7 GIS Software

OVERVIEW

This chapter provides an overview of GIS software from various perspectives including architecture, functionality, history and key vendors.

LEARNING OBJECTIVES

By the end of this chapter students should:

- **Understand the architecture of GIS software systems, including organization by project, department, or enterprise; and, the three-tier architecture of software systems (graphical user interface; tools, and data access);**
- **Describe the process of GIS customization;**
- **Describe the main types of commercial software**
  - **Desktop**
  - **Web mapping**
  - **Server**
  - **Virtual globe**
  - **Developer**
  - **Hand-held**
  - **Other**
- **Outline the main types of commercial GIS software products currently available.**

KEY WORDS AND CONCEPTS

GIS software, graphical user interfaces (GUIs), COTS, Web services, software architecture, three-tier architecture, desktop and internet GIS, enterprise GIS, client-server, thick and thin clients, customization, API, components, thick and thin servers, middleware, hand-held GIS.

Outline

CHAPTER SUMMARY

7.1 Introduction

- Focus is on the different ways in which GIS capabilities are realized in GIS software products and implemented in operational GIS
- Takes a fairly specific view of GIS software, concentrating on systems with a range of generic capabilities to collect, store, manage, query, analyze, and present geographic information.
- The discussion is also restricted to GIS software products – well-defined collections of software and accompanying documentation, install scripts, etc. – that are subject to multi-versioned release control. By definition it excludes specific-purpose utilities, unsupported routines, and ephemeral codebases.
- Software can be:
    - COTS – commercial-off-the-shelf software
    - Shareware - (often intended for sale after a trial period)
    - Liteware - shareware with some capabilities disabled
    - Freeware - free software but with copyright restrictions
    - Public domain software - free with no restrictions
    - Open source software - the source code is provided and users agree not to limit the distribution of improvements

7.2 The evolution of GIS software

- Provides a very brief summary of the evolution of GIS from command line to GUI.
- Two key developments in the late 1980s were GUIs and customization capabilities
- The recent emergence of the Web services paradigm is mentioned.
- A Web service is an application that exposes its functions via a well-defined published interface that can be accessed over the Web from another program or Web service.

7.3 Architecture of GIS software

7.3.1 Project, departmental, and enterprise GIS

- Project GIS – a single, fixed term, one-off project, data are collected specifically for the project and little is thought of reuse, absence of organizational vision, sharing data and experience is a low priority
- Department GIS – several projects in the same department are amalgamated, creation of common standards, development of a focused GIS team, procurement of new GIS capabilities
- Enterprise GIS – standards are accepted across multiple departments, resources are centrally-funded and managed
- Societal implementation – tens of thousands of users become engaged in GIS and connected over the Web – e.g. Google Earth, Microsoft Virtual Earth, and ESRI's ArcGIS

7.3.2 The three-tier architecture

Three key parts of a GIS are

- The user interface – via a GUI, an integrated collection of menus, tool bars and other controls
- The tools – define the capabilities or functions available
- The data management system
- Describes the classical three tier IS architecture – presentation, business logic and data server – and maps it to the key parts of a GIS
- Explains the four types of computer system architecture configurations – desktop, client-server, centralized desktop, and centralized server.
- Introduces the terms client-server, thick and thin clients

7.3.3 Software data models and customization

- A data model defines how the real world is represented in a GIS
- A software data model defines how the different tools are grouped together, how they can be used, and how they interact with data.
- Customization is the process of modifying GIS software
- A number of industry standard programming languages (such as Visual Basic, Java, and Python) are available for customizing GIS software systems.
- Integrated development environments (IDEs) combine several software development tools including a visual programming language; an editor; a debugger, and a profiler.
- To support customization using open, industry-standard IDEs, a GIS vendor must expose details of the software package's functionality using a set of application programming interfaces (APIs).
- Components are important to software developers because they are the mechanism by which reusable, self-contained, software building blocks are created.
- Allow many programmers to work together
- Can be easily assembled into larger systems
- Can be reused
- Support multiple third party extensions

7.3.4 GIS on the desktop and on the Web

Describes the concepts of thick and thin servers

Network GIS use the cross-platform Web browser to host the viewer interface

7.4 Building GIS software systems

- Start with a formal design for a software system and then build each part of component separately before assembling the whole system.
- Core GIS software systems are usually written in a modern programming language like Visual C++, C# or Java.
- A key choice that faces all software developers is whether to design a software system by buying in components, or to build it more or less from scratch.

7.5 GIS software vendors

This section very briefly describes the origins and product environment of four leading GIS vendors

- Autodesk
- Bentley

- ESRI
- Intergraph

7.6 Types of GIS software systems

7.6.1 Desktop GIS software

- Owes its origins to the personal computer and Microsoft Windows operating system
- Are the mainstream workhorses of GIS today
- Free GIS viewers are able to display and query popular file formats
- These help to establish market share and can create *de facto* standards
- Focus on use rather than data creation
- Professional GIS are full-featured desktop GIS with a superset of capabilities

Applications Box 7.2 Desktop GIS: Intergraph GeoMedia

Outlines the components of this full featured product

Applications Box 7.4 Desktop GIS: ESRI ArcGIS ArcInfo

Summarizes the history of the development of this modern GIS software

7.6.2 Web Mapping

- There are signs that the next decade will in turn be dominated by Web and server GIS products
- Web mapping is taken to mean integrated Web-accessible software, a 2-D database comprising one or more base maps, and an associated collection of services.
- Web access is provided via easily accessible, open interfaces running in web browsers and returning image tiles (fragments of the total map)
- Website functions can easily be accessed programmatically via well-defined application programming interfaces (APIs)

7.6.3 Server GIS

- Server GIS runs on a computer server that can handle concurrent processing requests from a range of networked clients
- Initially, server GIS were nothing more than ports of desktop GIS products
- Second-generation systems were subsequently built using a multiuser services based architecture that allows them to run unattended and to handle many concurrent requests from remote networked users

Applications Box 7.4 Server GIS: Autodesk MapGuide

Describes the components and key functionality of this server GIS

7.6.4 Virtual Globes

- Virtual globes allow users to visualize geographic information on top of 3-D global base maps
- Virtual Globes include: Google Earth, Microsoft Virtual Earth
- Neogeography is the “new” geography that among other things includes the overlay or mashing up two or more sources of geographic information

7.6.5 Developer GIS

- Toolkits of GIS functions (components) that a reasonably knowledgeable programmer can use to build a specific-purpose GIS application

7.6.6 Hand-held GIS

- GIS for mobile and personal use on hand-held systems
    - development of low-cost, lightweight location positioning technologies and wireless networking has further stimulated this market
- Recently, “smartphones” can deal with comparatively large amounts of data and sophisticated applications

7.6.7 Other types of GIS software

- Mentions raster-based and CAD-based GIS and explains how they have merged with more general GIS
- Middleware offer centralized management of data, the ability to process data on a server and control over database editing and update
- Standard DBMS have extensions to store and process geographic information efficiently
- Also mentions public-domain, open source and free software
- Seamless GIServices offer functionality delivered packaged along with data

7.7 Conclusion

ESSAY TOPICS

1. With reference to specific examples, outline the main types of commercial GIS products currently available.

2. Section 7.1 lists some ‘GIS-like’ products, which includes mapping systems, image processors and spatial extensions to standard database management systems. In each case, give a reasoned justification for the view that these products are not GIS.
3. Discuss the role of each of the three tiers of software architecture in an enterprise GIS implementation.
4. With reference to a large organization that is familiar to you, describe the ways in which its staff might use GIS, and evaluate the different types of GIS software systems that might be implemented to fulfill these needs.
5. Compare and contrast the roles of GIS software used in ‘project’, ‘departmental’ and ‘enterprise’ frameworks.
6. Distinguish between ‘desktop’, and both ‘thin’ and ‘thick’ client serving in GIS and explain how they GIS would be implemented in each environment.
7. What are the advantages and disadvantages of component architecture in a GIS?
8. From the perspective of both user and supplier, how has the coming of the Internet and World Wide Web affected GIS?
9. What do you understand by the phrase ‘client server architecture’ and why is it so popular in GIS implementations?
10. You are working in the research department of a hospital, responsible for processing data on the health of a small city. List and describe the factors that would influence your choice of software configuration and supplier.

MULTIPLE CHOICE QUESTIONS (MCQ)

1. For each of the listed software distribution models, match it to its most appropriate description:

Distribution Model	**ANSWER**	**Description**
‘shareware’		a) for direct sale
Open source		b) free with no restrictions on use
Commercial off the shelf (COTS)		c) code provided free but with an agreement not to distribute improvements
‘freeware’		d)for sale after a trial period
Public domain		e) free, but with copyright restrictions

2. Which of the following programming languages is not currently used in customizing GIS?
    a. Python
    b. Java
    c. FORTRAN
    d. Visual Basic

3. Starting with the simplest, arrange the following types of GIS implementation into their logical order (a) – (d):

Type of Implementation	**Answer (a) to (d)**
Workgroup	
Societal	
Project	
Enterprise	

4. Which of the following are standards for defining and re-using software components?

Standard	**Answer (Yes or No)**
HTML	
.NET	
Java	
XML	

5. For each of the following features, chose the alternative feature that most characterizes desktop and network GIS:

Feature	**Choices**	**Desktop GIS**	**Network GIS**
Client size	Thick/Thin		
Client platform	Windows/Browser		
Server size	Thin/Thick		
Server platform	.Net/Java		
Component standard	.Net/Java		
Network	LAN/WAN		

6. Rank the three systems listed in section 7.5 by their 2007 market share
    a. Intergraph
    b. ESRI
    c. Autodesk
    d. Bentley

7. Arrange the four types of computer architectural configurations used to build operational GIS implementations in order of their probable software complexity from (a, most) to (d, least):

Configuration	**Answer (a) to (d)**
Desktop	
Client server	
Centralized desktop	
Centralized server	

8. Which is the most important component of a full GIS implementation?
    a. Software
    b. People
    c. Data
    d. Hardware

9. From the user's viewpoint, which two of the following were to two key GIS software developments of the 1980s?
    a. Web services
    b. Graphical user interfaces
    c. Integrated development environments
    d. Customization capabilities

CLASS AND INDIVIDUAL ACTIVITIES

Design a GIS architecture that 25 users in 3 cities could use to create an inventory of recreation facilities.

Use an Internet search engine to find the websites of the main GIS software vendors and compare and contrast what you infer is their individual product strategies. In what ways are they different?

Section 7.6.6 describes some hand-held GIS based primarily on GPS as their vocational technology. Find appropriate descriptions of these devices and then collectively assess the problems of delivering maps and map like information to their users. Useful information on 'wearable' GIS can be found in the Project Battuta website at http://dg.statlab.iastate.edu/dg/.

Re-read 7.5. on popular GIS, then visit the website of a popular image processing system such as ERDAS Imagine at http://www.erdas.com/tabid/84/currentid/1050/default.aspx. Now use the 'brainstorming' technique to develop a list of the key differences between the GIS. The technique is described by Gold et al (1992) at http://www2.glos.ac.uk/gdn/gold/ch5.htm

There are three views on the suitability of GIS for educational use. One offers an open source and fully functional GIS (for example Quantum GIS from http://www.qgis.org/), the second offers a 'cut down' version of a full GIS (e.g. ArcGIS Explorer - http://www.esri.com/software/arcgis/explorer/index.html), and the third (exemplified by AEGIS-3, see www.advisory-unit.org.uk) offers strongly curriculum-linked functions. Organize a debate or seminar on the relative strengths and weaknesses of each.

As discussed in Section 7.6.7, it is possible to create a GIS-like environment using essentially free of charge systems such as GeoDa, gvSIG, PostGIS and GRASS. Download, install and use one, but keep a journal of your experiences during this work. Your log may show that getting this type of software 'up and running' isn't as easy as might at first sight be thought.

A full GIS implementation consists of appropriately configured hardware, geospatial data, the software and the 'liveware' to make it all work. Debate the proposition that 'This house believes that it is the people who are the most important component of any GIS implementation'.

FURTHER READING

Bishr Y. and Radwan M. 2000 'GDI Architectures'. In Groot R. and McLaughlin J. (eds) *Geospatial Data Infrastructure: Concepts, Cases, and Good Practice*. New York: Oxford University Press, pp. 135–50.

Covers the main architectures to 2000.

Peng Z-H. andTsou M-H. 2003 *Internet GIS: Distributed Geographic Information Services for the Internet and Wireless Networks*. Hoboken, NJ: Wiley.

A clear account of the issues in delivering GIS over the Internet

Haklay, M., Singleton, A.D., Parker, C. (2008) Web Mapping 2.0: the Neogeography of the Geospatial Internet. *Geography Compass*, 2(6), 2011–2039

RELATED READING

Longley P.A., Goodchild M.F., Maguire D.J. and Rhind D.W. (eds) 2005 *Geographical Information Systems: Principles, Techniques, Management and Applications* (abridged edition). Hoboken, NJ: Wiley.

22. GIS in networked environments, D J Coleman, pp. 317–29.
23. Desktop GIS software, S Elshaw Thrall and G I Thrall, pp. 331–45
25. GIS customization, D J Maguire, pp. 359–69

Maguire D.J., Goodchild M.F. and Rhind D.W. (eds) 1991 *Geographical Information Systems: Principles and Applications*. Harlow, UK: Longman (text available online at www.wiley.co.uk/gis/volumes.html).

3. The technological setting of GIS, M F Goodchild, pp. 45-54
4. The commercial setting of GIS, J Dangermond, pp. 55-65

ONLINE RESOURCES

NCGIA Core Curriculum in GIScience, 2000 (www.ncgia.ucsb.edu/giscc)

2.1.1. Fundamentals of Data Storage - *Carol Jacobson* (037)

2.14.5. WebGIS (133), *Kenneth Foote and Anthony Kirvan*

NCGIA Core Curriculum in GIS, 1990 (www.ncgia.ucsb.edu/pubs/core.html)

3. Introduction to computers
4. Raster GIS
13. Vector GIS

18. Modes of user/GIS interaction
24. GIS marketplace