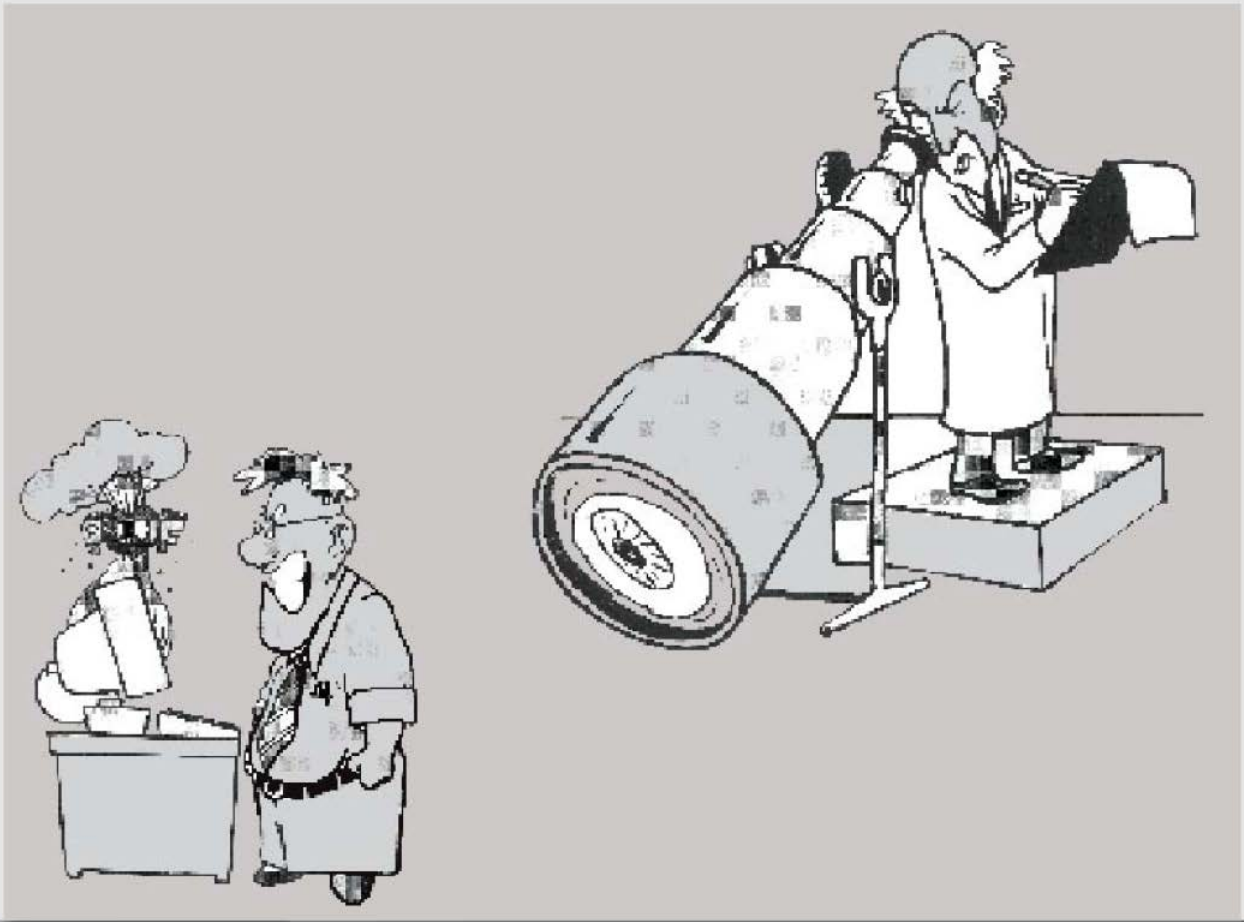
# Chapter 10

# Selection of a GIS



# THE EVOLUTION OF GIS SOFTWARE

- An early GIS landmark : an international survey of software conducted by the International Geographical Congress in 1979 (a part of which is Complete Geographic Information Systems). (influential in deciding on the name 'GIS')
  - Most cartographic programs were not integrated but single-purpose GIS operations such as digitizing, data format conversion, plotting on a specific hardware device such as a pen plotter, map projection transformations, or statistical analysis of data.
- The early computer mapping systems devising many GIS functions
  - SURFACE Ⅱ, CALFORM, SYMAP, CAM, VisiCale, SASGRAPH, Harvard Graphics
  - The ancestry of GIS is completed by the first advances in the relational database management systems.

# THE EARLY GIS SOFTWARE PROGRAMS

- One of the earliest civilian systems to evolve all the capabilities of a true GIS was the CGIS (Canadian Geographical Information System)
  - the georeferencing and geocoding of the data, database management capability, a single integrated software package without separate, stand-alone elements, and a single user interface
  - GIS packages had unsophisticated user interfaces.
- The second generation of GIS software included graphical user interfaces, usually involving the use of windows, icons, menus, and pointers.
  - The typical system has pop-up, pull-down, and pull-right menus for selecting choices.
  - The typical GIS can support multiple windows-for example, one for the database and one to display a map-and the tasks can be opened and closed as needed.

# OPERATING SYSTEMS AND GIS

- Early GIS was heavily influenced by the types of operating systems in use (IBM's systems, MSDOS, and VMS).
- The graphical user interface(GUI) based operating systems took over as the dominant microcomputer operating environment.
  - two critical capabilities : multitasking and device independence,
- Unix : complete integrated network support and several full GUIs for Unix in the public domain, the most important being the X-Windows system.
  - The user can switch the GUI to suit particular needs or applications.
- Two main avenues for GISs have evolved as far as operating systems are concerned : the microcomputer platform and the workstation platform.

# GIS Functional Capabilities

## Data Capture

- Data capture is getting the map into the computer which is a critical first step in GIS.
- Data absorbing formats
  - Auto CAD DXF format file
  - DBF, ASCII format
  - scanning, digitizing
- Editing the maps
  - vector data set : delete and reenter a point or line
  - raster data set : select subsets, change the grid spacing, change a specific erroneous grid value
  - node snapping, dissolving, mosaicing or 'zipping', map generalization (point, line, area, and attributes)

- Checking the attributes (done at data-entry time)
  - database system should enforce the restrictions on the GIS that are specified during the data definition phase of database construction and stored in the data dictionary.
  - checking whether values fall within the correct type and range
  - automatic cleaning of topology, snapping nodes, eliminating duplicate lines, closing polygons, and eliminating slivers.
  - Be careful when using automatic cleaning, for the tolerances may eliminate important small features or move the features around in geographic space without accountability.
- Dealing with GPS data conversion, with survey-type data from coordinate geometry systems, or with remotely sensed imagery.
  - serving as GIS and image processing system (GRASS, ERDAS)
  - Essential to geocoding capabilities is the geocoding software's ability to move between coordinate system and map projection.

## Data Storage

- Issue on space for data storage
  - Storage cost reduction, high-density storage media, and the integration of compression methods into common operating systems have made this issue less critical .
  - As data become higher resolution, as more raster layers are used, and as finer and finer detail becomes available, many GIS data sets can easily move into the gigabyte range in size.
- Issue on access to data : how flexible a GIS is in terms of making the data available for use.
  - Consequence of the rise of distributed processing, the Internet, and the World Wide Web
  - Many GIS packages are now capable of using metadata.

- Issue on the mechanism for user interaction with the software's functionality
  - 'Language' for the user to communicate with the system allows users to add their own custom functions, automate repetitive tasks, and add features to existing modules.
- Degree to which the system itself provides help to users (help system)
- Support for data formats is important to a GIS when data are to be brought in from outside.
- Ability to convert between raster and vector data.
- Development of GIS functions that support data in standard exchange formats.

## Data Management

- Every GIS is built around the software capabilities of a database management system (DBMS), a suite of software capable of storing, retrieving selectively, and reorganizing attribute information.
  - partitioning the data between fi les and memory locations
  - structuring the data in several formats and physical data models.
  - data entry, data editing, and supporting many list types of output such as tabular
  - retrieving, sorting
  - other operations on data, such as masking, dynamic segmentation

## Data Retrieval

- retrieval of features by both their attributes and their spatial characteristics.
- the most basic act : to show the position of a single feature
  - coordinates, length (line), area (polygon), …
  - We can calculate and store some properties as new attributes in the database and retrieve them.
    - polygon-in-polygon, point-in-polygon, …
- retrieval of features from the database using the map as the query vehicle
  - supporting the ability to point at a feature, using a device such as a mouse or a digitizer cursor, to see a list of attributes for that feature
  - Select-by-attribute capability is normally a command to the database query language that generates a subset of the original data set.

- retrieval based on using one or more map features as handles to select attributes of those features
  - selecting a feature by its proximity to a point, a line, or an area
    - point -> a certain radius, line and polygon -> buffering
- Map overlay is an important part of a major GIS function, that of redistricting, in which new districts can be drawn and the data restructured into the regions so that tests and analyses can be performed by trial and error.
- network construction and query
  - subway systems, pipes, power lines, river systems, …
  - In map algebra, the retrieval operations used are Boolean, multiply, recode, and algebra.
- clumping or aggregating areas and sifting
- computing numbers that describe shape

## Data Analysis

- Data analysis in GIS systems varies remarkably.
  - the computation of the slope and direction of slope on a surface
  - interpolation of missing or intermediate values
  - line-of-sight calculations on a surface
  - the incorporation of special break or skeleton lines into a surface; finding the optimal path through a network or a landscape
  - the computation of the amount of material that must be moved during cut-and-fill operations such as road construction
- Geometric tests can be absolutely fundamental to building a GIS.
  - point-in -polygon, line-in-polygon, and point-to-line distance
- other data analysis
  - doing spreadsheet and database tasks, computing a new attribute, generating a printed report or summarizing a statistical description, and doing simple statistical operations

## Data Display

- desktop mapping, generating geographical and thematic maps
  - several types of thematic mapping, including choropleth and proportional symbol maps
  - isoline and cross-sectional diagrams
  - interactive modification of map elements such as moving and resizing titles and legends
  - exporting the output into a package that has these capabilities, such as Adobe Illustrator or CorelDraw
- A very limited few GIS packages include cartographic design help .
  - editing of graphics, defaulting to suitable color schemes, or notifying the user if an inappropriate map type is being used for the data

# DATA STRUCTURES AND GIS SOFTWARE

- Many GIS features are predetermined by the GIS's particular data structure.
  - typically raster or vector but potentially also TIN, quadtree, or another model, such as object-based
- The driving force for the choice of structure
  - not only what type of system can be afforded
  - but more critically, what model is most suitable to a particular application, what retrieval and analysis functions will be used most, and what is the acceptable level of resolution and error.
- some examples where particular structures are favored
  - land characterization applications such as land use/land cover study , where detailed data are not required (favours raster)
  - applications involving irregular polygons and boundary lines, such as political units or census tracts (favours vector)
- The raster to vector conversion is done outside of the GIS in specialist conversion software.

# THE LEADING GIS SOFTWARES

## Arc GIS (by ESRI)

- the latest version of Arc/Info (first release in 1999)
- a long-lived, full function GIS package that has been ported to the microcomputer, the workstation, and the mainframe
- incorporation of hundreds of sophisticated tools
  - map automation, data conversion database management, map overlay and spatial analysis, interactive display and query, graphic editing, and address geocoding
- macro and programming language : Visual Basic
- using a generic approach to geographic information systems that is not application specific
- substantial modification of the program's user interface and functionality (Object-modelling capability, the Spatial Data Base Engine and Oracle are included)
- The compatibility between ArcGIS and Arc View has been increased.

## ArC View (by ESRI)

- desktop system available for windows and various Unix platforms
- more oriented toward map display than database management
- An intuitive graphical user interface includes data display and a viewing tool.
- Spatial and tabular queries, ‘hot links’ to other desktop applications and data types, business graphics functions such as charting, bar and pie charts, and map symbolization, design, and layout capabilities are supported.
- geo-coding and address matching
- Spatial Analyst tool kit
- other extensions : network analysis, allow Web activation of ArcView maps, and support advanced display features such as three-dimensional data visualization
- ArcView GIS since version 8 has been more compatible with ArcGIS.

## MapInfo (by MapInfo Corporation of Troy)

- one of the first GIS programs to do desktop mapping
- well distributed and a broad variety of applications worldwide
- running under DOS, Windows, Macintosh, and on various Unix platforms
- MapBasic : the Basic programming language
- customized ‘mapplications’
  - extending MapInfo’s built-in functionality and allowing use of a common graphical interface
- MapInfo has several GIS products aimed at different applications area, including MapInfo Professional, MapInfo MapX, MapXtreme, MapXSite, MapInfo Spatialware, Proviewer, and GIS Extension.
- MapInfo also supplies information products spanning geographic, economic, political, cultural, and industry application
- extensive training program

## GeoMedia (by Intergraph Corporation of Huntsville)

- widely distributed layer-based GIS with a tradition in computer-assisted design
- running on workstations, PCs, and under the Windows NT system
- modules allowing users to configure GIS capability
  - GeoMedia, GeoMedia Professional, Intelliwhere Ondemand, GeoMedia Webmap, and GeoMedia WebMap Professional
- extensions aimed at applications in land information, parcel management, public works, and transportation
- The layered implementation permits effi cient storage structures for the geometry and linkages to relational database records.
- GeoMedia incorporates use of the Oracle and SQL relational interface system.
- fully integrated with Intergraph's traditional products such as MGE

## ILWIS (by International Institute for Aerospace Survey an Earth Sciences)

- acronym for the Integrated Land and Water Information System
- running on the most basic of common computer platforms
- image processing capabilities
- raster based software, and designed to be easy to use, yet provide professional-level GIS, image processing and spatial statistics analytical capability

## Autodesk Map

- built on the capabilities of the substantial AutoCAD software for automated drafting and design
- Because this package is extensively used in planning, engineering, and architectural offices, many people can easily build upon their existing knowledge to enter the field of GIS.
- supporting topology, query using Oracle and SQL, data management, and thematic mapping
- The Autodesk Raster Design module supports grids and images and the Autodesk Onsite module handles all of the standard GIS data operations.
- extensive tools for coordinate conversion and specifi cation, rubber-sheeting, and map editing and digitizing
- programming language : C++
- Output control and plotting support are strong.

# ERDAS

- acronym for Earth Resource Data Analysis
- basically image processing capability but also vector module and virtual GIS functions
- modules such as Imagine Advantage, Imagine Professional, Imagine Essentials and Virtual GIS etc
- Imagine Vrtual GIS
  - powerful viewing and fast display with a range of superior 3D visual analysis capabilities
  - creation of DEM
- Imagine Vector
  - import/export of vector data, its cleaning and typology building
- ArcView extensions and ERDAS MapSheets module

## GRASS (by U.S. Army Construction Engineering Research Laboratories)

- acronym for Geographic Resources Analysis Support System
- an open source, free software GIS with raster, topological vector, image processing, and graphics production functionality that operates on various platforms through a graphical user interface and shell in X-Windows
- Since 1996, the headquarters for GRASS support, research, and development has been at Baylor University, within the Department of Geology.
- The GRASS GIS uses a standardized command line input designed to resemble the Unix shell command language, but also uses a GUI under X-Windows.

## Idrisi (by Clark University Graduate School of Geography)

- free software, the most broadly used raster GIS in the world
- Idrisi is easy to use, yet provide professional-level GIS, image processing and spatial statistics analytical capability on both DOS – and Windows – based personal computers.
- running on the most basic of common computer platforms
- designed with an open architecture so that researchers can integrate their own modules
- a graphical user interface, flexible cartographic composition facilities, and an integrated database management system to the analytical tool kit.
- special routines for change and time – series analysis, spatial decision support, and uncertainty analysis and incorporation
- A stand alone cartographic product, CartaLinx, allows topological editing and database development.

- **GRAM++ (by Center of Studies in Resource Engineering)**
  - acronym for GeoReferenced Area Management
  - user-friendly GIS package developed indigenously
  - modular DOS based integrated package designed for low cost computer configuration.

- **GeoSmart (by Department of Space, Government of India)**
  - exclusively used by Regional Remote Sensing Service Centers

## Maptitude (by Caliper Corporation)

- The latest version includes census data, a developer's toolkit and extended file support.
- The software comes with a considerable amount of geocoded and system-ready data.
  - every street in the United States with the address information, state, county, zip codes, and census tracts as polygons with associated demographic data, and additional assorted U.S. and global data
- Users can create and maintain geographic databases, analyze geographic relationships in data, and create highly professional map displays for presentations and reports.
- running under Windows NT, and with networks
- object linking and embedding of Windows