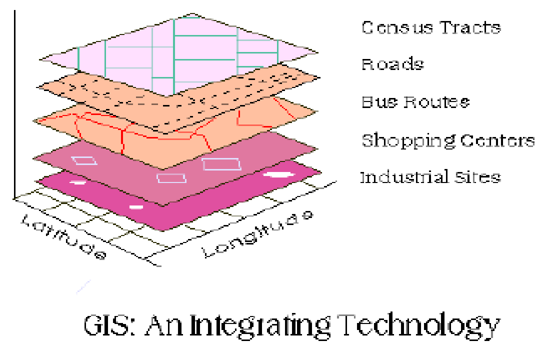
1.7 MAJOR TERMINOLOGIES ON GIS

The three major topics on GIS are:

1) Geodatabase
2) Geoprocessing
3) Geovisualization

- The ability of a GIS to handle and process geospatial data distinguishes GIS from other information systems and allows GIS to be used for integration of geospatial data and other data.





GIS includes the following major elements:

- hardware/software
- database
- applications/infrastructure

- GIS allows you to discover patterns and relationships you cannot easily see in a table.
- GIS stores two types of information:
    1. Features – Objects found on Earth (mountains, rivers, and lakes)
    2. Attributes – Description of Features

1.8 OBJECTIVES OF GIS

a) Maximize the efficiency of planning and decision making
b) Provide efficient means for data distribution and handling
c) Elimination of redundant data base - minimize duplication
d) Capacity to integrate information from many sources
e) Complex analysis/query involving geographical referenced data to generate new information.

1.9 BACKGROUND OF GIS

- On March 11, 2011, a magnitude 9.0 earthquake struck off the east coast of Japan, registering as the most powerful earthquake to hit Japan on record.
- The earthquake triggered powerful tsunami waves that reportedly reached heights of up to 40 meters and traveled up to
- 10 kilometers inland. In the aftermath of the earthquake and tsunami, GIS played an important role in helping responders and emergency managers to conduct rescue operations, map severely damaged areas and infrastructure, prioritize medical needs, and locate temporary shelters.
- GIS was also linked with social media such as Twitter, YouTube, and Flickr so that people could follow events in near real time and view map overlays of streets, satellite imagery, and topography.

- Geospatial data describe both the locations and characteristics of spatial features.
- To describe a road, for example, we refer to its location (i.e., where it is) an its characteristics (e.g., length, name, speed limit, and direction), as shown in below figure:

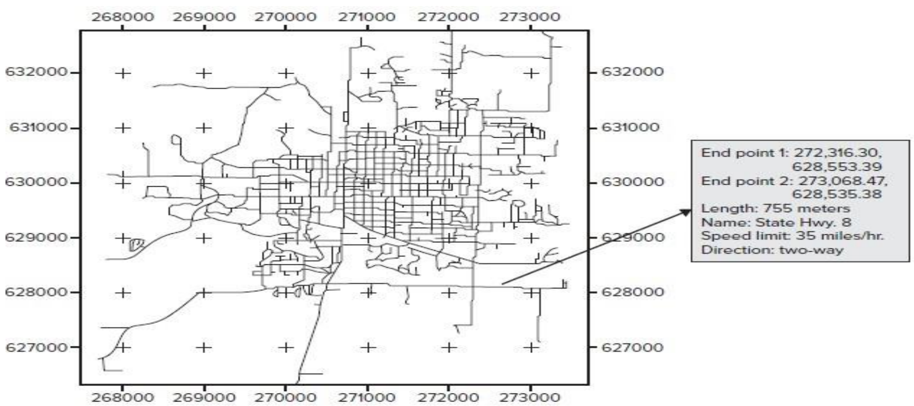


Figure: An example of geospatial data.

- The street network is based on a plane coordinate system.
- The box on the right lists the x and y coordinates of the end points and other attributes of a street segment.

1.10 GIS in ACTION

The questions that a GIS is required to answer are mainly as follows:

What is at.....? (*Locational question* ; what exists at a particular location)

Where is it.....? (*Conditional question* ; which locations satisfy certain conditions)

How has it changed......? (*Trendy question* ; identifies geographic occurrence or trends that have changed or in the process of changing)

Which data are related .....? (*Relational question* : analyzes the spatial relationship between objects of geographic features)

What if.......? (***Model based question*** ; computers and displays an optimum path, a suitable land, risky area against disasters etc. based on model)

1.11 MAJOR PROCESSES OF GIS

1. Data Capture

Data sources are mainly obtained from manual digitization and scanning of aerial photographs, paper maps, and existing digital data sets

2. Database Management and Update

Data security, data integrity, and data storage and retrieval, and data maintenance abilities

3. Geographic Analysis

The collected information is analyzed and interpreted qualitatively and quantitatively.

4.Preparing Result

One of the most exciting aspects of GIS technology is the variety of different ways in which the information can be presented.

1.12 MAJOR BENEFITS OF GIS

a) Once a GIS is implemented, the following benefits are expected.
b) Geospatial data are better maintained in a standard format.
c) Revision and updating are easier.
d) Geospatial data and information are easier to search, analyze and represent
e) More value added product.
f) Geospatial data can be shared and exchanged freely.
g) Productivity of the staff is improved and more efficient.
h) Time and Money are saved.
i) Better decisions can be made.

1.13 MAJOR APPLICATION AREARS OF GIS

a) Geography

b) Cartography

c) Remote Sensing

d) Surveying and photogrammetry

e) Computer Science

f) Mathematics & Statistics

g) Engineering

h) Marketing

i) Finance

GIS Applications

Domain	Applications
Business	Site Location, Delivery Systems, Marketing
Government	Local State, Federal, Military
Economic Development	Polpulation Studies, Incomes, Censes and Demographic studies
Emergencies	Fire & Police
Environmental	Monitoring and Modeling
Industry	Transportation, Communication, Mining, Pipelines, Healthcare,
Public Health	Epidemiology Studies
Urban Planning	Land use, Historic Studies, Environmental and Conservation Studies, Housing Studies, Crime Analysis
Politics	Elections, Reappointment
Education	Research, Teaching Tool, Administration

1.13.1 Other Major Application Areas of GIS

Digitalizing- In this era, where information is overflowing, we can’t rely upon hard data like book and files.

Even the need and requirements for information across the globe is high, so we need a system that stores data and process which everyone can access. It also reduces space and ensures speedy access to data.

Mapping- To present maps of cities, villages, mountains, factories, buildings etc.

This can be used in the time of emergencies like epidemics, wars, natural disasters etc for locating and rescuing people. Urban planning can be effective with help of GIS.

Borders- For getting an accurate drawing of borders between two countries and establishing border checkpoints and security.

Pollution and Climate Change- The most affected areas like rivers, factories, cities with bad air quality, can easily be mapped and utilised for analysis.

Even places where Humans can physically travel like Polar Icecaps and the middle of Oceans can utilise GIS for mapping and planning future actions. Also, change in temperature and feature fluctuations can easily be monitored.

Ecology and environment- Forests, deforestation, migratory birds, endangered species, etc can easily be observed and tracked by Organisations and Governments.

Farming- For precision farming, observing weather patterns, irrigation of crops etc can easily be done using GIS.

Geology and Astronomy- Nothing in science and technology is confined to the Earth, so GIS can be ultimately used in any celestial object like the Moon, Mars, Venus or Sun. NASA uses image processing technology for the same.

Military- Militaries across the globe, can use GIS for mapping their bases, warships, aircraft stations, enemy bases, border controls, anti-terrorism, 3D modelling, rescuing civilians, etc.

Criminology- Crime patterns, Crime statistics in a region, tracking criminals, law enforcement etc can be done using GIS.

Services- GIS is very much useful for governments in planning services like public health, education, traffic monitoring, transportation etc.

1.14 SCOPE OF GIS

An information system has a full range of functions to find:

a) Hospitals & Health care Centers

b) Schools, Colleges & Edu. Campus

c) Hotels, Restaurants

d) Banks , ATMs

e) Govt. Offices, Police Stations

f) Railway Stations, Bus Stations, etc.

1.15 ADVANTAGES OF GIS

a) GIS allows us to view, understand, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

b) A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

c) GIS give the accurate Data.

d) Better Predictions and Analysis.

a) User can

   i. print and save the image of the required map.

   ii. view different parameters of particular area.

   iii. get path from source to destination

1.16 DISADVANTAGES OF GIS

a) Excessive damage in case of internal fault. Long outage periods as Repair of damaged part at site may be difficult.

b) Expensive software.

c) Integration with traditional map is difficult.

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2. BASIC SPATIAL CONCEPTS

BASICS ON SPATIAL Geographically Based Data Sets

- A Geographic Information System (GIS) is a system of computer applications that can be used to display, manipulate, and analyze spatially varied information from multiple sources all in one place.
- Most often the datasets used in a GIS are categorized into multiple categories for easier storage and use.

- Each dataset that a GIS can support is divided into two main parts:
    a) graphical (spatial) information and
    b) tabular (attribute) information.
- Spatial data is data that is geo-referenced or location specific and is what is shown graphically on the computer screen.
- Each piece of graphic information is called a feature.
- Features can be points, lines, or even polygons.

Functions/Tasks of GIS

a) Data Input
b) Data Management
c) Data Analysis and Manipulation
d) Data Display/Visualization

a) Data Input

- The procedure of encoding data into a computer-readable form and writing the data to the GIS database is called Input.
- Data input includes three major steps (the latter two steps are also called data preprocessing):
    a) Data capture
    b) Editing and cleaning
    c) Geo-coding
- Keyboard entry
- Manual digitizing
  (e.g., tablet, on-screen)

- Scanning

Data Sources for GIS

1. Maps
2. Aerial photos
3. Satellite images
4. Technical descriptions
5. GPS data

Data Input : Geographic Data Characteristics

•Geographic data contains four integrated components, namely, location, attribute, spatial relationship and time.
•Geographic data include those which are spatially referenced.
•A GIS includes operations which support spatial analysis.
- Spatial data and their attributes are linked (seamless)
    - By their geographic location
    - By unique identifiers

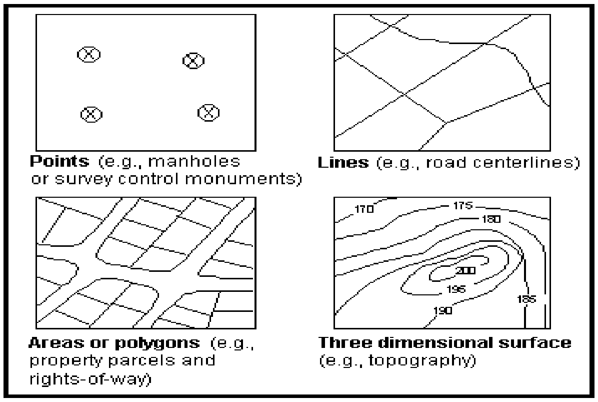
Geographic Data Organized into Layers

Kinds of Data GIS Handles

•Spatial data usually translated into simple objects: points, lines, areas and grids (pixels).represented as maps.
•Example: a parcel of land

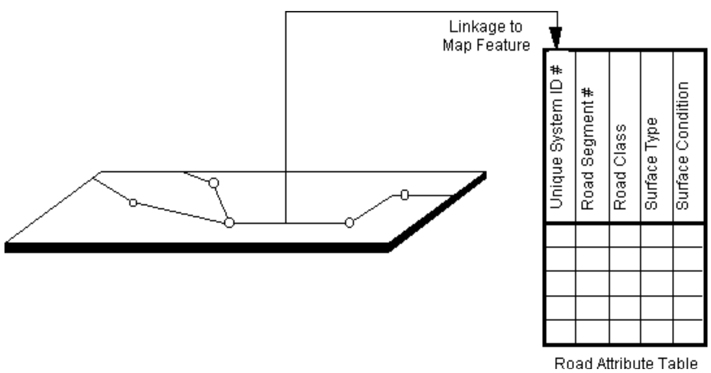
•Attribute data (Non-spatial or Aspatial Data) are descriptive information about specified spatial objects.
•often have no direct information about the spatial location but can be linked to spatial objects they describe.

•Usually organized in tables
•Example: the owner of a parcel of land



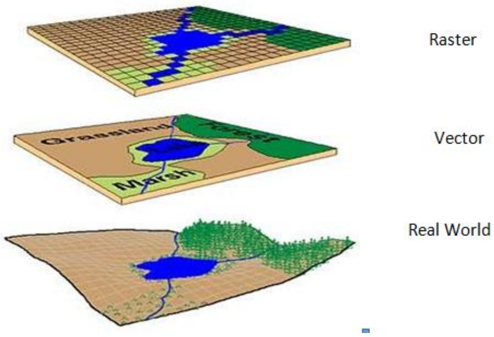
Identifiers

•Enable both spatial and attribute data to be stored separately but accessed together.
•Identifiers are
- •Unique values - usually integers
- •Stored as part of the spatial data structure - as a numeric value (i.e., system- generated ID)
- •Stored as part of the attribute data structure - as a field in a table.



Data Models

Conversion of real world geographical variation into discrete objects is done through data models. It represents the linkage between the real world domain of geographic data and computer representation of these features.
•Two major categories of spatial data representation in GIS: raster and vector.
- •Raster approach: cells
- •Vector approach: points, lines, and polygons



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3. COORDINATE SYSTEMS

GEOGRAPHIC COORDINATE SYSTEMS

INTRODUCTION TO GIS DATA

- A GIS is a specific information system that is applied to geographic data and it is mainly referred to as a system of hardware, software, personnel and procedures
- A GIS is designed to support capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems.

[Burroughs, 1986; NCGIA, 1990].

BASICS OF GEOGRAPHIC COORDINATE SYSTEMS

- G (Geography) is a particular form of Information System applied to geographic data :
- Location, Co-ordinates, Maps, etc.
- I(Information) S (System) is a set of processes, executed on raw data , to produce information which will be useful in decision-making.

- GIS Data Handling is the series of steps from observation and collection of data through analysis to Geographic information.

The GIS DATA into GIS INFORMATION PATHWAY :

GIS Data = G F's (Graphic Facts)

GIS Information = Geographic Facts with Meaning

What is GIS Data ?

- GIS data are basically a collection of spatial or Geographic Based Data Sets.
- Spatial data is data that is geo-referenced or location specific and is what is shown graphically on the computer screen.

- A GIS integrates spatial and other kinds of information within a single system to provide a consistent framework for analyzing geographic (spatial) data.
- Each piece of graphic information is called a feature.
- Features can be points, lines, or even polygons.

- Hardcopy Maps

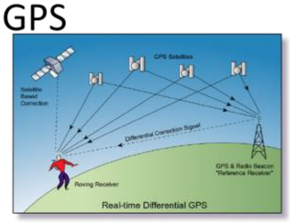
- Coordinates

POINT_X	POINT_Y	POINT_Z
528394.080810	9594467.580890	-31
525818.559926	9598560.217260	-55
550245.403528	9622455.389690	-30
549308.195344	9621266.216650	-30
501009.579927	9593618.537130	-297

- Digital Data

uspga050_2008	Folder
Database1.mdb	Personal Geodatabase
seis_1994.mdb	Personal Geodatabase
Copy of major_eq.dbf	dBASE Table
global_dropshadow.shp	Shapefile
Label_earthquakes.shp	Shapefile
Label_earthquakes_mjr.shp	Shapefile
pga	Raster Dataset
pga_contour.shp	Shapefile
SEIS_1994_gh40.xls	Excel File
seis_1994_ght_40.txt	Text File
seis_1994_ght_40_clean.txt	Text File
seis_1994_gth40.shp	Shapefile
SEIS_2000_gh50.xls	Excel File
seis_2000_ght_50.txt	Text File
seis_2000_gth50.lyr	Layer

- GPS



<u>Geo Data or Geospatial Data at a Glance</u>

- Geospatial data describes **<u>both the locations and characteristics of spatial features.</u>**

<u>Example:</u>

- To describe a road, we refer to its
  1. location (i.e., where it is) and
  2. its characteristics (e.g., length, name, speed limit, and direction)

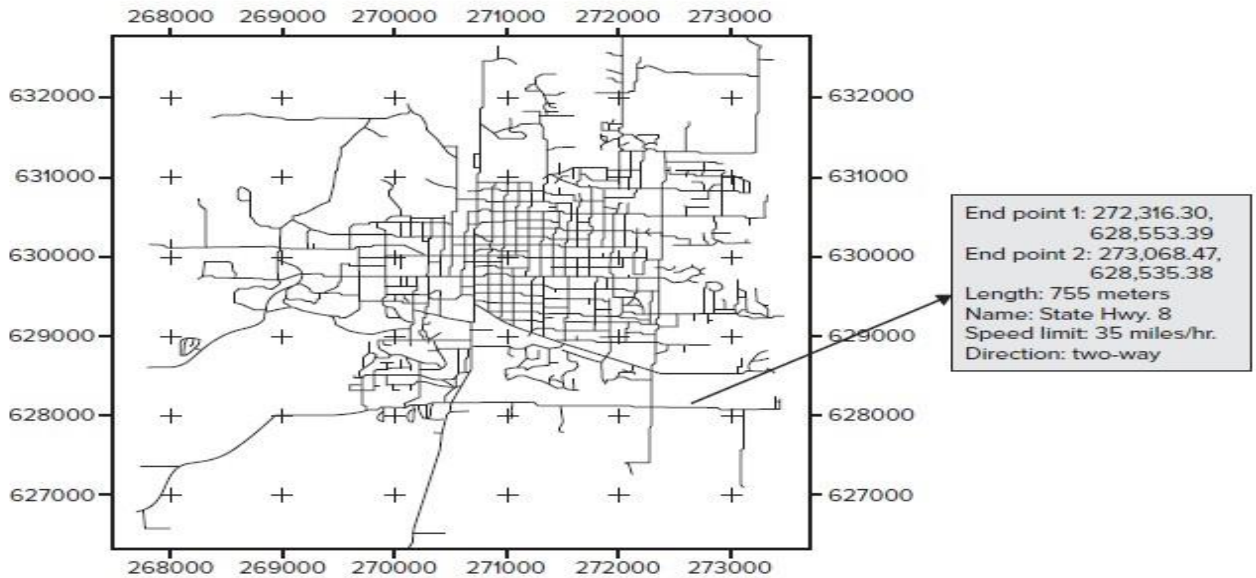


Figure: An example of geospatial data

- The street network is based on a plane coordinate system.

- The box on the right lists the x and y coordinates of the end points and other attributes of a street segment.

- The Data and process of geospatial data distinguishes GIS from other information systems
- GIS to be used for integration of geospatial data and other data.
- The ability of a GIS is to handle Geospatial Data.

- Most often the datasets used in a GIS are categorized into multiple categories for easier storage and use.

Each dataset that a GIS can support is divided into two main parts:

1. graphical (spatial) information and
2. tabular (attribute) information.

AN OUTLINE OF COORDINATE SYSTEMS

- The geographic coordinate system (GCS) is a reference framework that defines the locations of features on a model of the earth.

- It's shaped like a globe—spherical.
- Its units are angular, usually degrees.
- A projected coordinate system (PCS) is flat.

- A basic principle in geographic information system (GIS) is map layers to be used together must align spatially.
- Obvious mistakes can occur if they do not.
- The two maps do not register spatially.

Example:

- To connect the highway networks across the shared state border, we must convert them to a common spatial reference system.
- The coordinate system provides spatial reference and is location, attribute(s)

GIS Data and users

- GIS users typically work with map features on a plane (flat surface)and it represent spatial features on the Earth's surface.
- The locations of map features are based on a plane coordinate system.
- Map features are expressed in x and y coordinates
- The locations of spatial features on the Earth's surface are based on a geographic coordinate system expressed in longitude and latitude values.

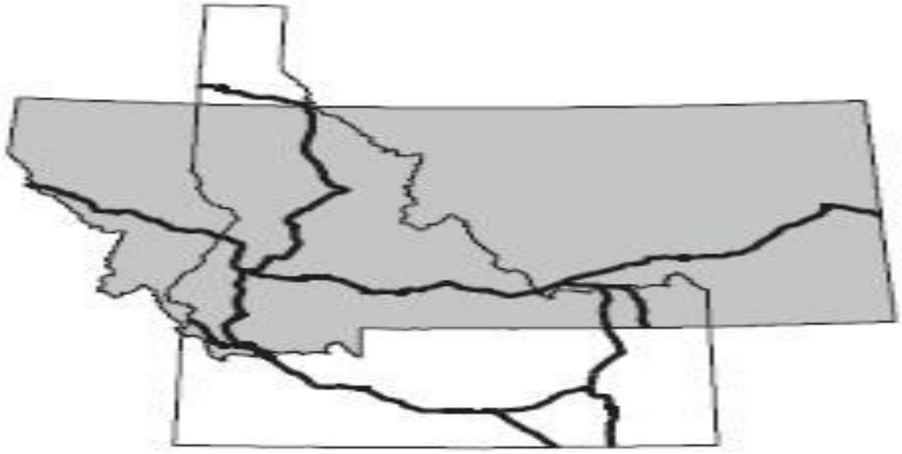
Map Projection

A map projection bridges the two types of coordinate systems.

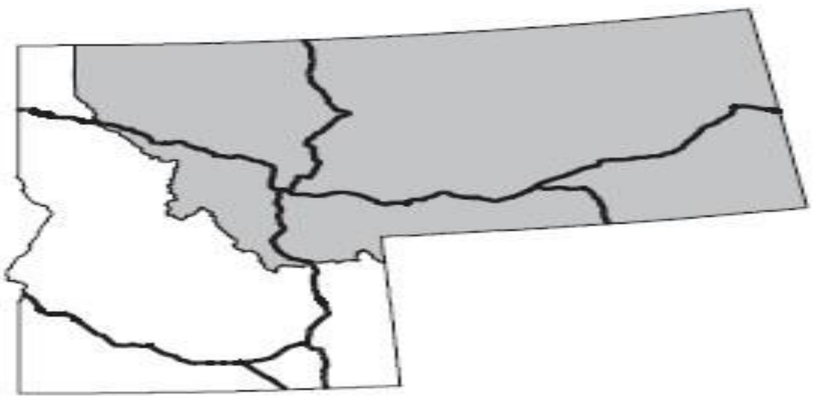
- The process of projection transforms the Earth's surface to a plane, and the outcome is a map projection, ready to be used for a projected coordinate system.

- For example, below figure shows the interstate highway maps of Idaho and Montana downloaded separately from the Internet.

Example of Coordinate Systems



The map shows the interstate highways in Idaho and Montana based on different coordinate systems.

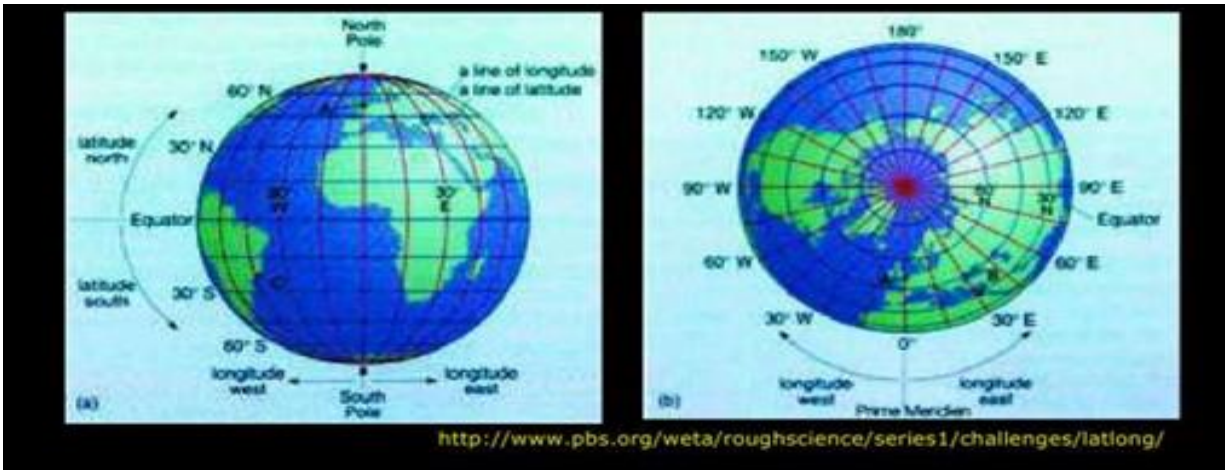


The map shows the connected interstate networks based on the same coordinate system.

An Overview on GIS Map

- A GIS map contains layers - a collection of graphic objects that are alike Layers may contain features or surfaces.
- Features have shape and size
- Location can be displayed at different sizes linked to information, spatial relationships
- Surfaces have a geographic expanse numeric values
- Meridians are lines of equal longitude.
- The prime meridian passes through Greenwich, England, and has the reading of 0°.
- Using the prime meridian as a reference, we can measure the longitude value of a point on the Earth’s surface as 0° to 180° east or west of the prime meridian.
- Meridians are therefore used for measuring location in the E–W direction. Parallels are lines of equal latitude.

- GIS brings together and associate representations from diverse sources and infer relationships based on spatial references.
- The ability depends on a defined (coordinate) referencing system of the data source
- The Latitude and Longitude provide a framework for referencing places on the earth.



Coordinate System and Projection
Problem with Representation
Latitude and Longitude are angels , not distance.
The earth is not spherical (Isaac Newton)
Used in geographic databases that are not specific to a particular place.

To portray information on a map or to make calculations, angular measures to be transformed to orthogonal coordinates called Projection.

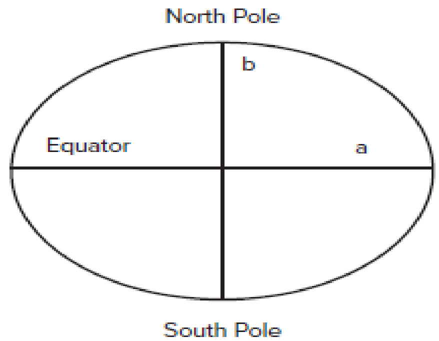
Projection Systems

- Universal Transverse Mercator (UTM) System.
- The basic for most national and global map series.
- Divides the world into 60 longitudinal zones.
- State plane coordinate system
- The basic for all states in the US.
- Divides the US into different state plane zones.

Geographic Coordinate System

- The angular measures of longitude and latitude may be expressed in degrees-minutes- seconds (DMS), decimal degrees (DD), or radians (rad).

- Given that 1 degree equals 60 minutes and 1 minute equals 60 seconds, we can convert between DMS and DD.



- The flattening is based on the difference between the semimajor axis and the semiminor axis b.
- For example, a latitude value of 45°52'30" would be equal to 45.875° (45 + 52/60 + 30/3600).
- Radians are typically used in computer programs.
- One radian equals 57.2958°, and one degree equals 0.01745 rad.

Map Projections

- A map projection transforms the geographic coordinates on an ellipsoid into locations on a plane.
- The outcome of this transformation process is a systematic arrangement of parallels and meridians on a flat surface representing the geographic coordinate system.
- A map projection provides a couple of distinctive advantages.
    1. First, a map projection allows us to use two-dimensional maps, either paper or digital.
    2. Second, a map projection allows us to work with plane coordinates rather than longitude and latitude values.
- Map projections can be grouped by either the preserved property or the projection surface.
- Cartographers group map projections by the preserved property into the following four classes:
    1. conformal,
    2. equal area or equivalent,
    3. equidistant, and

4. azimuthal or true direction.

- A conformal projection preserves local angles and shapes.
- An equivalent projection represents areas in correct relative size.
- An equidistant projection maintains consistency of scale along certain lines.
- And an azimuthal projection retains certain accurate directions.
- The preserved property of a map projection is often included in its name, such as the Lambert conformal conic projection or the Albers equal-area conic projection.

- A map projection is defined by its parameters. Typically, a map projection has five or more parameters.

1. A standard line refers to the line of tangency between the projection surface and the reference globe.
2. The standard line is called the standard parallel if it follows a parallel, and the standard meridian if it follows a meridian.
3. The principal scale, or the scale of the reference globe, can be derived from the ratio of the globe's radius to the Earth's radius (3963 miles or 6378 kilometers).
4. The scale factor is the normalized local scale, defined as the ratio of the local scale to the principal scale.
5. The false easting is the assigned x-coordinate value and the false northing is the assigned y-coordinate value.
6. Essentially, the false easting and false northing create a false origin so that all points fall within the NE quadrant and have positive coordinates.

The following are the commonly used map projections:

- Transverse Mercator,
- Lambert Conformal Conic,
- Albers Equal-Area Conic,
- Equidistant Conic,
- Web Mercator.

Projected Coordinate System

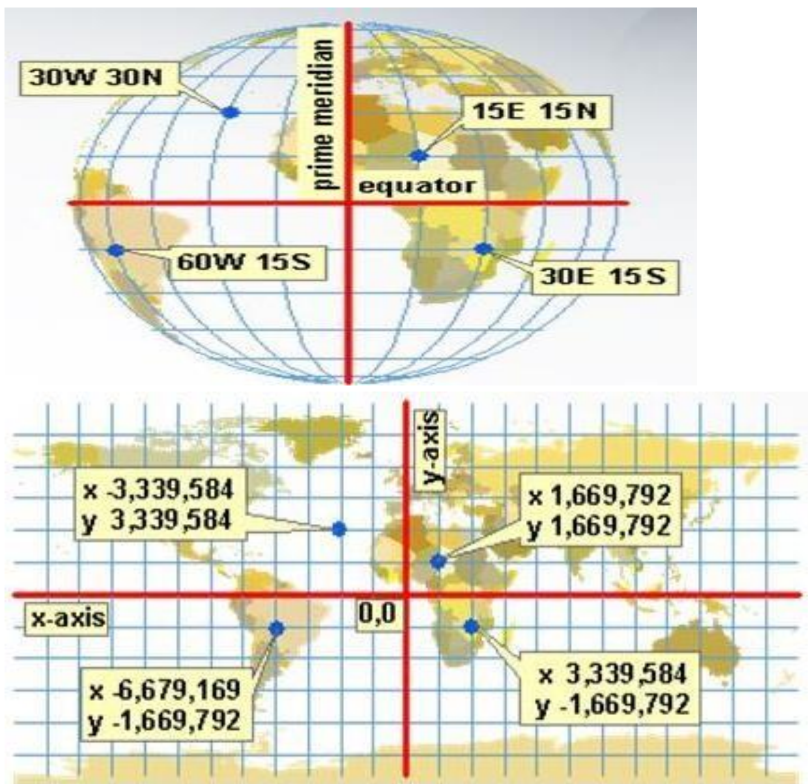
- A projected coordinate system is built on a map projection.
- Projected coordinate systems and map projections are often used interchangeably.
- For example, the Lambert conformal conic is a map projection but it can also refer to a

coordinate system.

- In practice, however, projected coordinate systems are designed for detailed calculations and positioning, and are typically used in large-scale mapping such as at a scale of 1:24,000 or larger.

- Accuracy in a feature's location and its position relative to other features is therefore a key consideration in the design of a projected coordinate system.

- To maintain the level of accuracy desired for measurements, a projected coordinate system is often divided into different zones, with each zone defined by a different projection center.



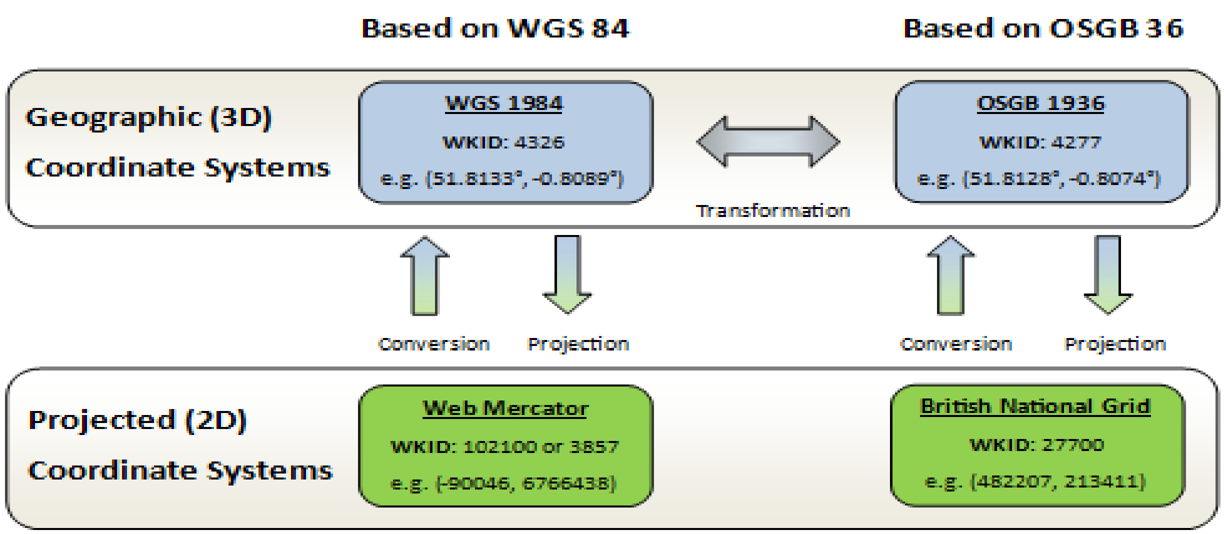
<u>The Projected Coordinate System</u>
(a): Representation of points in Geographic Coordinate System
(b): Equivalent representation in Projected coordinate system

Three coordinate systems are commonly used in the United States:

- the Universal Transverse Mercator (UTM) grid system,
- the Universal Polar Stereographic (UPS) grid system, and
- the State Plane Coordinate (SPC) system.

World Geodetic System (WGS-84)

- World Geodetic System (WGS-84) is familiar to many non-geographers because it is used by GPS devices to describe locations all over the Earth.
- A different GCS, called OSGB- 36, which is more accurate for describing locations in Britain but not as good for other countries, is used specifically for British data.
- Web Mercator is a PCS based on WGS-84 used for global maps, and British National Grid is a PCS based on OSGB-36 used for British maps.
- Converting between coordinate systems that are based on the same GCS is relatively straightforward, but when converting, for example, GPS (WGS-84) coordinates to BNG, a mathematical transformation is required.
- The "Petroleum" transformation is an accurate transformation from WGS-84 to OSGB-36.



Example Coordinate Systems

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3. GIS AND INFORMATION SYSTEM

GIS Definitions

- GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data, which is geographically referenced to a map projection in an earth coordinate system.
- GIS is a special-purpose digital database in which a common spatial coordinate system is the primary means of reference.
- GIS is a facility for preparing, presenting, and interpreting facts that pertain to the surface of the earth.
- GIS is an information system that is designed to work with data referenced by spatial or geographic coordinates.
- GIS is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information."
- Geographic information systems (GIS) or geospatial information systems is a set of tools that captures, stores, analyzes, manages, and presents data that are linked to location(s).

(Wikipedia)

GIS and Information Systems

Introduction to GIS

- A Geographic Information System (GIS) is a computer system that analyzes and displays geographically referenced information.
- It uses data that is attached to a unique location.
- GIS technology allows all these different types of information, no matter their source or original format, to be overlaid on top of one another on a single map.
- GIS uses location as the key index variable to relate these seemingly unrelated data.

Access to GIS

- Access to geographic information using Virtual globes would be a very powerful way of sharing information about future scenarios, at both global and local scales.
- The impacts of community planning decisions, global economic recession, new diseases, or global environmental change could all be visualized through
- a single, easy-to-use portal, providing a direct connection between the predictive work of scientists, the decisions of public officials, and the general public.

Geographic Information System (GIS) Vs Information System (IS)

- The main difference between GIS and other information systems is that the information stored and processed is geographic coded, and the geographic location and feature information related to the geographic location constitute an important part of information retrieval.

- Geographic information systems fall into four more-or-less well-defined categories: systems for positioning, data acquisition, data dissemination, and analysis.

a) positioning

- The global positioning system (GPS) and its Russian and European analogs have revolutionized the measurement of position on the Earth's surface.
- Versions of GPS can be embedded in mobile phones, wristwatches, and Vehicles.
- Millions of densely sampled tracks are now being acquired every day in the interests of map-making, wildlife management, and the modeling of human spatial behavior.

b) Data acquisition

- Satellite and airborne remote sensing is now firmly established as a major source of geographic information.
- Optical panchromatic sensors now image the Earth's surface at 50 cm resolution, while multispectral sensors add the potential for detailed differentiation of surface types.
- Geospatial data acquisition over the past few years has been the rapid emergence of user-generated content, a process by which users of the Internet are able to create and upload information.

c) Data dissemination

- The traditional media for dissemination of compiled geographic information – paper maps, globes, and atlases – were expensive to produce, cumbersome to ship and house, and difficult to catalog.

- Map libraries emerged as one solution to these issues, sequestering geographic information in specialized departments that developed their own systems of collection management.
- The concept of a geoportal (Maguire and Longley 2005) has emerged.
- These are single points of entry into a network of linked repositories, offering search across a unified catalog plus remote access to data sets that remain housed in their original collections.

d) Analysis

- GIS is widely accepted, and such systems are capable of a wide range of forms of manipulation and analysis (Longley et al. 2005).

- Some are targeted at particular application domains, such as transportation; some emphasize particular types of geographic information, such as remotely sensed images; and some are particularly adapted to the needs of dynamic simulation of Earth processes

GIS APPLICATIONS IMPACT

- Geographic information systems support a vast range of applications.
- In commerce, they are widely used to maintain inventories of distributed assets in the utility industry, to manage marketing efforts and to determine optimal locations for retail businesses and services, and to schedule delivery and pickup services.
- In science, they are particularly useful for examining patterns of phenomena on the Earth's surface, formulating and testing hypotheses about the spread of disease, the distribution of plant species and the behavior of animals, and the spatial organization of society.
- In government, they are used to make choices between alternative planning options and to manage social services.
- In the military, they are essential to battlefield control.

How does GIS differ from other information systems?

- GIS technology allows all these different types of information, no matter their source or original format, to be overlaid on top of one another on a single map.
- GIS uses location as the key index variable to relate these seemingly unrelated data.
- Putting information into GIS is called data capture.

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5. GIS DEFINITIONS

GIS: a formal definition

• "A system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth.

• This is normally considered to involve a spatially referenced computer database and appropriate applications software" Chorley Report, 1987

What is GIS?

GIS is a technology.

- An information handling strategy - to improve overall decision making an organized collection of computer hardware, software, geographic data and personnel.
- GIS comprises of: Data input, Storage, Management, Analysis and Output.
- GIS is designed to efficiently to GIS Data.

Why is GIS unique?

• GIS handles SPATIAL information referenced by its location in space
• GIS makes connections between activities based on spatial proximity
• Multidisciplinary, Integrated and Holistic.
• Measuring and Integrating the Parts.
• Social Factors Biodiversity Engineering Land Use Environmental Considerations which means Seeing the Whole.
• Watersheds Communities Neighborhoods Ecosystems Context and Content Context and Content Patterns Linkages Trends Seeing the Whole Managing Places.

• A good GIS system should be able to answer the following questions

1. Location : What is at ?
2 .Condition : Where is it ?
3 .Trend : What has changed since ?
4. Routing : Which is the best way ?
5. Pattern : What spatial patterns exist ?
6. Modeling: What if ?

GIS Capabilities

Location : What is at…?

A location can be described in many ways (place name, zip code, or a geographic reference)
• Involves querying a database to determine the types of features that occur at a given place
Eg: What is the material composition of a specified water line? GIS Capabilities

Condition: Where is it…?

• Involves finding the location of sites which have certain characteristics
• Instead of identifying what exists at a given location, you want to find a location where certain conditions are satisfied
• Eg: If you are looking for an unforested section of land at least 2,000 square meters in size,

within 100 meters of a road, and with soils suitable for supporting building GIS Capabilities.

Trend : What has changed…?
• Involves monitoring how things change over time

• Pattern : What is the pattern…?
• Allows describing and comparing the distribution of phenomena and understanding the processes which account for their distribution
• Eg: You may ask this question to determine whether cancer is a major cause of death among residents next to a nuclear power plant.

Modeling : What if…?
• Allows different models of the world to be evaluated.
• These types of questions are posed to determine what happens, for example, if a toxic substance seeps into the local groundwater supply.

GIS AS A MANAGEMENT TOOL
• The scope of GIS and the operations that are unique to GIS have been restricted, it is appropriate to re-evaluate the process-oriented definition.

• GIS are often understood as large-scale operations with high initial capital costs usually financed by government at the federal, provincial, or municipal levels.

The main purpose of these GIS is
• to help politicians and bureaucrats make sensible decisions in the management of natural or human resources" (Muller, 1985).

• Marble et al. (1983) state that
• "Operational applications of GIS today include such areas as land and resource management, traffic planning, marketing, military planning as well as a variety of other uses."

GIS AS A DECISION SUPPORT SYSTEM
• Geographic information systems have sometimes been called decision support systems. Most of the work on GIS system design emphasizes this approach.
• A successful GIS must support the management of some resource or some problem-solving process.

BENEFITS AND FUNCTIONS OF GIS

• The benefits of GIS include:

• Better information management Higher quality analysis Ability to carry out ‘what if?’ scenarios Improve project efficiency

• Principal Functions of GIS

• Data Acquisition

• Database Management and

• Update Analysis

• Presenting Results

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6. HISTORY OF GIS

• GIS was born when Dr Roger Tomlinson, • who is also known as the father of GIS, and a Geographer himself, wanted to make Urban and Rural Planning easier.

• Spatial analysis is considered to be the major principle behind GIS technology.

• The first operational GIS is reported to have been developed by Roger Tomlinson in the early 1960s for

1. storing,
2. manipulating, and
3. analyzing

• data collected for the Canada Land Inventory (Tomlinson 1984).

• In 1964, Howard Fisher founded the Harvard Laboratory for Computer Graphics where several well known computer programs of the past such as SYMAP, SYMVU, GRID, and ODESSEY were developed and distributed throughout 1970s.

• These earlier programs were run on mainframes and minicomputers, and maps were made on line printers and pen plotters.

• In the 1980s, commercial and free GIS packages appeared in the market.

• As GIS continually evolves, two trends have emerged in recent years.

• One, as the core of geospatial technology, GIS has increasingly been integrated with other geospatial data such as satellite images and GPS data.

• Two, GIS has been linked with Web services, mobile technology, social media and cloud computing.

FOUR PHASES OF GIS

• There have been four distinct phases in the development of Geographic Information Systems.

1. Phase one, between the early 1960s and the mid 1970s saw : a new discipline being dominated by a few key individuals who were to shape the direction of future research and development.

2. The second phase, from the mod 1970s to early 1980s saw : the adoption of technologies by national agencies that led to a focus on the development of best practice.
3. Phase three, between 1982 until the late 1980s saw: the development and exploitation of the commercial market place surrounding GIS.
4. The Final phase since the late 1980s has seen a focus on ways of improving the usability of technology by making facilities more user centric.

- The field of geographic information systems (GIS) started in the 1960s as computers and early concepts of quantitative and computational geography emerged.
- Early GIS work included important research by the academic community.
- Later on Wars, the Epidemic prompted technology to be used for various aspects like Nuclear Weapon Research.
- The first model of GIS was called Canada GIS designed by Dr Roger Tomnilson in 1960.
- Canada used it for mapping and utilizing the resources of Rural Canada ie Soil, agriculture, forests etc at a scale of 1:50,000.
- With the rise of WWW, GIS became more prominent in many developed countries and now in developing countries.
- GIS is linked closely to geography, • cartography, and computer science history.
- The modern computerized GIS we know today is attributed to Roger Tomlinson.
- He was given the title of the 'father of GIS' due to his creation in the 1960's of the Canada Geographic System while working for the Canadian Government.
- This was the first computerized geographic information system in the world.
- In 1969 Jack Dangermond founded ESRI (Environmental Systems Research Institute) to undertake land use analysis..
- Nowadays it is the largest GIS software developer in the world.

The First GIS

• Roger Tomlinson's pioneering work to • initiate, plan, and develop the Canada Geographic Information System resulted in the first computerized GIS in the world in 1963.

• The Canadian government had commissioned Tomlinson to • create a manageable inventory of its natural resources.
• He envisioned using computers to merge natural resource data from all provinces.
• Tomlinson created the design for automated computing to• store and process large amounts of data,• which enabled Canada to begin its national land-use management program.
• He also gave GIS its name.

The Future of GIS

• With its movement to web and cloud computing, and integration with real-time information via the Internet of Things.
• GIS has become a platform relevant to almost every human endeavor—a nervous system of the planet.

- As our world faces problems from expanding population, Loss of nature, and pollution, GIS will play an increasingly important role in • how we understand and address these issues and provide a means for communicating solutions using the common language of mapping.

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7. COMPONENTS OF GIS

There are five major components of GIS.
They are:

• Hardware

Computer System, Scanner, Printer, Plotter, Flat Board

• Software

GIS software in use are MapInfo, ARC/Info, AutoCAD Map, etc. The software available can be said to be application specific.

• Data

GIS will integrate spatial data with other data resources and can even use a DBMS, used by most organization to maintain their data, to manage spatial data.
Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider.

• People

GIS users range from technical specialists who design and maintain.

• Method

The map creation can either be automated raster to vector creator or it can be manually victories using the scanned images.

Illustration of Components of GIS

Components of GIS: Key software components

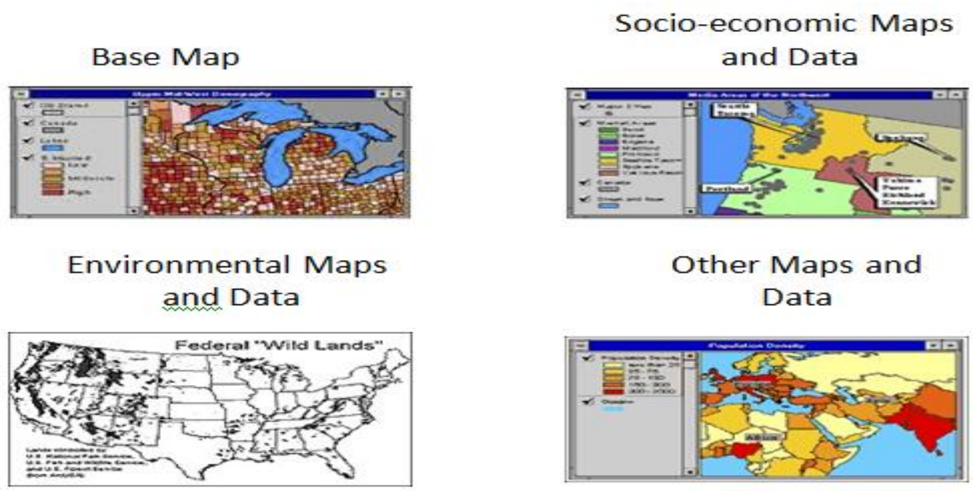
1. Tools for the input and manipulation of geographic information
2. A database management system (DBMS)
3. Tools that support geographic query, analysis, and visualization
4. A graphical user interface (GUI) for easy access to tools

Components of GIS: GIS Data

• Base Maps - include streets, highways, boundaries for census, postal, and political areas, rivers and lakes, parks and landmarks; place names

• Environmental maps - include data related to the environment, weather, environmental risk, satellite imagery, topography, and natural resources.

• Socio-economic data - include data related to census/demography, health care, real state, telecommunications, emergency preparedness, crime, business establishments, and transportation.



<u>Roles of People</u>

a) GIS Manager
b) GIS Specialist
c) GIS Technician
d) GIS Analyst
e) Computer Programmer
f) Data Encoder
g) Information Systems Analyst
h) Information Technology Officer
i) Engineer
j) Planning Officer

<u>Components of GIS: Procedures/Methods</u>

1. Well-designed plan
2. Business rules
3. Models and operating practices unique to each organization

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9. PROPRIETARY AND OPEN SOURCE SOFTWARE

PROPRIETARY SOFTWARE

- Proprietary software, also known as non-free software or closed-source software, is
- computer software for which the software's publisher or another person reserves some rights from licenses to use, modify, share modifications, or share the software.
- It is the opposite of open-source or free software.

. Wikipedia

- Proprietary software source code is kept secret.
- The source code reveals how the product works, so by concealing it, developers prevent users from tampering with the product and competitors from stealing the ideas behind the source code and using it as inspiration for their own products.
- Proprietary software is software which is owned by an individual or company.
- It's therefore subject to copyright laws, and only the author or owner has control over its development, just like with any other product.
- Producing proprietary software provides a clear business model -the owners sell their product and make money.

What is proprietary software?

• Proprietary software is software that legally remains the property of its creator, whether that's an individual, an organization or a company.

• That means they own all rights to the product, including the intellectual property rights to the source code: the code that makes the program run.

Two camps of Proprietary Software

• : Whether software should be developing using the opensource model or the proprietary model.

• The source code is effectively the building blocks of the software.

• It's the human-readable version of the software, usually written in a higher-level programming language.

Proprietary Vs Opensource

• The availability of this source code provides the fundamental difference between open source and proprietary software.

• With open source software, users are allowed to inspect the source code, study it, modify it and redistribute it.

• With proprietary software, only the creators can see the source code, meaning it is only the creators who fully understand how it works, who can make changes to the code and distribute

it on.
• For these reasons, proprietary software is sometimes known as closed source software.

Advantages of proprietary software
• The proprietary model attracts a lot of developers, primarily because they get to commercialize their products.

• Money
• The most obvious factor where developers are concerned is that creating proprietary software means they can make money.
• Microsoft tech giant has built an empire by producing copyrighted software - the bulk of its revenue comes from selling Windows and Microsoft Office.
• Microsoft is now worth over $1 trillion.

• Product stability
• As open source software is continually evolving and developing, users have no control over how it develops.
• For users who aren't looking to develop or modify the software, a proprietary solution represents far more stability.

• A clearer roadmap
• Any business needs clear direction. When a developer or organisation produces commercial software, part of their business model includes a plan for the development and evolution of the product.

Tailored support
• For the user, paying for a product means better customer service.
• Closed source vendors spend significant time and money fine-tuning specific products.
• Easier to use
• Another perk for the user is improved overall user experience.
• Again, commercial vendors rely on you choosing their solutions over the number of free, open source alternatives on the market

OPENSOURCE SOFTWARE

What is Open source software ?

Open source software refers to software released without the usual copyright restrictions.
• This means the developer/s who invented are happy for other people to use their software for their own purposes, adapt and develop it as they see fit.
• More often than not, open source software is free, too, making it the perfect solution for individuals and businesses alike.

• Developers release open source software without restrictions into the public domain.

• This means anybody can inspect, study and modify the software's 'source code', its building blocks, whether that's to understand how it works, change it for their own purposes or make improvements for other users.
• Open source licenses, sometimes known as free software licenses, can be implicit or explicit.
• They are unique in that they grant users ample freedom over the product: specifically the freedom to alter and redistribute the software, which is something usually prohibited by copyright law.

Examples of open source products
• WordPress (a content management system),
• Open Office,
• the internet browser Mozilla Firefox,
• Wikipedia,
• the GNU/Linux operating system and
• its derivative Android, an operating system for mobile devices.

Types of open source license
• There is a range of open source licenses available to software creators.
• MIT license: Originating at MIT, this license permits users to modify original code with very few restrictions. It's GPL compatible meaning that users can relicense MIT software as GPL software.
• GNU General Public license (GPL) 2.0./3.0.: Anyone who writes software code under GPL must release it as open source, too.
• Apache license 2.0: This license has stricter rulers, particularly when it comes to redistribution.
• Common Development and Distribution license 1.0 (CDDL-1.0): All users who own a CDDL can reproduce and distribute any original work or derivative work.
• BSD licenses.: The BSD license places fewer restrictions on its developers, though there's disagreement over whether this makes the software freer or not.

Free & Open Source Software (FOSS): Applications & Technologies
• Applications of which you can access the source code
• Similar functionality as commercial software applications
• Becoming less IT oriented and more GUI friendly
• Provides useful information to users about the construction of applications
• Provide the ability to learn how to construct tailored applications for specific uses
• Allows for a more informed decision on what is needed outside the free and open source environment.

GIS SOFTWARE PRODUCTS
The below table shows a select list of commercial software in the left column and free and open source software(FOSS) for GIS in the right column.

Commercial	Free and Open Source
• Environmental Systems Research Institute (Esri) (http://www.esri.com/): ArcGIS	• Center for Spatial Data Science, University of Chicago (http://spatial.uchicago.edu/): GeoDa
• Autodesk Inc. (http://www.autodesk.com/): AutoCAD Map3D and Autodesk Geospatial	• Open Source Geospatial Foundation (http://grass.osgeo.org/): GRASS
• Bentley Systems, Inc. (http://www.bentley.com/): Bentley Map	• gvSIG Community (http://www.gvsig.com/en): gvSIG
• Intergraph/Hexagon Geospatial (http://www.intergraph.com/): GeoMedia	• International Institute for Aerospace Survey and Earth Sciences, the Netherlands (http://www.itc.nl/ilwis/): ILWIS
• Blue Marble (http://www.bluemarblegeo.com/): Global Mapper	• MapWindow GIS Project (http://mapwindow.org/): MapWindow
• Manifold (http://www.manifold.net/): Manifold System	• Open Jump (http://www.openjump.org/): OpenJump
• Pitney Bowes (http://www.mapinfo.com/): MapInfo	• Quantum GIS Project (http://www.qgis.org/): QGIS
• Caliper Corporation (http://www.caliper.com/): Maptitude	• SAGA User Group (http://www.saga-gis.org): SAGA GIS
• General Electric (https://www.gegridsolutions.com/GIS.htm): Smallworld	• Refractions Research (http://udig.refractions.net/): uDig
• Clark Labs (http://www.clarklabs.org/): TerrSet/IDRISI	

• ArcGIS is composed of applications and extensions at three license levels.
• The applications include
• ArcMap,
• ArcGIS Pro,
• ArcCatalog,
• ArcScene, and
• ArcGlobe

• The extensions include
•3D Analyst,
• Network Analyst,
• Spatial Analyst,
• Geostatistical Analyst, and others.

• GRASS GIS (Geographic Resources Analysis Support System), the first FOSS for GIS, was originally developed by the U.S.
Army Construction Engineering Research Laboratories in the 1980s.
• Well known for its analysis tools, GRASS GIS is currently maintained and developed by a worldwide network of users.
• Academicians, government agencies (NASA, NOAA, USDA and USGS) and GIS practitioners use this open source software because its code can be inspected and tailored to their needs.
• SAGA GIS (System for Automated Geoscientific Analyses) is one of the classics in the world of free GIS software.
• It started out primarily for terrain analysis such as hillshading, watershed extraction and visibility analysis.
• Now, SAGA GIS is a powerhouse because it delivers a fast growing set of geoscientific methods to the geoscientific community.

• UMN Mapserver is fully functional; it does not have significant limitations, and in several respects it is superior to its commercial counterparts
• PostgreSQL+PosGIS as a relational geodatabase is a very reliable and powerful solution, and has already replaced commercial top-end solutions.

• GeoDa is a free GIS software program primarily used to introduce new users into spatial data analysis.
• Its main functionality is data exploration in statistics.
• One of the nicest things about it is how it comes with sample data for you to give a test-drive.
• From simple box-plots all the way to regression statistics, GeoDa has complete arsenal of statistics to do nearly anything spatially.

Advantages of Opensource Model

• It's predominantly free - estimations show that open source software collectively saves businesses almost £50 billion a year.

- Versatility - using open source software means you aren't locked into using a particular vendor's system that only works with their other systems.
- Security - a lot of people prefer working with open source software because of the transparency it offers.
- Rapid evolution - Not only does software usually evolve faster when its open source, it also evolves faster.
- Community - open source software represents a philosophy.
- OSS inspires collaboration from a community of users and developers around the world to make the software the best it can be.
- Training - promoting this exchange of knowledge also makes the industry far more accessible to people looking to learn about coding and programming.
- Stability - it's also often far more stable for a company to base their software and operations on open source software

Disadvantages of Opensource Model

- Stability - it's also often far more stable for a company to base their software and operations on open source software.
- If you're a small company basing your software on open source software,bear in mind that no one is required to help you if things go wrong.

Why make software as opensource?

- More heads together equals more progress.
- They hoped that by opening up the table to other developers, they could create software better suited to their needs.
- The critical thing to remember is that each company manipulates the source code for their own uses.
- The idea isn't to replicate and privatize the same design but to share base knowledge to create different solutions for differing purposes.

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10 , 11: TYPES OF DATA, SPATIAL, ATTRUBUTE DATA

Introduction to GIS Data

• The GIS Data is - a collection of Geographic Features
1. Spatial data (information about location)
2. Attribute data (descriptive data about particular feature)

• Spatial data Attribute data GIS+ Linking of this spatial data & attribute data gives a full picture of a feature in GIS.

• Geographic information systems (GIS) or geospatial information systems is a set of tools that captures, stores, analyzes, manages, and presents data that are linked to location(s).
• A database whose elements have Geographic Information (geo-coded)

GIS DATA SOURCE

• Digitized and scanned Maps
• Purchased , Donated, free (internet)
• Created by user

• Government agencies
• [G]overnment
• of the people,
• by the people,
• for the people.
•
• Corporate Sources
• Utilities
• Private Satellites
• The Public
• Open Street Map

GIS Data

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• Spatial data Attribute data GIS+ Linking of this spatial data & attribute data gives a full picture of a feature in GIS.

• Spatial Data: Vector format
• Point - a pair of x and y coordinates
• Line - a sequence of points
• Polygon - a closed set of lines
•
• Spatial Data: Raster format
• Point
• Line
• Polygon
• Raster data are described by a cell grid, one value per cell Zone of cell.

<u>Describing Geospatial Data</u>
• By recognizing two types of data:
• Spatial data which describes location (where)
• Attribute data which specifies characteristics at that location (what, how much, and when)

<u>Digital representation of GIS data</u>
• by grouping into layers based on similar characteristics (e.g hydrography, elevation, water lines, sewer lines, grocery sales) and using either:
• vector data model (coverage in ARC/INFO, shapefile in ArcView)
• raster data model (GRID or Image in ARC/INFO & ArcView)

• by selecting appropriate data properties for each layer with respect to:
• projection,
• scale,
• accuracy, and
• resolution

• Raster Images : Grids - ‘pixels”
• Satellite images
• Aerial photos

• Vector - Grids
• Features: Points, Lines & polygons
• Attributes: Size, Type, Length, etc

- Data bases - Tables of data
- GPS (Global Positioning Systems)
- Filed sampling of Attributes
- Remote Sensing & Aerial Photography
- Location Data
- How Many? - What kind? - Where?

- Scale of Data
- Global to Local

- Data Presentation
- Words, Charts, Graphs, Tables, Maps, Photos
- GIS connects Graphics to Data.

- Two major Data types of GIS
- Spatial data types
- Attribute data types

• Two major data structures of GIS

1. Raster data structures: represents geography via grid cells

- tessellations
- run length compression
- quad tree representation
- BSQ/BIP/BIL
- DBMS representation
- File formats

2. Vector data structures: represents geography via coordinates

- whole polygon
- point and polygon
- node/arc/polygon
- Tins
- File formats

Spatial Data Structure

- Spatial data is information about the shape, location and relationship of geographic features.
- A GIS requires that hard copy maps be scanned or digitized in order to transfer them into a digital form.

- Spatial data is information about the shape, location and relationship of geographic features.

• A GIS requires that hard copy maps be scanned or digitized in order to transfer them into a digital form.

Spatial Data:

What is spatial data?

• Location or extent of geographic features is stored as spatial data.

• Example :
• For example, location of a Taj Mahal, road network from Ahmedabad to Delhi or administrative boundry of Gujarat state.

• Vector format Point - a pair of x and y coordinates
• Line - a sequence of points
• Polygon - a closed set of lines

Raster Data

• Point
• Line
• Polygon
• Vector Raster

• Raster data are described by a cell grid, one value per cell Zone of cells.

Basic types of Spatial Data
• SPATIAL DATA (where)
• Specifies location
• Stored in a shape file, geodatabase or similar geographic file

• Attribute (descriptive) data.(what, how much, when)
• Specifies characteristics at that location , natural or human created.
• Stored in a database table.

• GIS system traditionally maintain spatial and attribute data separately ,then “join” them for display or analysis.

Properties of spatial Data

• continuous: elevation, rainfall, ocean salinity
• areas:
• unbounded: landuse, market areas, soils, rock type
• bounded: city/county/state boundaries, ownership parcels, zoning

• moving: air masses, animal herds, schools of fish
• networks: roads, transmission lines, streams
• points:
• fixed: wells, street lamps, addresses
• moving: cars, fish, deer

Examples of Spatial Data

• Satellite imagery
• Topographic Maps
• Road Networks
• Any other data set that contains location information about features.

• Storing of Spatial data
• Two basic types of models have evolved for storing geographic data digitally.
• Vector Data
• Raster Data

VECTOR DATA

• Vector features (geographic object with geometry are graphical data type to represent features with discrete boundaries such as streets, rivers, parcels and states.
• Typically vectors are spatially represented as points, lines and polygons, or annotations
• A vector data storage format for storing the location, shape and attributes of geographical features.
• A shapefile stored in a set of related files and contains on feature class.

RASTER DATA

• Rasters are used to represent continuous layers such as elevation, slope and aspect, temperature, rainfall, etc.
• Most commonly, rasters are used for the storage of aerial photographs imaginary of various kinds.

What is Point?

• Geographic feature which do not have length or width are stored point.
• For example: location of hospital in a city.

• Line
• Geographic feature which have adequate length but no width are stored as line object.

• Polygon
• Geographic feature which are large enough and have closed boundary are stored as polygon object.

• A spatial data model that defines space as an array of usually sized cells arranged in rows and columns.
• Each cell contains an attribute value and location coordinates.
• Unlike vector structures, which stores coordinates explicitly , raster coordinates contained in the ordering of the matrix.

• Group of cells that shares the same value represent the same type of geographic features.
- Files
- Shapefiles
- Grids
- Triangulated Irregular Networks(TINS)
- Vector product Format (VPF files)
- CAD Files (numerous formats)
- Tables (numerous formats)

- Databases
- Oracle
- SQL Server
- Personal Geodatabases (MS access)

• A coordinate-based data model that represents geographic features as points, lines, and polygons.
• Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices.

• Examples of discrete objects are fire hydrants, roads, ponds, or a cadastral.
• A vector data models broken down into three basic types: points, lines, and polygons.
• All three of these types of vector data are composed of coordinates, and attributes.
• A point uses a single coordinate pair to define its location.
Vector data structures represent specific features on the Earth's surface along with attributes of those features.
• Vector objects are either points, lines, or polygons.

Vector data Vs Image Data

Vector data	Image data
Use points and lines to represent features	Represented as 2-dimensional array of brightness values for pixels
Resolution is determined by precision of vertices' coordinates	Resolution is determined by pixel size
Efficiently represents sparse data	Efficiently represents dense data
Spatial relations exist	Spatial relations do not exist
Efficient storage of sparse data	Requires large amounts of storage space
Small redundancy to hide watermark	Considerable redundancy to hide watermark
Explicit representation of linear features	Deals poorly with linear features

12. TYPES OF ATTRIBUTES

- The GIS Data is a collection of Geographic Features Spatial data (information about location)
- Attribute data (descriptive data about particular feature)
- Spatial data Attribute data GIS+ Linking of this spatial data & attribute data gives a full picture of a feature in GIS.

By recognizing two types of data:

- Spatial data which describes location (where)
- Attribute data which specifies characteristics at that location (what, how much, and when)

1) Spatial Data: Vector format

Point - a pair of x and y coordinates
Line - a sequence of points
Polygon - a closed set of lines

2) Spatial Data: Raster format

- Point
- Line
- Polygon

Raster data are described by a cell grid, one value per cell Zone of cell.

Attributes in GIS

- Nonspatial information about a geographic feature in a GIS, usually stored in a table and linked to the feature by a unique identifier.
- For example, attributes of a river might include its name, length, and sediment load at a gauging station.

- There are two components to GIS data:
    - spatial information (coordinate and projection information for spatial features) and
    - attribute data.

- Attribute data is information appended in tabular format to spatial features.
- The spatial data is the where and attribute data can contain information about the what, where, and why.
- Attribute data provides characteristics about spatial data.

Attribute data can be store as one of five different field types in a table or database:

1. Character
2. Integer

3. Floating
4. Date
5. BLOB.

1) Character

- . The character property (or string) is for text based values such as the name of a street or descriptive values such as the condition of a street.
- The character property (or string) is for text based values such as the name of a street or descriptive values such as the condition of a street.
- Character attribute data is stored as a series of alphanumeric symbols.
- Aside from descriptors, character fields can contain other attribute values such as categories and ranks.
- For example, a character field may contain the categories for a street: avenue, boulevard, lane, or highway.
- A character field could also contain the rank, which is a relative ordering of features.
- For example, a ranking of the traffic load of the street with “1” being the street with the highest traffic.
- Character data can be sorted in ascending (A to Z) and descending (Z to A) order.
- Since numbers are considered text in this field, those numbers will be sorted alphabetically which means that a number sequence of 1, 2, 9, 11, 13, 22 would be sorted in ascending order as 1, 11, 13, 2, 22, 9.

2) Numeric Data

- Integer and floating are numerical values
- Within the integer type, the is a further division between short and long integer values.
- As would be expected, short integers store numeric values without fractional values for a shorter range than long integers.
- Floating point attribute values store numeric values with fractional values.
- Therefore, floating point values are for numeric values with decimal points (i.e numbers to the right of the decimal point as opposed to whole values).

Numeric values will be sorted in sequentially either in ascending (1 to 10) or descending (10 to **1) order.**

Numerical value fields can have operations performed such as calculating the sum or average value.

Numerical field values can be a count (e.g. the total number of students at a school) or be a ratio (e.g. the percentage of students that are girls at a school).

Date/Time Data

Date fields contains date and time values.

BLOB Data

- BLOB stands for binary large object and this attribute type is used for storing information such images, multimedia, or bits of code in a field.

- This field stores object linking and embedding (OLE) which are objects created in other applications such as images and multimedia and linked from the BLOB field.

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13. SCALES OR LEVELS OF MEASURES

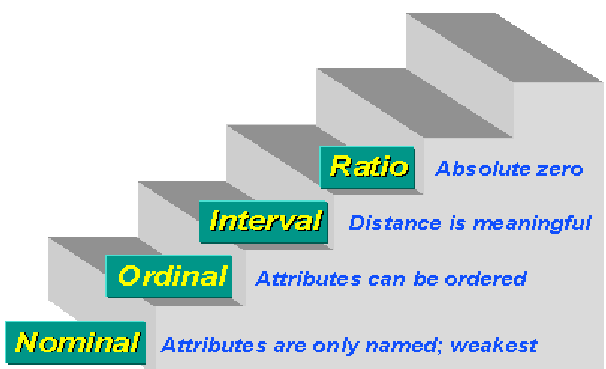
Introduction to Scales / Levels of Measures

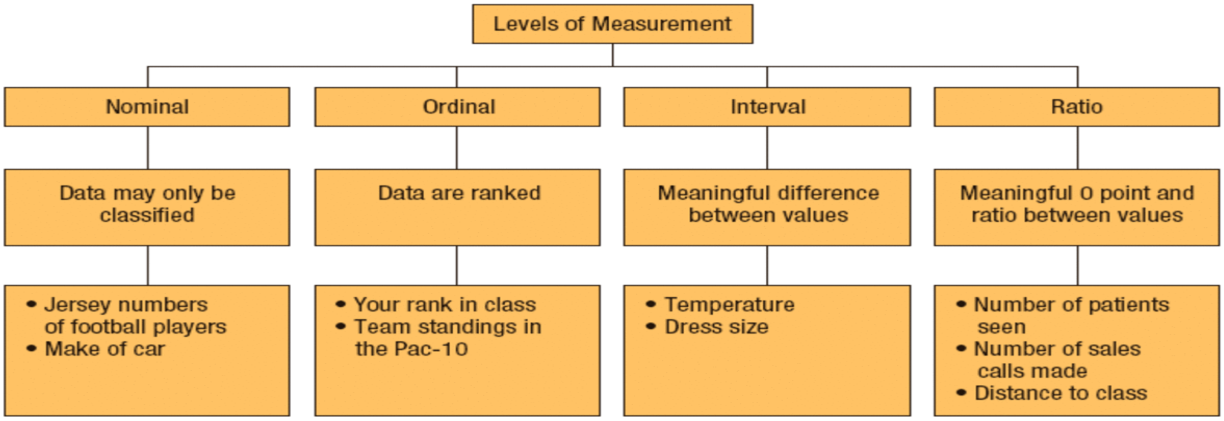
- The type of measurement system used may have a dramatic effect on the interpretation of the resulting values.
- The type of measurement system being used in the raster dataset is an influencing factor in GIS.
- So that the appropriate operations and functions can be implemented and the results will be predictable.
- Spatial Analyst does not distinguish between the four different types of measurements when asked to process or manipulate the values.

The four scales of measurement are nominal, ordinal, interval, and ratio.

Measurement values can be broken into four types:

1. Nominal.
2. Ordinal
3. Interval
4. Ratio



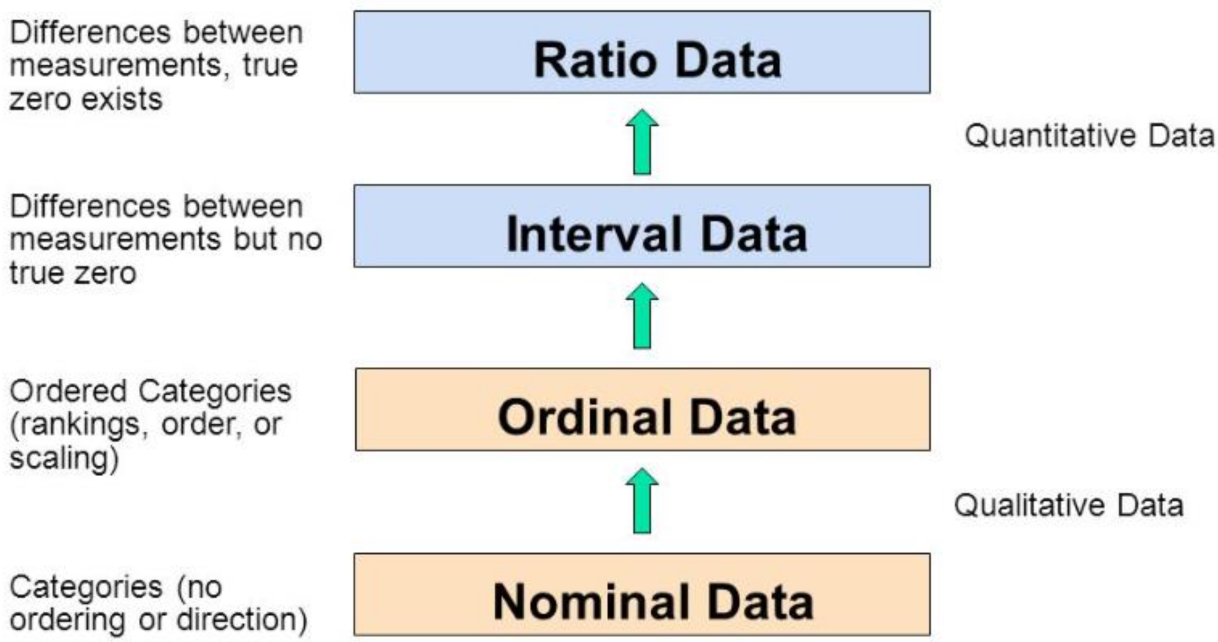


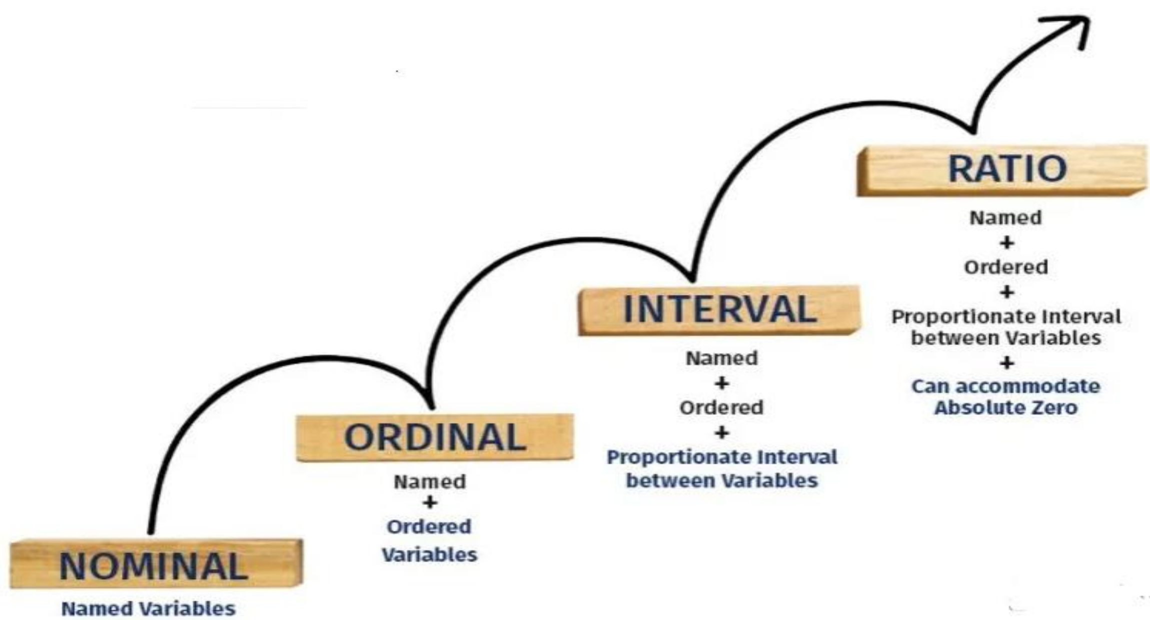
Nominal	Ordinal	Interval	Ratio
"Eye color"	"Level of satisfaction"	"Temperature"	"Height"
Named	Named	Named	Named
	Natural order	Natural order	Natural order
		Equal interval between variables	Equal interval between variables
			Has a "true zero" value, thus ratio between values can be calculated

	Nominal	Ordinal	Interval	Ratio
Categorizes and labels variables	✓	✓	✓	✓
Ranks categories in order		✓	✓	✓
Has known, equal intervals			✓	✓
Has a true or meaningful zero				✓

What is the difference between ordinal, interval and ratio variables?

- In the 1940s, Stanley Smith Stevens introduced four scales of measurement: nominal, ordinal, interval, and ratio.
- These are still widely used today as a way to describe the characteristics of a variable.
- Knowing the scale of measurement for a variable is an important aspect in choosing the right statistical analysis.





a) nominal

- no inherent ordering
- land use types, county names

b) ordinal

- inherent order.
- road class; stream class often coded to numbers
- eg SSN but can't do arithmetic

Numerical

- Known difference between values interval
- No natural zero
- can't say 'twice as much' temperature (Celsius or Fahrenheit)

ratio

- natural zero
- ratios make sense (e.g. twice as much)
- income, age, rainfall
- may be expressed as integer [whole number] or floating point [decimal fraction]

Measurement Categories

Variable	Measurement Levels	Values
1.1 Age	Interval	Years
1.2 Gender	Nominal (2 categories)	1 = Male 2 = Female
1.3 Tribe of origin	Nominal (2 categories)	1 = Qabily2 = Hadari
1.4 Relationship status	Nominal (4 categories)	1 = Single, 2 = Married, 3 = Divorced; 4 = Widow/Widower
1.5 Highest level of education	Ordinal (6 categories)	From 1 = Uneducated to 6 = Postgraduate degree
1.6 Monthly Income	Ordinal (8 categories)	From 0 = None to 7 > SA 20,000
1.7 Religious level	Ordinal (4 categories)	From 1 = Highly religious to 4 = Not religious

1) Nominal:

- Categorical data and numbers that are simply used as identifiers or names represent a nominal scale of measurement.
- Nominal data divides variables into mutually exclusive , labeled category.
- Coding schemes for land use, soil types, or any other attribute qualify as nominal measurements.
- A nominal scale describes a variable with categories that do not have a natural order or

ranking.

- You can code nominal variables with numbers if you want, but the order is arbitrary and any calculations, such as computing a mean, median, or standard deviation, would be meaningless.

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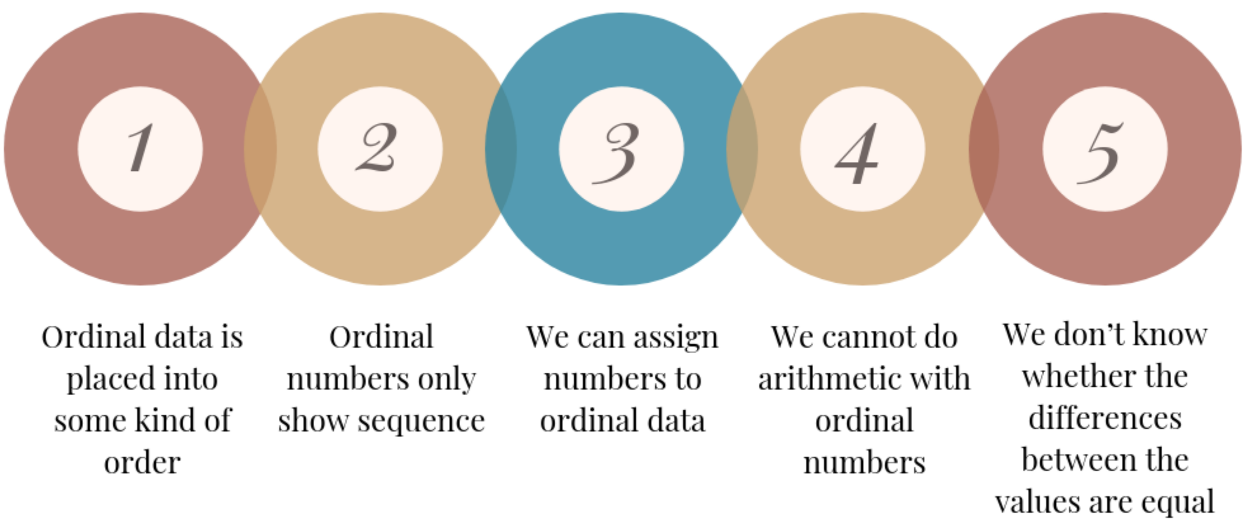
- but the order is arbitrary and any calculations,
- such as computing a mean, median, or standard deviation, would be meaningless.

2) Ordinal

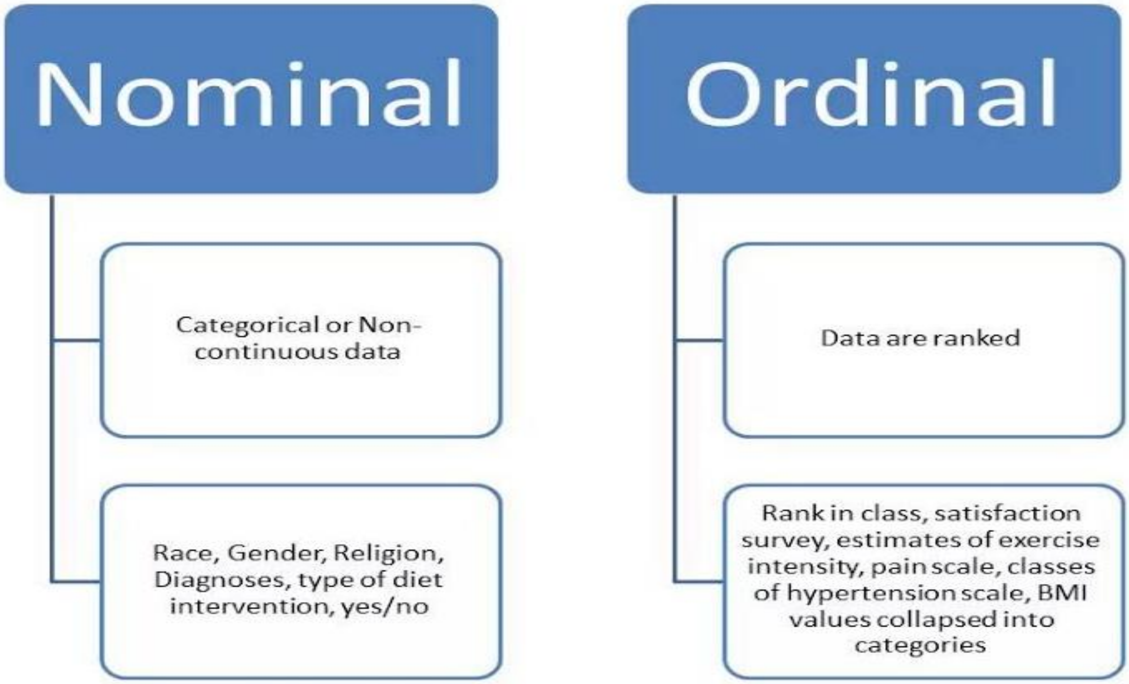
- Ordinal values determine position.
- Ordinal show place
- first, second, and third, but they do not establish magnitude or relative proportions.
- An ordinal scale is one where the order matters but not the difference between values.
- Note the differences between adjacent categories do not necessarily have the same meaning.
- But how much better, worse, prettier, healthier, or stronger something is cannot be demonstrated from ordinal numbers.

- For example, a runner who was first place in a race probably did not run twice as fast as the second-place runner.

- Knowing the winners only by place,
- you do not know how much faster the first-place runner was compared with the second-place runner.



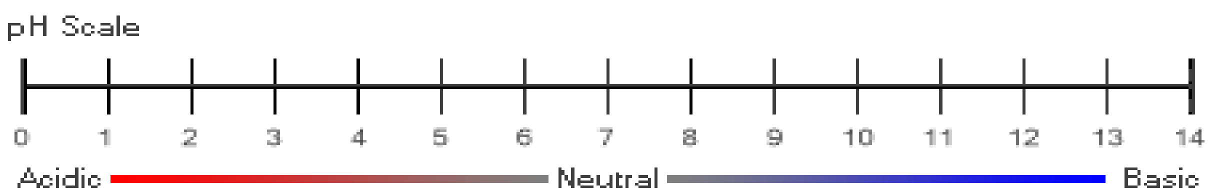
Nominl Vs Ordinal



3) Interval

- An interval scale is one where there is order and the difference between two values is meaningful.
- These are values on a linear calibrated scale, but they are not relative to a true zero point in time or space.
- Because there is no true zero point, relative comparisons can be made between the measurements, but ratio and proportion determinations are not as useful.

temperature (Farenheit)
temperature (Celcius)
pH values
SAT score (200-800)
credit score (300-850)
Time of day
calendar years
are all examples of interval measurements.



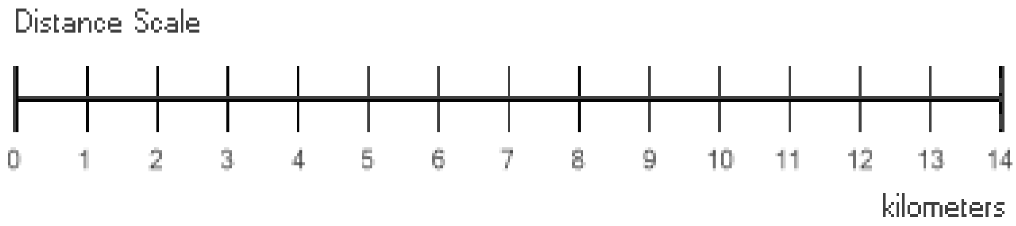
4) Ratio

- The values from the ratio measurement system are derived relative to a fixed zero point on a linear scale.
- A ratio variable, has all the properties of an interval variable, and also has a clear definition of 0.0.
- When the variable equals 0.0, there is none of that variable.

- Mathematical operations can be used on these values with predictable and meaningful results.

- Examples of ratio measurements are age, distance, weight, and volume.

- enzyme activity
- dose amount
- reaction rate
- flow rate
- concentration
- pulse
- weight
- length
- temperature in Kelvin (0.0 Kelvin really does mean "no heat") survival time.



Most mathematical operations work well on ratio values,
but when interval, ordinal, or nominal values are multiplied, divided, or evaluated for the square root, the results are typically meaningless.

On the other hand, subtraction, addition, and Boolean determinations can be meaningful when used on interval and ordinal values.

Attribute handling within and between raster datasets is most effective and efficient when using nominal measurements.

Discrete versus continuous data

- A categorical object has known and definable boundaries.

- An integer value is normally associated with each cell in a discrete raster dataset.

- Most integer raster datasets can have a table that carries additional attribute information. Floating-point values can be used to represent discrete data, but this is not common.

- Discrete data is best represented by ordinal or nominal numbers.

Continuous

- A continuous raster dataset or surface can be represented by a raster with floating-point values (referred to as a floating-point raster dataset) or occasionally by integer values.

- The value for each cell in the dataset is based on a fixed point (such as sea level),
- a compass direction, or the distance of each location from a phenomenon in a specified measurement system (such as the noise in decibels monitored at various sites near an airport).

- Many times, meaningless results will occur when combining discrete and continuous data, for instance, adding land use (discrete data) to elevation (continuous data).

- A value of 104 on the resulting raster dataset could have been derived from
- adding single-family housing land-use type, with a value of 4, to an elevation of 100.

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