Geography 360: GIS & Mapping

Introduction to GIS

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Review

- What were the topics discussed on Monday (Jan 07) during the lecture?

Review

- **Syllabus on Canvas**
  - **How to access course syllabus, lecture notes, readings, schedule (labs, assignments, exams) on canvas.**
  - **Lab sections, lab location and lab timings based on sections.**
- **Submit Assignment 00 (10 points) on canvas : Self Introduction**
- **Tips: How to succeed in this class.**
- **Class Participation:**

1. **Bring a A4 size sheet(**s) to every lecture session.
2. **Write answers** to all questions asked during each lecture session.
3. submit hard copy during the labs session to their TA.
4. **(Monday, Friday = Tuesday; Wednesday = Thursday).**
5. TIP: Take a picture on your cell phone/scan the sheets to **create a digital copy** and save
6. **before you submit** them to your TA (in case you loose your paper copy).
7. Every week, we will **randomly select a day** (M/W/F) and **grade** that sheet.
8. In total, this quarter has 10 weeks. Only **8 sheet submissions** will **count** towards your **final**
9. **score (10%).**

Prepare for Class Participation

- **Write your Name, Section, Day, Date, Topic on your sheets.**
- **Write your responses to all questions asked during the lecture.**

Learning Objectives

- Know definitions of the terms used, including geographic information (GI) (What is GIS? Components of GIS?).
- Be familiar with a brief history of GI technology (History of GIS).
- Recognize the sometimes invisible roles of GI in everyday life, business, and government (GIS Applications).
- Understand the significance of GI science, and how it relates to GI systems.
- Understand the many impacts GI technologies and their underpinning science are having on society and the need to study those impacts.

Outline

- What is GIS?
- Components of GIS
- History of GIS
- GIS Applications
- Careers in GIS

Outline

- **What is GIS?**
- Components of GIS
- History of GIS
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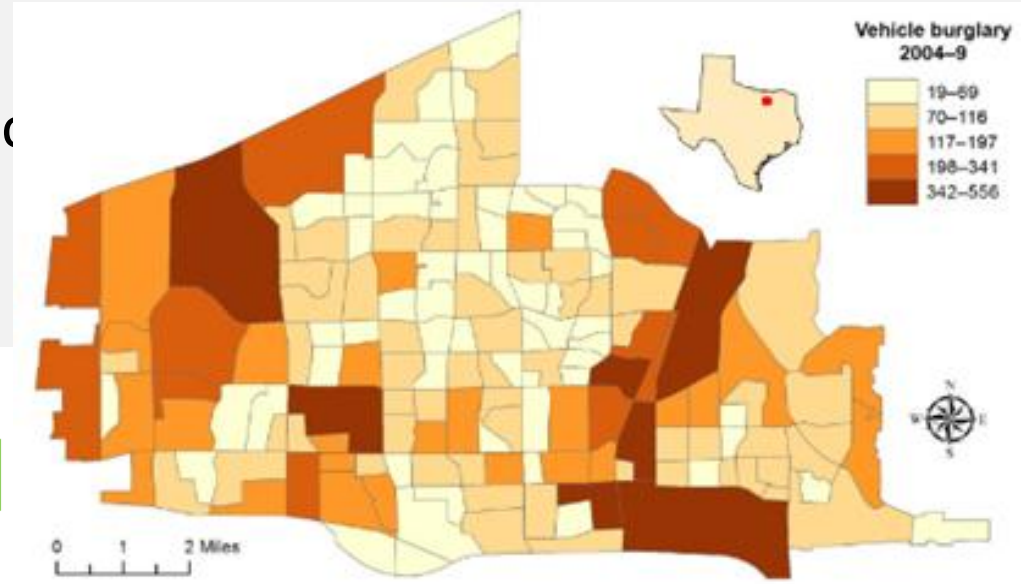
What is GIS?

No easy answer anymore!

- **What does GIS stand for**
  - G---Geographic/Geospatial
  - I --- Information

- **almost everything that happens, happens somewhere (location)**
- **Information about places on the surface or near the surface of the Earth**
- **knowledge about "what is where when, "** (Don't forget time!)

  - S---
    - Systems : the technology
    - Sciences: the concepts and theo
    - Studies: the societal context



The Spatial pattern of vehicle burglary in the city of Plano, Texas, during 2004-2009 (Chun 2014)

What is a Geographic Information System?

- **Geographic relates to a specific place on or in relation to the Earth's surface.**
- **Information – is data to which some value or interpretation has been added.**

  In GI, the information relates to measurements, maps, images, sounds etc. of the Earth's surface.
- **Systems – a system designed to perform a wide range of functions on and with GI.**

Spatial is Special

- **Geographic:**
  the Earth's surface and near-surface.

- **Spatial:**
  any space (not just the space of the Earth's surface).

- **Spatial Analysis:**
  application of techniques (in GI technology) to geographic and non-geographic spaces.

- **Geospatial:**
  subset of spatial, applied specifically to the Earth's surface and near-surface.

Geographic Information Technologies

- **Global Positioning Systems (GPS)**
  - a system of earth-orbiting satellites which can provide precise (100 meter to sub-cm.) location on the earth's surface (in lat/long coordinates or equiv.).
- **Remote Sensing (RS)**
  - **use of satellites or aircraft to capture information** about the earth's surface.
  - Digital ortho-images a key product (map accurate digital photos).
- **Geographic Information Systems (GISy)**
  - **Software** systems with capability for input, storage, manipulation/analysis and output/display of geographic (spatial) information.

- ***GPS and RS are sources of input data for a GISy.***
- ***A GISy provides for storing and manipulating GPS and RS data.***

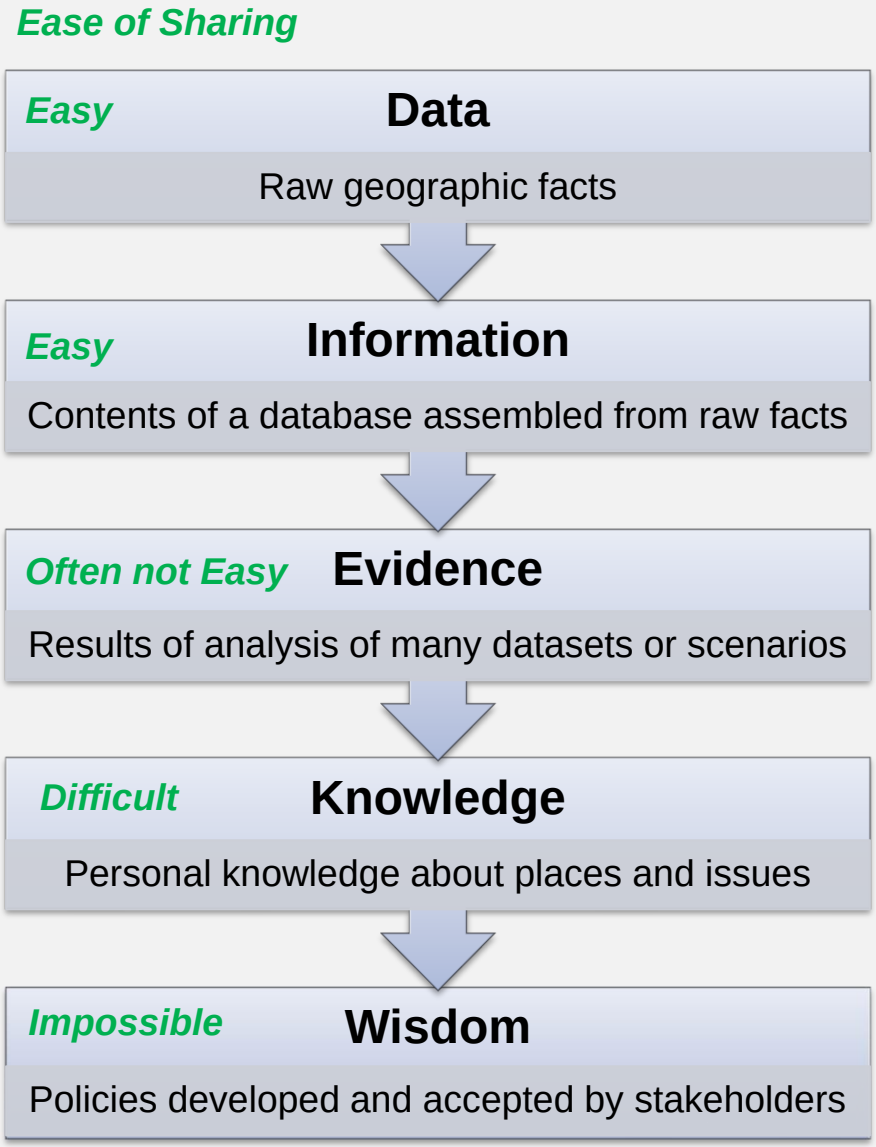
GI Systems, Science and Studies

Which will we study?

- **GISystems**
  - Technology for the acquisition and management of spatial information.
  - Computerized tool that helps solve geographic problems
- **GIScience**
  - the identification and study of issues that are related to GIS use
  - comprehending the underlying conceptual issues of representing data and processes in space-time
  - the theory and concepts behind the technology
  - Introduce enough of the science to apply the systems correctly and understand their capabilities and limitations
  - Examples : Analysis techniques, Visualization techniques, Algorithms for geographical data
- **GIStudies**
  - the systematic study of society's use of geographic information.

Combine hands-on technical training with an understanding of the underlying science and an emphasis on various applications

Decision-Making Support Infrastructure



- **Mundane** information
- Consists of **numbers, text, symbols**
- Are **neutral** and **context free**

- That can be represented in **digital form**
- Data that is **selected, organized** and prepared for practical purpose **i.e. data serving some purpose.**

- **Halfway between** information and knowledge.
- **Multiplicity of information** from different sources.

- Information to which **value** has been **added by interpretation** (particular context, experience, purpose).
- **Read and understood.**

- **Decisions made or advice given** based on information and knowledge.

What are Information Systems?

- **Information systems help us to manage "what we know"…**
  - **organize** and **store**
  - **access** and **retrieve**
  - **manipulate** and **synthesize**
  - apply to the solution of **problems**

What is GIS?- no universally accepted GIS definition

- A set of tools for collecting, storing, retrieving, transforming, and displaying spatial data from the real world (Burroughs, 1986).

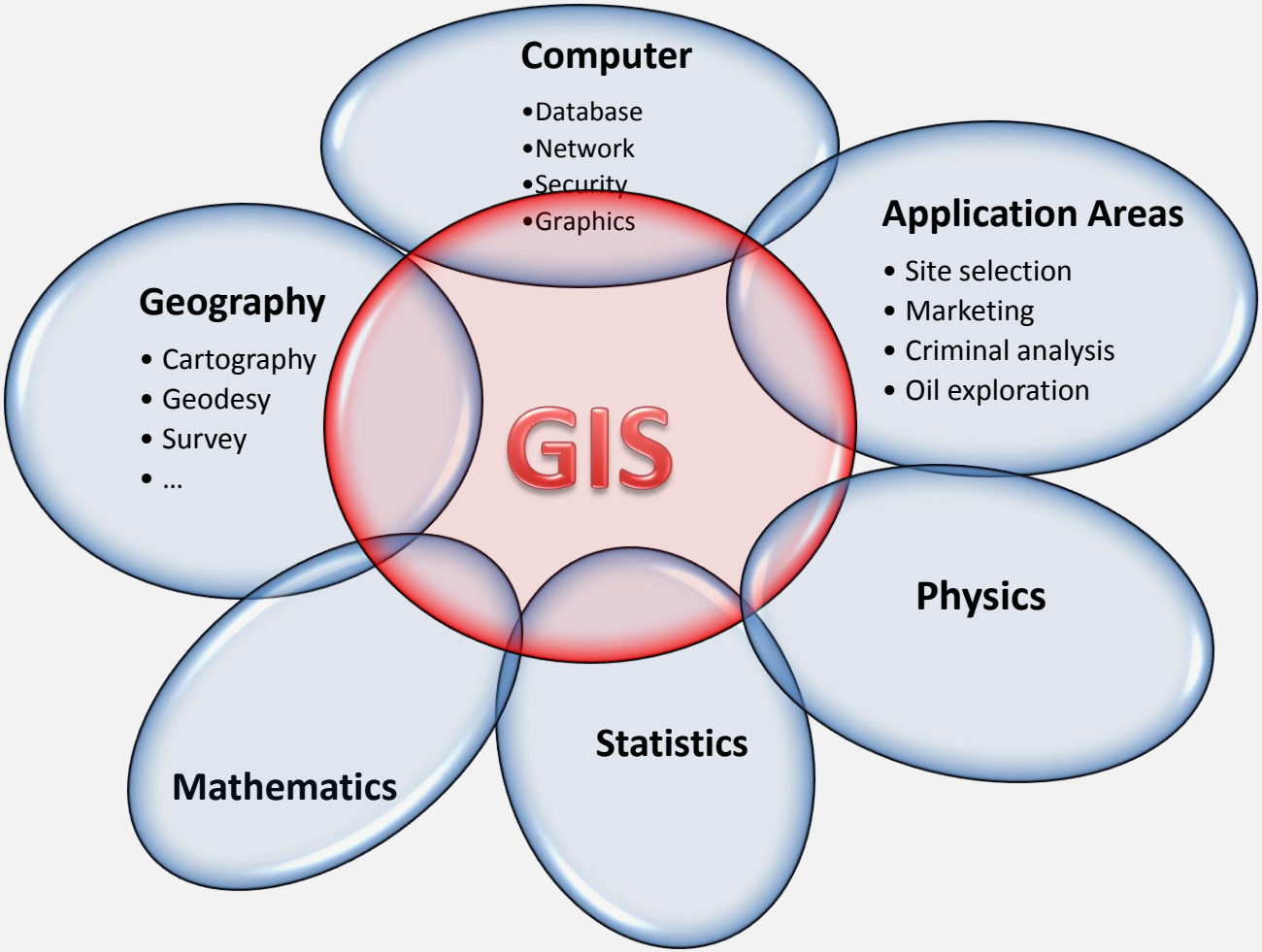
- An information system used to manipulate, summarize, query, edit, and visualize spatial and non-spatial information stored in a computer database (Goodchild, 1997).

- A computer-based system designed to manage and use geospatial data to solve spatial problems. (Lo and Yeung, 2007).

Knowledge Base for GIS

Where did GIS come from?

- It has intellectual origins in many different fields.
- The convergence of technological fields and traditional disciplines.



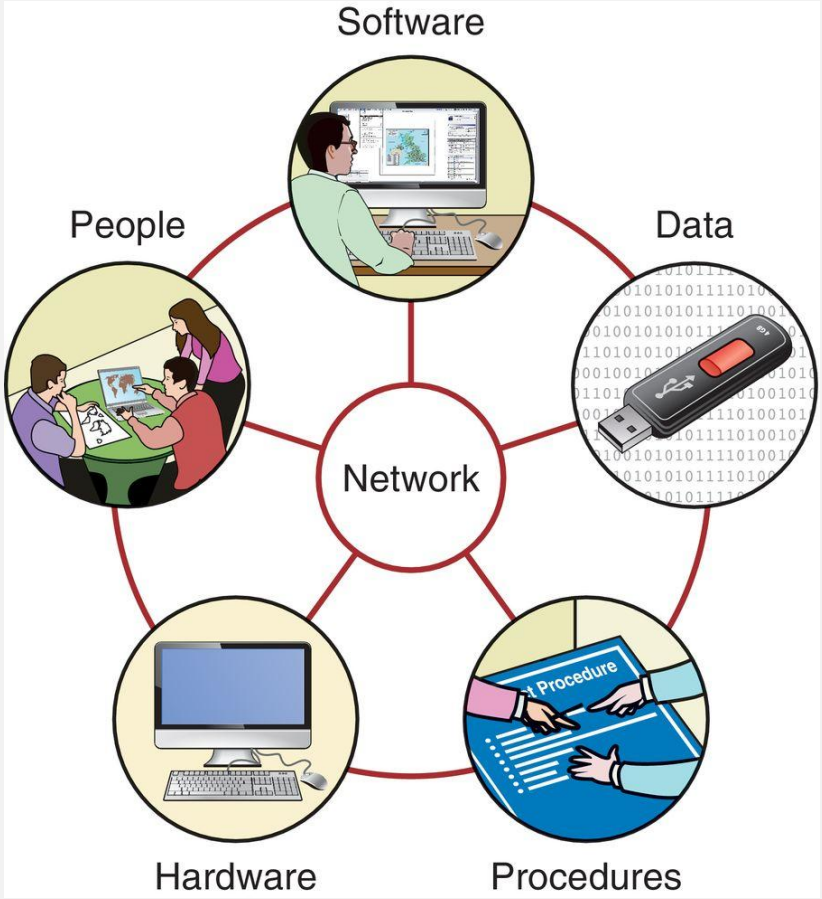
Outline

- What is GIS?
- **Components of GIS**
- History of GIS
- GIS Applications
- Careers in GIS

Components of GIS

GIS extends the study of information systems by including spatial data, spatial processing and spatially mediated knowledge

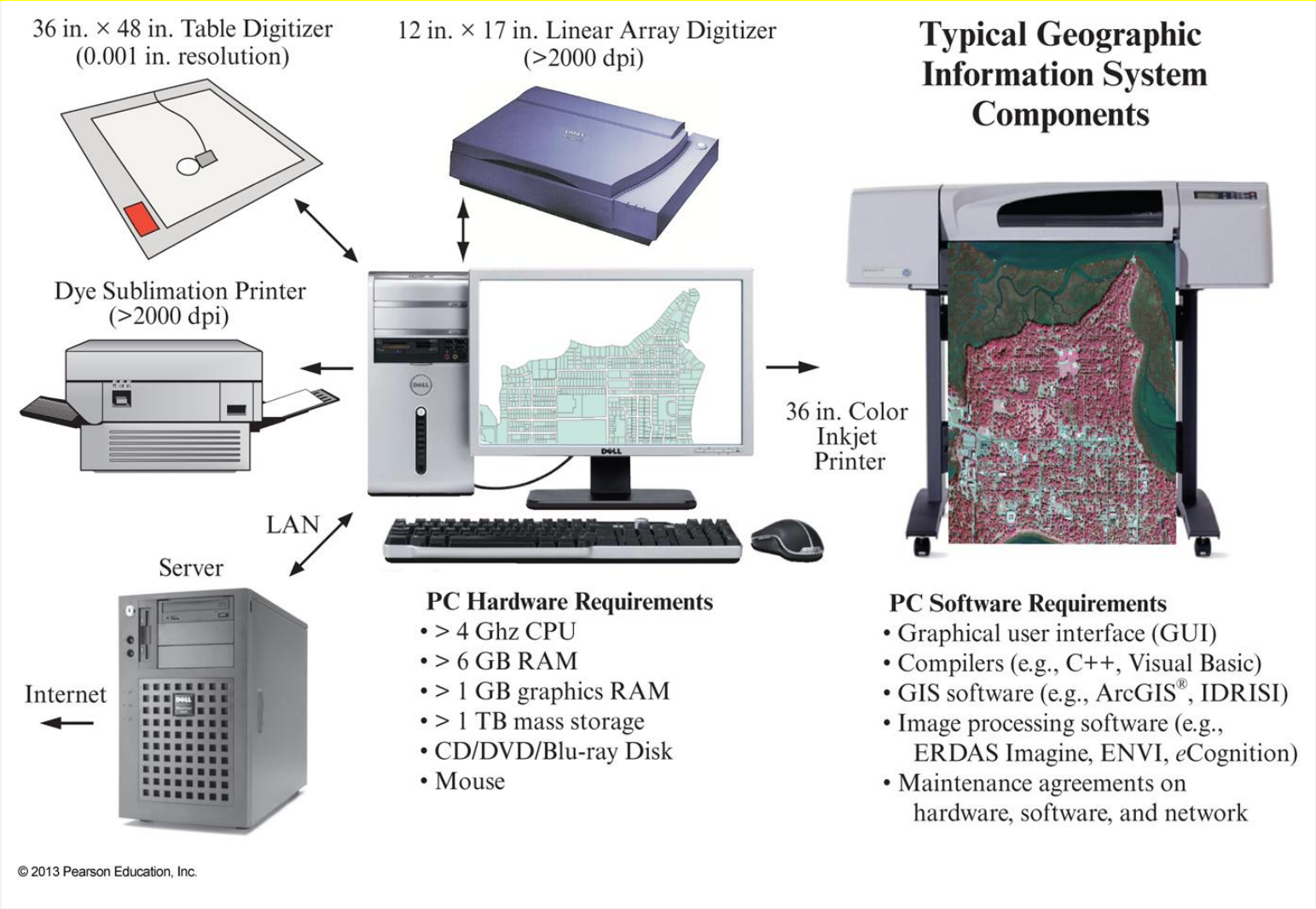
- **Hardware**
- **Software**
- **Network**
- **Data**
- **People**
- **Procedures**



The **Internet** is core to most aspects of GIS use, and the days of standalone GISystems are mostly over.

Network – for rapid communication or sharing of digital information.

Hardware and Software of GIS



Hardware is the device that the user interacts directly in carrying out GISystem operations (type, point , click , speak). Returns information by displaying on device's screen (or sounds).

Typical GIS computer hardware and software characteristics

TABLE 1–1 Typical GIS computer hardware and software characteristics. Additional information about computer hardware/software, and GIS computer programming is provided in Chapter 11.

Computer Hardware	Characteristics	Importance
Central Processing Unit (CPU)	Single CPU Multiple CPUs	Multiple CPUs significantly increase the speed of operations associated with GIS data analysis and the processing of large datasets.
Arithmetic Co-processor	Reduced instruction set code	Increases the speed of calculations.
Memory	Read only memory (ROM) Random access memory (RAM) Graphics memory	Used to perform system operations. > 6 GB > 1 TB graphics RAM
Mass Storage	Hard Disk Compact Disk (CD) Digital Video Disk (DVD) Blu-ray Disk (BD)	> 1 TB is ideal Dual-layered if possible
Display	Minimum of 1900 x 1200 pixels 24 to 32-bit color look-up tables	Goal is to view the maximum geographic space possible at the highest color resolution.
Peripheral Input and Output Devices	Mouse Scanner (≥2000 dpi) Tablet digitizer (≥2000 dpi) Printers/plotters	Projects may require digitization of hard-copy maps or hard-copy remote sensor data. High quality printers and plotters are used to display GIS-related products.
Networking	Local area network (LAN) Internet backbone Cloud computing	Essential for sharing spatial data, GIS processing, and distributing GIS-related products.
Computer Software	**Characteristics**	**Importance**
Operating System	Microsoft, UNIX, LINUX, Apple	Use a widely adopted, reputable system.
Database Management System (DBMS)	Store and access attribute data	Critical to the usefulness of the GIS.
Functions	Cartography Data coordinate conversion Data interoperability Data management Digital image processing Geocoding/address matching Geostatistical analysis Linear referencing Network analysis Programming software Spatial analysis Spatial statistics 3-dimensional analysis	The GIS software must be able to perform the tasks required for specific geospatial applications.
Network	Local area network software Internet data access software Internet GIS software	Facilitates data sharing and processing between computers in a local area network (LAN) and on the Internet.

GIS Software

TABLE 11–1 Commonly-used GIS software programs and selected characteristics. The greater the capability, the greater the number of ***.

GIS Software	Operating System	Data Input	Vector/Raster Processing	Vector/Raster Data Handling	Carto-graphic Output	Integration of Remote Sensing
AccuGlobe	Windows	***	**	**	*	
AGIS	Windows		*	*		
ArcGIS® for Desktop	Windows	****	****	****	****	****
AUTOCAD	Windows/UNIX	***	***	***	****	***
AUTOCAD Raster Design	Windows/UNIX	*	***	****	**	***
Cadcorp SIS Map Modeller	Windows	**	***	***	**	*
Caliper Maptitude	Windows	****	***	***	****	
CARIS Carta	Windows	***	***	***	***	*
ERDAS ER Mapper	Window/UNIX	****	***	***	***	****
ERDAS IMAGINE (Intergraph)	Windows/UNIX	****	****	****	****	****
GRASS	Windows/Mac/ Linux/UNIX	***	****	****	****	**
IDRISI Taiga	Windows	****	****	****	****	****
ILWIS	Windows	**	***	***	*	***
Intergraph	Windows/UNIX	****	****	****	****	****
Kosmo Desktop	Windows/Linux	***	**	**	**	*
LandSerf	Windows/Mac/ Linux/UNIX	***	***	****	**	*
Manifold	Windows	****	****	**	*	
MapInfo	Windows/UNIX	***	***	***	****	**
OpenJump	Windows/Mac/ Linux/UNIX	**	**	**		
PCI Geomatica	Windows/UNIX	***	***	***	*	****
Quantum GIS	Windows/Mac/ Linux/UNIX	*	*	**	*	
SPRING	Windows/UNIX	***	***	***	**	***
SuperMap DeskPro	Windows/UNIX	***	***	***	*	

GIS Software

- **Huge number of technologies**
  - Desktop vs. Web
  - Analysis vs. Visualization
  - Proprietary ($$$) vs. Opensource

- **ESRI has long dominated the field**
  - Desktop: **ArcMap**, migrating toward **ArcGIS Pro**
  - Web: ArcIMS (old), ArcGIS Server, **ArcGIS Online**
  - Full suite of capabilities from visualization to analysis
  - Proprietary and expensive

- **Other commercial software: ENVI (remote sensing), ERDAS IMAGINE (remote sensing), MapInfo (GIS)**

GIS Software

- **Increasing number of open source alternatives**
  - **Desktop**: QGIS, GRASS, etc
  - **Web map servers**: GeoServer, Mapnik, MapServer, etc
  - **Spatial database management**: PostGIS
  - **Web development libraries**: OpenLayers, Leaflet.js, Google Maps API
- **Programming is important too!**
  - JavaScript (Web mapping)
  - Python (analysis)
  - R (analysis)
  - SPSS (analysis)

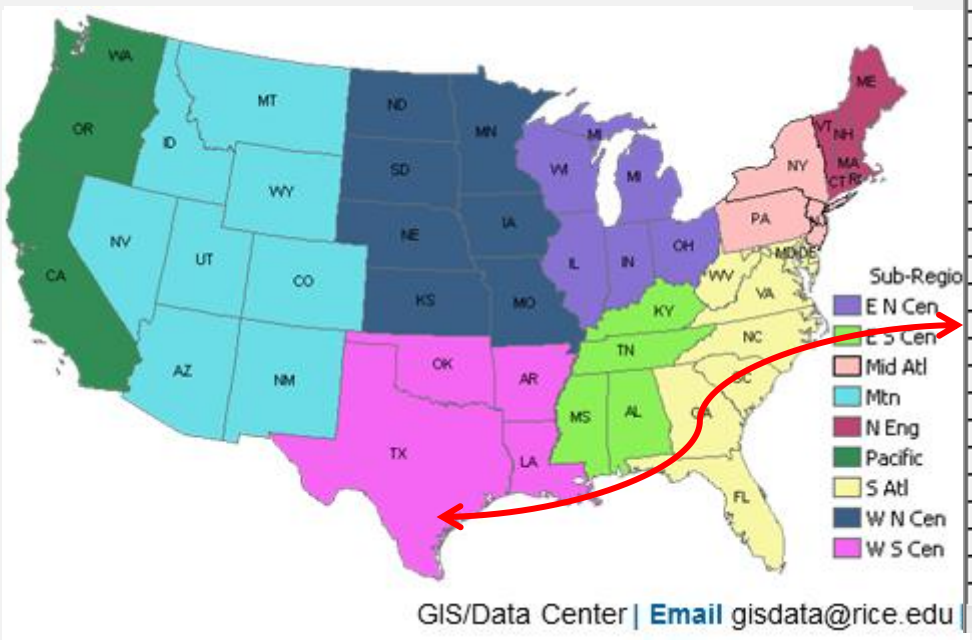
Data

- Provides foundations for digital representation of Earth's surface or near earth surface.
- **Open data**
- **Big Data -** too large and complex to process using standard processing software or database management tools.
- Geographic databases are often big (include large numbers of location coordinates and many raster images).
- Challenge to capture, store, maintain, share, visualize and analyze.

Data

- **Spatial Data(where)**
  - Graphic spatial representation of real-world physical features
  - Have unique geographic coordinates

- **Non-spatial data (what, when, how)**
  - Attributes describing spatial data



STATE_NAME	DRAWSEQ	STATE_FIPS	SUB_REGION	STATE_AE
California	25	06	Pacific	CA
Ohio	26	39	East North Central	OH
Illinois	27	17	East North Central	IL
District of Columbia	28	11	South Atlantic	DC
Delaware	29	10	South Atlantic	DE
West Virginia	30	54	South Atlantic	WV
Maryland	31	24	South Atlantic	MD
Colorado	32	08	Mountain	CO
Kentucky	33	21	East South Central	KY
Kansas	34	20	West North Central	KS
Virginia	35	51	South Atlantic	VA
Missouri	36	29	West North Central	MO
Arizona	37	04	Mountain	AZ
Oklahoma	38	40	West South Central	OK
North Carolina	39	37	South Atlantic	NC
Tennessee	40	47	East South Central	TN
Texas	41	48	West South Central	TX
New Mexico	42	35	Mountain	NM
Alabama	43	01	East South Central	AL
Mississippi	44	28	East South Central	MS
Georgia	45	13	South Atlantic	GA
South Carolina	46	45	South Atlantic	SC
Arkansas	47	05	West South Central	AR
Louisiana	48	22	West South Central	LA
Florida	49	12	South Atlantic	FL
Michigan	50	26	East North Central	MI
Alaska	51	02	Pacific	AK

People

- **Humanware**
  - Defined as characteristics and capabilities of the people responsible for designing, implementing, and using the GIS.
  - The most important component of GIS

- **The benefits of GIS technology may be minimal without users skilled at**
  - We need people to design, program, maintain it, supply it with data, and interpret its results.
  - Peoples of GIS have various skills, depending on the roles they perform.
  - Depending on skills, they apply GIS to real-world problems

What is GIS?- no universally accepted GIS definition

Definition of a GIS	The group who find them useful
A container of maps in digital form	The general public
A computerized tool for solving geographic problems	Decision makers, community groups, planners
A spatial decision support system	Management scientists
A mechanized inventory of geographically distributed features and facilities	Operations researchers
A tool for revealing what is otherwise invisible in geographic information	Scientists, investigators
A tool for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand	Resource managers, planners

A Tool or a Science?

- **GI systems =** a technology for collecting, managing, storing, analysing, and visualizing geographic information
- **GI science =** a fundamental field of study which examines the representation, storage, analysis, and visualization of geographic information (Longley et al, 2005)

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Brief History of GI Technology…

- **Mid 1960s - the first GI system was the Canada Geographic Information System**
  - Mid 1960s computerized mapping system
  - Land-use management
  - Resource monitoring
  - Regulatory procedures
- **Late 1960s U.S. Bureau of the Census developed DIME (Dual Independent Map Encoding)**
  - Digital records of all US streets, for automatic referencing and aggregation of census records.

Brief History of GI Technology…

- **Early GI system developers recognized that the same basic needs were present in many different application areas, from resource management to the census**

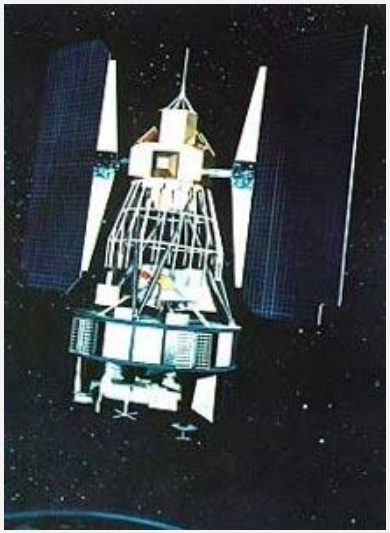
- **Harvard University – Laboratory for Computer Graphics and Spatial Analysis**
  - Developed general-purpose GI system **– 1970s** ODYSSEY GIS

Brief History of GI Technology…

- **Separate needs of cartographers and mapping agencies**
  - The quest to **reduce the cost and time** of map production.
  - **Computer** support for map **editing**.
  - Partial computerization of cartographic agencies by the late 1970s.
  - **Great Britain – first country with national digital map coverage** (1995).

Brief History of GI Technology…

- **Role of remote sensing**
  - **military** satellites of the 1950s
    → early 1970s **civilian** systems
  - military needs also developed the **GPS**
  - many **technical developments** originated in the Cold War



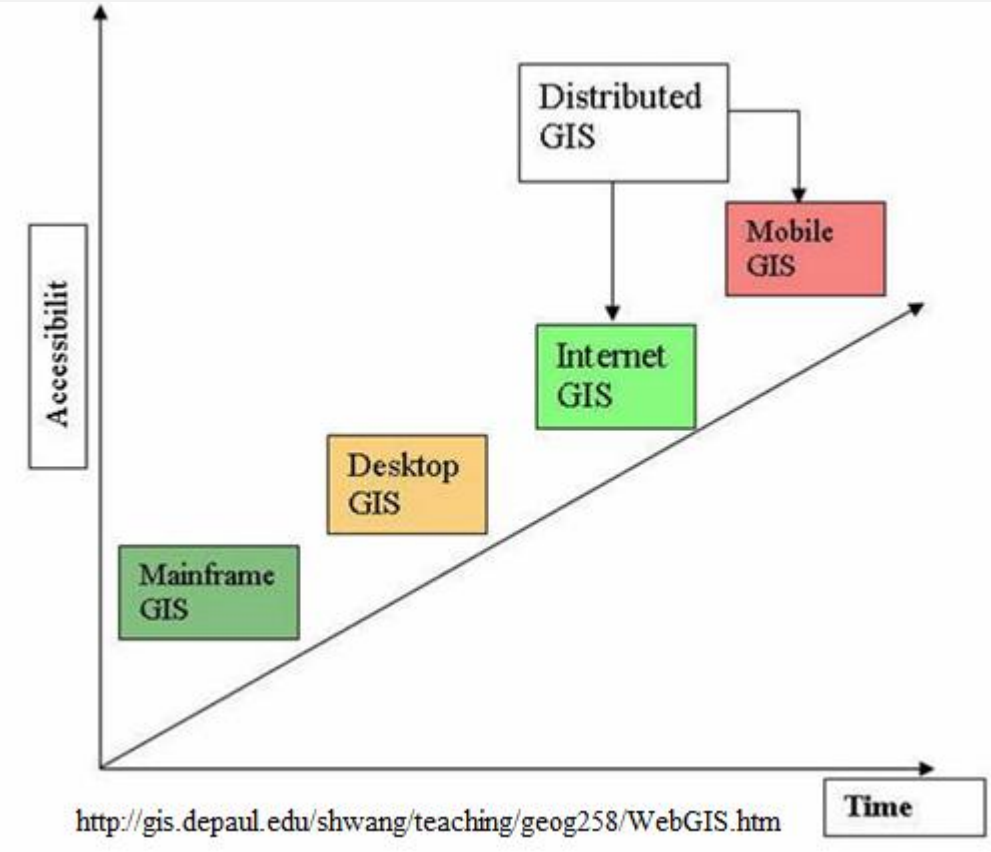
Landsat 2

Brief History of GI Technology…

- Early 1980s take-off (hardware prices could sustain software industry) $250,000 computers and $100,000 software (large-scale resource managers).
- The modern history of GI technology dates from the early 1980s, when the price of sufficiently powerful computers fell below a critical threshold.

The History of GIS

- Major events that shaped GIS can be found in Table 1.4 (Longley)
- The evolution of GIS is companied by
  - Conceptual advancement
  - Hardware Improvement
  - Software development
  - Data availability
  - Education and organization



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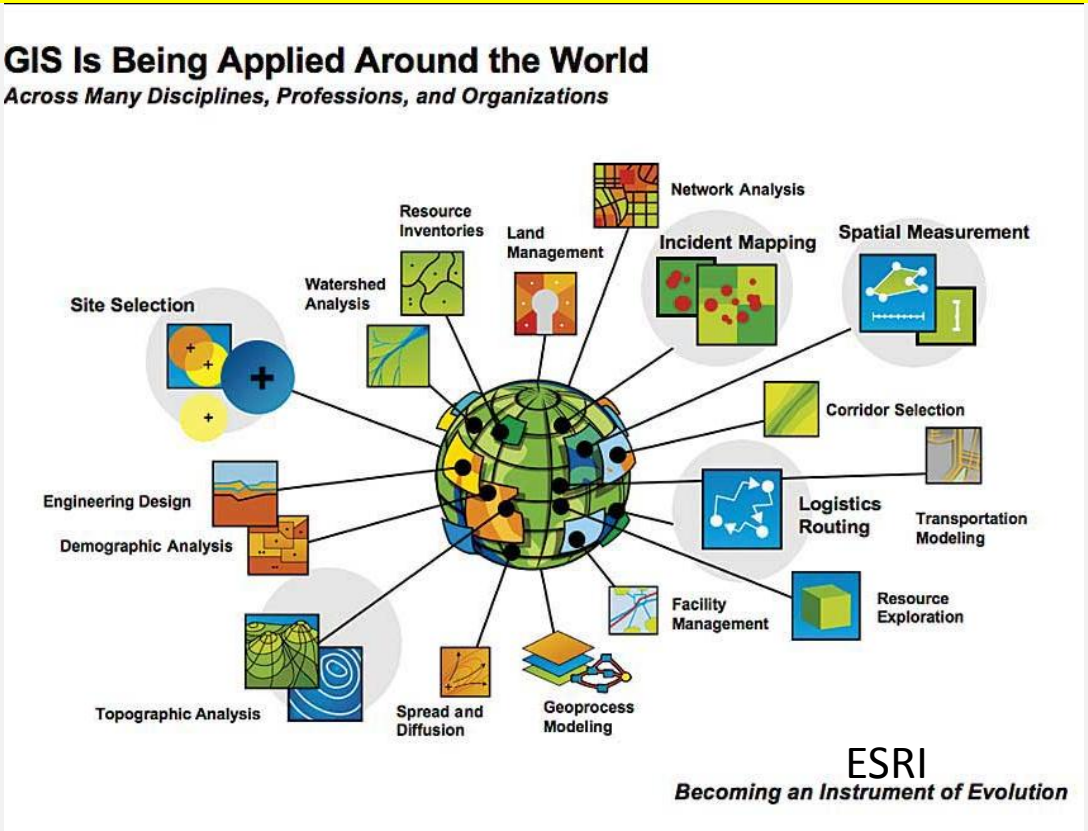
GIS Application

- Five Ms:
  - Mapping
  - Measurement
  - Monitoring
  - Modeling
  - Management



GIS Application Areas

http://www.esri.com/industries

Aid and Development
- Humanitarian Aid
- Sustainable Development

Business
- Insurance
- Retail
- Manufacturing
- Real Estate
- Banking
- Marketing
- Media

Defense and Intelligence
- Military Operations
- Intelligence
- Installations and Environment
- The Geospatially Enabled Enterprise

Education
- Libraries and Museums
- Schools (K–12)
- Universities and Community Colleges

Government

Health and Human Services
- Public Health
- Human Services
- Hospital and Health Systems
- Managed Care
- Academic Programs and Research

Mapping and Charting
- Aeronautical
- Cartographic
- Nautical
- Topographic

Natural Resources
- Agriculture
- Climate Change
- Conservation
- Environmental Management
- Forestry
- Mining
- Oceans
- Petroleum
- Water Resources

Public Safety
- Emergency Call Taking and Dispatch
- Emergency/Disaster Management
- Fire, Rescue, and EMS
- Homeland/National Security
- Law Enforcement
- Wildland Fire Management

Transportation
- Aviation
- Highways
- Logistics
- Railways
- Ports and Maritime
- Public Transit

Utilities and Communications
- Electric
- Gas
- Location-Based Services
- Pipeline
- Telecommunications
- Water/Wastewater

Journals, Magazines and Books

- ***Major GIS-Only Journals***
  - **International Journal of Geographical Information Science**
  - **Geographical Systems**
  - **Transactions in GIS**
  - **Geo Info Systems**
  - **GIS World**
- ***Regular GIS Papers***
  - **Annals of the Association of American Geographers**
  - **Cartographica**
  - **Cartography and GIS**
  - **Computer; Computers, Environment, and Urban Systems**
  - **Computers and Geosciences**
  - **IEEE Transactions on Computer Graphics and Applications**
  - **Photogrammetric Engineering and Remote Sensing**
- ***Specialty Journals***
  - **Business Geographics**
  - **GIS Law**
  - **GrassClippings**
  - **GIS Asia/Pacific**
  - **GIS World Report/CANADA**
  - **GIS Europe**
  - **Mapping Awareness**

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Why Study GIS?

- **80% of local government activities estimated to be geographically based**
  - –zoning, public works (streets, water supply, sewers), garbage collection, land ownership and valuation, public safety (fire and police)
- **Significant portion of state government has a geographical component**
  - – natural resource management
  - – highways and transportation
- **Businesses use GIS for a very wide array of applications**
  - –retail site selection & customer analysis
  - –logistics: vehicle tracking & routing
  - –natural resource exploration (petroleum, etc.) & precision agriculture
  - –civil engineering and construction
- **Military and defense**
  - –Battlefield management
  - –Satellite imagery interpretation
- **Scientific research employs GIS**
  - –geography, geology, botany
  - –anthropology, sociology, economics, political science, criminology

Conclusions

- GI Systems are systems used to handle data pertaining to geographic locations.
- Information systems help us manage and interpret data.
- Spatial information is important as almost all human decisions involve a spatial component.
- Knowledge about how the world works is more valuable than knowledge about how it looks, because it can be used to predict.

Questions ?

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Upcoming

- Lecture : Representing Geography.
- Week 1, GIS Lab 01: Introduction to Web Mapping will be assigned (know your sections).
- Submit Wednesday's class participations sheets to TA on Thursday.
- Continue reading syllabus for updates on readings, due dates, etc.