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Coming to Terms With Interoperability and Standards

# ESRI's Continued Commitment to Standards and Interoperability

*One of the hallmarks of GIS is its inherently collaborative nature. GIS illustrates relationships, connections, and patterns in data. The unique integration capabilities of GIS bring together data from many sources for visual display and analysis, creating a more complete picture of a situation than would otherwise be possible. This enables organizations to make better decisions based on all relevant factors. For this reason, GIS technology has become an integral part of the information infrastructure in many organizations.*

## GIS Is Data-Centric

Typically, GIS datasets are interrelated and often very large. Unlike business queries that may only return a few records, GIS queries for generating maps are routinely run against many thousands of features. This data usually comes from across an organization and, increasingly, from outside sources. Because GIS datasets are fundamentally distributed and dynamic, standards and interoperability have always been a fundamental part of GIS. This reliance on standards and interoperability has only deepened as GIS has moved from being a tool for individual projects and departments to become the framework for sharing information among organizations and across society.

The purpose of a GIS, or any information system, is to get answers to specific questions. Any GIS must produce information that answers these questions and share information among multiple users. GIS data management includes not only data collection but data dissemination. Interoperability enables data sharing between organizations and across applications and industries, which results in the generation and sharing of more useful information.

## Building Working Standards

Just as GIS exists to produce information that answers specific questions, the goal of standards and interoperability should be to help GIS users build working systems that are practical to implement and use with the current GIS technology and IT environment.

Computing industry standards provide the foundation for GIS interoperability. Ultimately, GIS interoperability specifications and standards must fit within the context of broad and widely adopted computing industry standards. ESRI realizes that it is necessary to evolve GIS interoperability within the world of ever-changing computing industry standards.

To be truly useful, standards aren't a product so much as a process. Often new specifications must still be tested in real-world scenarios and must evolve before widespread implementation

is practical. In the final analysis, the needs of GIS users determine the role of any standard.

Support for standards will be engineered into ESRI products based on user requirements employing the same three-step process ESRI has been using when incorporating new technologies or types of functionality into its software. This process starts with a design phase, then a pilot/prototyping phase (which often results in delivery of new functionality as add-ons or extensions), and finally the software engineering phase that incorporates this functionality into ESRI core products.

## The Need for Standards and Interoperability

The GIS community in general, and ESRI in particular, has been pursuing open standards and interoperability for many years. Interoperability is the ability to combine information and functionality from different systems. During the past 20 years, the concepts, standards, and technology for implementing GIS interoperability have evolved. The approaches listed in Figure 1 play a significant role in GIS interoperability.

Initially, the constraints of computational speed, and its associated cost, limited the choice of strategies and focused efforts on implementing data sharing. Practical solutions, such as data converters, transfer standards and, later, open file formats, have enabled data sharing between organizations with different GIS vendor systems. However, sharing spatial data with core business applications was rarely possible.

Today, most GIS products directly read, and sometimes dynamically transform, data with minimal time delay. In addition to developing numerous data converters, ESRI software supports direct read access for Spatial Data Transfer Standard (SDTS), Vector Product Format (VPF), imagery, CAD files, digital line graph (DLG), TIGER files, and other standard interchange formats.

### Metadata Support

Metadata has been used for centuries in the margins of maps and charts. Used within a GIS, standardization of metadata becomes increasingly important; it provides users with an understanding of geographic information and allows the exchange of “data about data.” Metadata standards identify and standardize the metadata user communities need to manage, share, and reuse their geographic data and promote global interoperability.

Recognizing that metadata support is crucial to building a strong spatial data infrastructure, ESRI has supported standard metadata representations and developed metadata servers that enable users to discover and evaluate data that originates from multiple sources in a variety of formats. ArcView, ArcEditor, and ArcInfo, the ArcGIS Desktop products, allow users to create, manage, and edit metadata stored in an XML representation of Federal Geographic Data Committee (FGDC) Content Standards for Digital Geospatial Metadata or of the ISO 19115 Metadata Standard. With ArcIMS Metadata Services, users can create a central, online metadata repository for publishing and browsing metadata over the Internet. The metadata documents stored as ArcIMS Metadata Services can then be accessed using a client that communicates using ArcXML. Examples of these clients include ArcCatalog (the ArcGIS Desktop application for managing data); the ArcIMS Metadata Explorer (a set

of JavaServer Pages that can be used to build a customized, browser-based application for searching for metadata); and Z39.50 and ISO 239.50 clients (national and international standards, respectively, that define protocols for computer-to-computer information retrieval).

### Going Mainstream

The migration of GIS from projects to mission-critical business processes at the enterprise level, coupled with an emphasis on delivering a better return for investments in GIS technology and databases, continues to drive improvements in interoperability. Truly open systems allow sharing of geographic data not only with other GIS technologies but also with non-GIS applications that operate on different platforms. The ability to scale applications to support a wide range of implementation scenarios from the individual to a large organization requires customization and extension of capabilities using industry standard development tools.

Initially, the open development environments available with SDE let developers use MapObjects with popular Windows development environments, such as Visual Basic and Visual C++, to create custom applications. The ArcInfo Open Development Environment (ODE), ARC Macro Language (AML), and Avenue also provided methods for extending and customizing GIS software.

The release of ArcGIS greatly enhanced the extensibility, customization, and integration

of GIS with non-GIS applications. ArcGIS Desktop is built using the ArcObjects framework. ArcObjects is a collection of software components with GIS functionality and programmable interfaces that is based on the COM architecture. ArcGIS applications, such as ArcMap, can be customized using the built-in Visual Basic for Applications (VBA) scripting language or COM-compliant programming languages such as Visual Basic, Visual C++, or Delphi. ArcObjects can also be used to build stand-alone applications or to add GIS functionality to existing, non-GIS applications.

As GIS has become integrated with the mainstream IT environment, interoperability with industrywide IT standards, as well as GIS standards, has taken on greater importance. ESRI has worked to ensure compatibility and interoperability with enterprise systems such as enterprise resource planning (ERP), customer relationship management (CRM), enterprise application integration (EAI), work management systems, and decision support systems.

Increasingly, GIS software is deployed in these types of multiuser environments. In these environments, spatial data is accessed from a variety of platforms and devices. Consequently, GIS must support platform-independent solutions that can be implemented for different server hardware, operating systems, networks, databases, development tools, and desktop

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Strategy	Example
Data converters	DLG, TIGER, MOSS, GIRAS, IGDS
Standard interchange formats	SDTS, DXF, GML
Open file formats	VPF, shapefiles, DGN
Direct read application programming interfaces (APIs)	ArcSDE API, CAD Reader, ArcSDE CAD Client
Common features in a DBMS	OGC Simple Feature Specification for SQL
Integration of standardized GIS Web services	WMS, WFS

Figure 1: Evolving strategies for interoperability and standards

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applications in addition to Web and mobile clients.

The ability of GIS to function in this sort of heterogeneous environment represents significant evolution from the situation in the mid-1990s. At that time, GIS was closely tied to native, proprietary spatial data structures. Although these early nonrelational file structures were optimized for fast access and relatively easy distribution between sites using the same GIS vendor software, the ability to share data among users across organizations was limited by network protocols and data sharing between organizations with different GIS vendor systems or business applications.

## Evolving GIS Structures

Gradually, GIS evolved into georelational structures that allowed related attribute data to be stored in a relational database that was linked to the file-based spatial features. However, the georelational format had limited scalability. The dual data structure (i.e., spatial features stored in proprietary file-based format with attributes stored in a relational database) also meant that the GIS could not take full advantage of relational database features such as backup

and recovery, replication, and fail-over. In addition, supporting large data layers required the use of complex tiling structures to maintain performance, and sharing spatial information with other core business applications was still not very feasible.

The development of the geodatabase enabled spatial data to be stored in relational databases. Spatially enabling databases opened a new era of broad scalability and made the support of large, nontiled, continuous data layers possible. When these databases were combined with client development environments that could be embedded within core business applications, the sharing of spatial features with core business applications, such as customer management systems, became a reality. With spatially enabled databases, organizations could begin eliminating organizational spatial data islands and implementing enterprise GIS.

## Data Model Development

In addition to geodatabases, the development of generic data models represents a fundamental move toward a higher level of interoperability. ESRI's objective in creating data models for various industries, such as telecommunications

and transportation, and applications, such as basemap and biodiversity, is to build designs that can be used by any GIS organization, regardless of the software being used. Each model has been developed by a consortium of domain expert users and business partners using accepted standards. These models support migration from existing file-based systems and are designed to be extensible, flexible, and easily adaptable to the requirements of specific organizations. Visit [www.esri.com/datamodels](http://www.esri.com/datamodels) to learn more about data models and download documentation.

## Promoting Standards and Interoperability

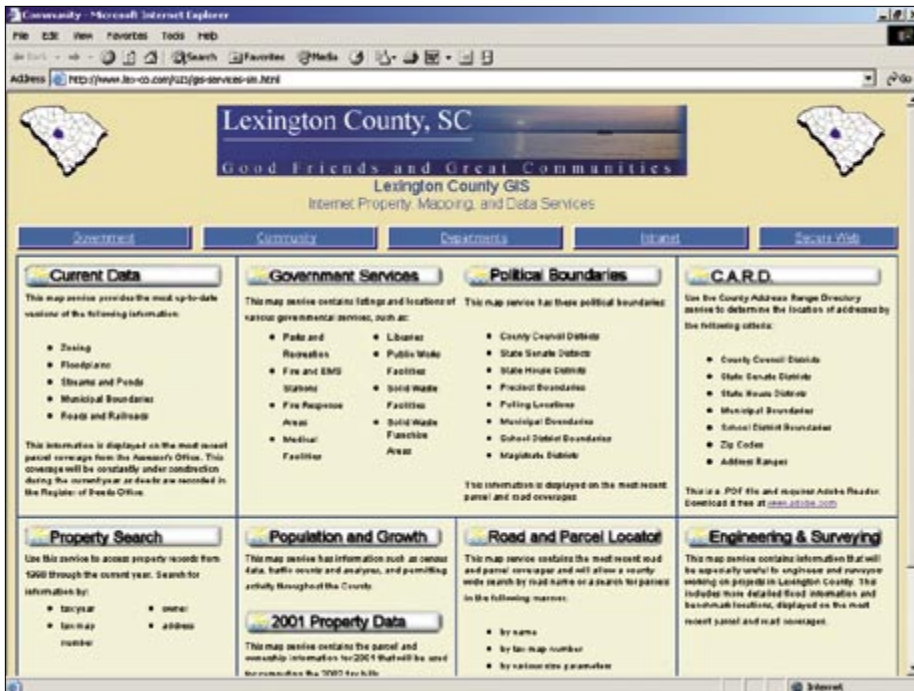
The open GIS movement began shortly after the advent of all-relational models capable of storing both spatial and attribute data in a relational database. Standards organizations, such as OGC, the International Organization for Standardization (ISO), and FGDC, began promoting the idea of data sharing through spatial data standards. The early work of these organizations focused on sharing simple spatial features in a relational database. This enabled interoperability between the commercial

## Working With GIS and IT Organizations

ESRI has supported standards both on the organizational level and in the way it has designed its products. On the organizational level, ESRI has participated in international and regional standards organizations as well as information community standards such as those of the North American Treaty Organization (NATO) and the United States government and its military.

ESRI has a long history of participation in a variety of organizations that promote standards and interoperability. Organizations that enable interoperability can be grouped into two categories. International organizations, such as ISO and GSDI, promote interoperability across communities rather than a particular discipline. Other organizations deal with standards and interoperability for specific technologies or industries, such as defense or navigation. ESRI supports both types of organizations through direct participation on boards of directors and chairing committees and by providing input for developing standards. The accompanying chart lists standards and interoperability organizations with which ESRI works.

Acronym	Organization	URL	Type
ANSI	American National Standards Institute	<a href="http://www.ansi.org">www.ansi.org</a>	Standards
CEN	European Committee for Standardization	<a href="http://www.cenorm.be">www.cenorm.be</a>	Standards
DGIWG	Digital Geographic Information Working Group	<a href="http://www.digest.org">www.digest.org</a>	Standards
FGDC	Federal Geographic Data Committee	<a href="http://www.fgdc.gov">www.fgdc.gov</a>	Standards
GSDI	Global Spatial Data Infrastructure	<a href="http://www.gsdi.org/">www.gsdi.org/</a>	Interoperability
IHO	International Hydrographic Organization	<a href="http://www.iho.shom.fr">www.iho.shom.fr</a>	Standards
ISO	International Organization for Standardization	<a href="http://www.iso.org">www.iso.org</a>	Standards
OASIS	Organization for the Advancement of Structured Information Standards	<a href="http://www.oasis-open.org">www.oasis-open.org</a>	Standards
OGC	Open GIS Consortium	<a href="http://www.opengis.org/">www.opengis.org/</a>	Specifications
OMA	Open Mobile Alliance	<a href="http://www.openmobilealliance.org">www.openmobilealliance.org</a>	Specifications
W3C	World Wide Web Consortium	<a href="http://www.w3.org">www.w3.org</a>	Standards
WS-I	Web Services Interoperability Organization	<a href="http://www.ws-i.org">www.ws-i.org</a>	Interoperability



*The County of Lexington, South Carolina, an early adopter and innovative user of GIS, received a Special Achievement in GIS award in 2002 for its work breaking down information silos and sharing 14 years' accumulation of GIS data across the city and in the community.*

ArcExplorer—Java Edition Interoperability extension reads and writes GML schemas and documents. The OGC Web Map Service (WMS) connector enables ArcIMS to provide Web map services that adhere to the OpenGIS Web Map Service Implementation Specification. The OGC WMS connector produces maps of georeferenced data in image formats (PNG, GIF, JPG) and creates a standard means for users to request maps on the Web and for servers to describe data holdings.

The OGC Web Feature Service (WFS) connector enables ArcIMS to provide Web feature services that adhere to the OpenGIS Web Feature Service Implementation Specification. The connector provides users with access to geographic (vector) data, supports query results, and implements interfaces for data manipulation operations on GML features served from data stores that are accessible via the Internet. The WMS and WFS connectors are described in greater detail in an accompanying article, "The Next Wave of Interoperability Via Web Services." Visit the ESRI Interoperability Technology Download Center at [www.esri.com/standards](http://www.esri.com/standards) to download the OGC connectors for ArcIMS and the ArcExplorer—Java Edition Interoperability extension.

By developing products based on open standards, ESRI has ensured a high level of interoperability across platforms, databases, development languages, and applications. From creating standards to reviewing standards to integrating them into products, ESRI is involved in every phase of open standards development and works directly with 12 major international and United States GIS and information technology standards and interoperability organizations as well as other related organizations. Another article in this section, "Working With GIS and IT Organizations," provides resources for learning more about these organizations.

ESRI's support for standards and interoperability, both in GIS data and technology interoperability and the interoperability of GIS technology with other information technologies, has benefited users in organizations both large and small.

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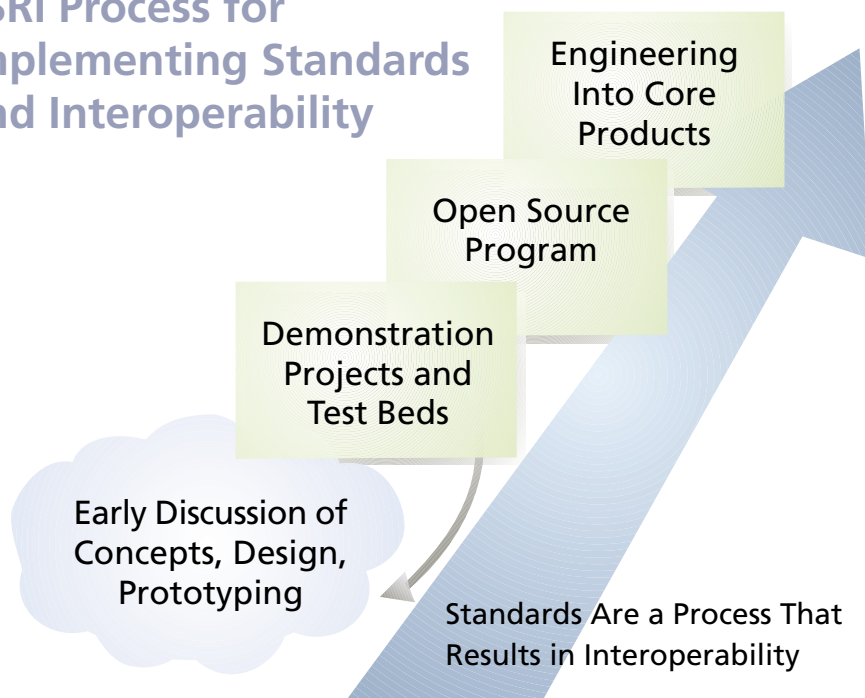
GIS vendors. OGC, an international industry consortium of private companies, government agencies, and universities, published an open spatial standard called the Simple Features Specification.

ESRI was the first vendor with products that successfully completed OGC conformance testing and the only vendor with both client and server products that conform to the OpenGIS Simple Features Specification for SQL. ArcSDE

uses the default binary schema for Oracle and SQL Server, which is fully compliant with the OpenGIS Simple Features Specification for SQL's binary geometry. ArcSDE also provides support for additional GIS data types, such as z values, measures, and annotation, and support for raster and survey data that extends beyond the OGC specification.

ESRI has developed OGC-supported extensions to ArcGIS and ArcIMS. The

## ESRI Process for Implementing Standards and Interoperability



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By taking advantage of all the interoperability strategies that have been developed, CenterPoint Energy, the third largest publicly traded natural gas delivery company in the United States, is building an enterprise GIS solution. CenterPoint Energy uses GIS throughout all of the operational parts of its organization. The County of Lexington, South Carolina, an early adopter and innovative user of GIS, employed ArcSDE and ArcIMS to break down information silos and share 14 years' accumulation of GIS data through map services that benefit not only departments throughout the county but also county residents.

Advances in GIS software based on standards and interoperability have made national and international GIS initiatives, such as the National Spatial Data Infrastructure (NSDI), possible. Data standards and a high level of interoperability are requisite for these ambitious projects. NSDI is a national strategy for promoting geospatial data sharing in the government and private sectors and reducing duplication of effort.

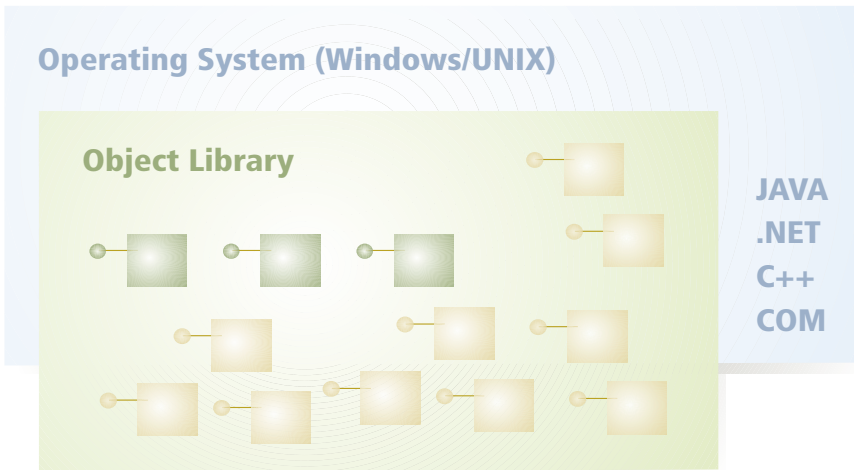
## Long-Range Strategies

As GIS technology continues to evolve, many organizations want to know what will be the best long-range solution for data sharing and interoperability. ESRI believes a complete GIS infrastructure, including a loosely coupled system architecture using Web service interfaces and common information models and formats, represents the best strategy for supporting a network of heterogeneous systems. ESRI has committed much of its research and development efforts to this approach.

The Geography Network is an example of a GIS implementation within a Web services framework. ESRI refers to this framework as the g.net architecture and provides products that enable users to create a full implementation of g.net architecture. ArcIMS provides both GIS services as well as broker services (metadata services). ESRI-developed clients, such as ArcGIS Desktop, ArcExplorer, MapObjects—Java Edition, and ArcPad, can integrate one or more of these Web services within existing applications.

With Web services, GIS applications aren't tied to the spatial schema of a specific DBMS vendor. GIS vendors can manage data using the methods and formats best suited to specific software tools and database environments. Server-to-server sharing of data and services, instead of doing this at the client level, allows GIS vendors to build and manage data and provide GIS services (e.g., data, maps, and geoprocessing) to a larger audience in a

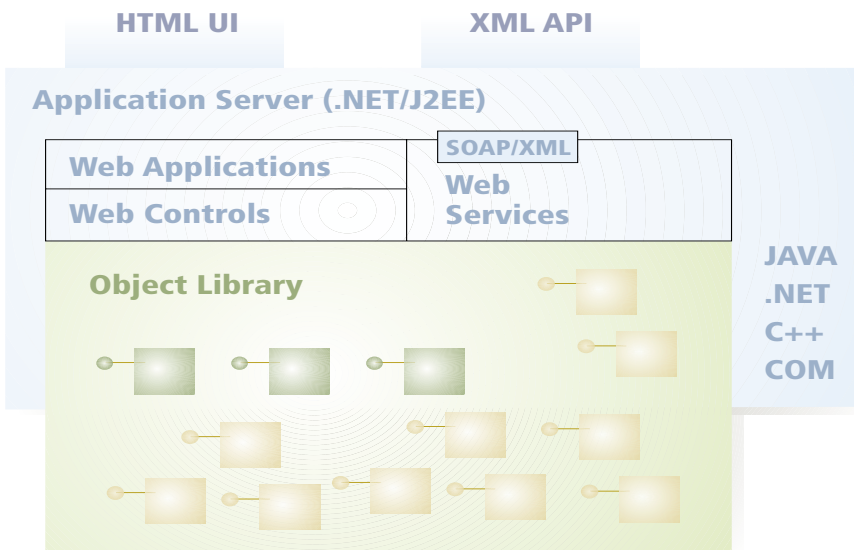
## ArcGIS Engine



- Environment for working with ArcObjects components
- Programmers interact with component object API
- Full GIS functionality—both fine- and coarse-grained components

*ArcGIS Engine is a simple API-neutral, cross-platform development environment for ArcObjects.*

## ArcGIS Server



*The ArcGIS Server provides comprehensive GIS functionality that includes mapping, data management, and geoprocessing and extends the ArcGIS Engine with Web application templates, controls, and services. With ArcGIS 9, XML will provide a representation of the full geodatabase, making it independent of any DBMS container.*

common environment. See the accompanying article "Web Services: A Standards-Based Framework for Integration."

For companies such as Five-Ten, this Web service strategy is already paying off. Five-Ten makes and markets technical footwear for climbing, trail running, paddling, and other

sports with demanding shoe requirements. Its Web site identifies the nearest dealer, routes customers to the store, and generates map and turn-by-turn directions using an assortment of ArcWeb Services. Their use didn't require the company to develop any GIS expertise or data.

### GIS as Information Infrastructure

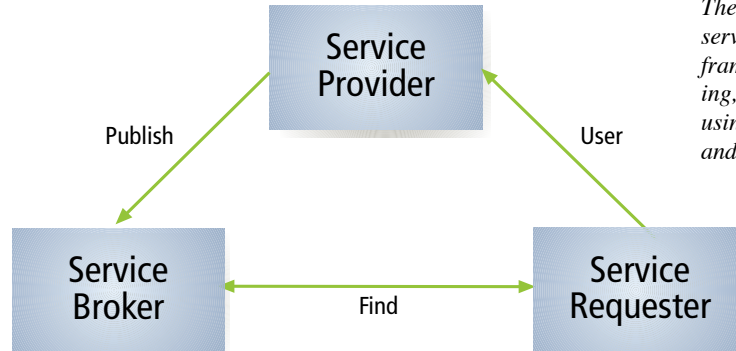
ESRI continues to build generic GIS technology that empowers users and works in today's heterogeneous distributed environment. ArcGIS 9, the next major release, is a platform for building geographic information systems that provides a single, unified software architecture for GIS applications, services, and development. ArcGIS 9 is built on and extended using ArcObjects. It encompasses three major components—ArcGIS Engine, ArcGIS Desktop, and ArcGIS Server.

ArcGIS Engine is a simple API-neutral, cross-platform development environment for ArcObjects. Its object library will make full GIS functionality available through both fine- and course-grained components that can be used in Java, .NET, C++, and COM development environments.

ArcGIS Desktop extends the engine with desktop application frameworks and user interface components.

The ArcGIS Server will provide comprehensive GIS functionality that includes mapping, data management, and geoprocessing and extends the ArcGIS Engine with Web application templates, controls, and services. It uses open Web services interfaces (e.g., Java API, .NET API, and a generic Web service API that uses XML/SOAP). With ArcGIS 9, XML will provide a representation of the full geodatabase, making it independent

## Web Services Future Service-Oriented Architecture



*The emergence of Web services provides a framework for publishing, discovering, and using GIS applications and data.*

of any DBMS container. All aspects of the geodatabase data model or a subset of the geodatabase can be exported, and exported files can be imported into an existing database. The XML export format is organized into a data definition section that defines all the geodatabase elements and a data section that is based on the OGC Simple Features Model.

### A Continuing Commitment

ESRI continues to make major investments in the development and implementation of open GIS standards and interoperability to serve users and promote the sharing of geographic data

across all GIS platforms. Interoperability and standards are required to deliver a distributed, multipurpose GIS. ESRI is developing information modeling, system architecture, and software engineering that incorporate standards and ensure interoperability, not just in the GIS world, but also in the larger IT community. The goal is to create one infrastructure that works everywhere—across all platforms and technologies and on all types of devices. For more about the latest developments in standards and interoperability as related to GIS and links to IT and GIS standards organizations, visit [www.esri.com/standards](http://www.esri.com/standards).

## ESRI Software Offers Many Choices

ESRI has always given users choices in how they will implement GIS. Now, in addition to choices in operating systems, desktop environments, and relational databases, ESRI software can be customized in a variety of developer environments and made available through many types of handheld devices using Web services.

<b>Handheld Devices</b>	ESRI software can run on a variety of handheld devices because it supports platforms such as Windows CE for the Pocket PC, Palm OS for Palm and Handspring, and Java 2 Platform Micro Edition (J2ME) for consumer and embedded devices as well as the 802.11 standard for wireless networks.
<b>Desktop Computers</b>	ESRI desktop software runs on Windows, UNIX, and Linux platforms.
<b>Servers</b>	ESRI provides a range of server software that is supported by UNIX, Linux, Windows, and Java.
<b>DBMS</b>	Commercial database management systems supported by ESRI software include Oracle, IBM DB2, Informix, and SQL Server (support for all spatial types).
<b>Networks</b>	Protocols, such as TCP/IP and HTTP, allow the transfer of data and HTML documents.
<b>Development Environments</b>	Developers have a choice of development environment when using ESRI software including VB, C++, .NET, and Java (J2ME, J2SE, J2EE, ASP/JSP).
<b>Web Services</b>	ESRI employs many Web standards such as XML, SOAP, UDDI, and WSDL. Web APIs, such as WFS, WMS, XML, and GML, are also supported.