Delivering Custom GIS Applications With ArcGIS® Engine

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An ESRI White Paper

Contents   **Page**

Contents   **Page**

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Introduction

Why the Interest in Delivering Custom GIS Applications?

Faced with an overabundance of raw information, organizations are awakening to the value of geographic analysis and spatial visualization because of their proven ability to improve operational efficiency and decision making within an organization. Call it business intelligence, analytic applications, or decision support, knowledge workers benefit from software applications that provide them with the information they need to quickly and accurately assess a situation and act accordingly. There are many potential users of geographic information system (GIS)-enhanced applications who are not GIS professionals and are unequipped to take advantage of the comprehensive tools available on the market without a steep learning curve. To provide spatial solutions to non-GIS users, developers need the ability to build domain specific, easy-to-use applications that can incorporate the power of a comprehensive GIS into a user-friendly experience. These applications, if built from scratch, can be an overwhelming development effort and may be time consuming and not cost-effective.

Solutions for Efficient GIS Development

The ideal solution to a prolonged GIS development effort is the availability of a component-based development framework that will allow solution providers or an organization's internal developers to rapidly build industry specific GIS applications. A GIS development framework provides the necessary comprehensive spatial functionality for applications and allows the software developer to focus on building application specific logic. ESRI® ArcGIS® Engine is such a GIS framework, created in response to ESRI software users' requests that the rich technology of ArcGIS be productized to enable embedding of spatial functionality in new or existing applications.

This white paper focuses on providing an overview of the ArcGIS Engine products, which will be of particular interest to programmers and project managers who want to embed mapping and GIS functionality in new or existing custom applications and deploy those applications, perhaps in a cross platform environment, in a cost-effective manner.

ArcGIS Developer Overview

ArcGIS is an integrated family of GIS software products for delivering a complete, scalable GIS at the individual project, work group, and enterprise levels. It is based on a common library of shared GIS software components called ArcObjects™. ArcGIS consists of the following key parts:

- **ArcGIS Desktop:** an integrated suite of advanced GIS products (ArcReader™, ArcView®, ArcEditor™, ArcInfo®, ArcGIS extensions).

- **ArcGIS Engine:** embeddable GIS component libraries for building custom, industry-focused applications using C++, COM, .NET, and Java™.

- **ArcGIS Server:** shared library of GIS software objects used to build serverside GIS applications in enterprise and Web computing frameworks. It is used for building both SOAP-based Web services and Web applications using .NET/ASP and Java/JSP.

- **ArcIMS®:** GIS Web services to publish maps, data, and metadata through open Internet protocols.

- **ArcSDE®:** an interface for managing geodatabases in numerous database management systems (DBMSs).

The ArcGIS system is built and extended using ArcObjects software components. ArcObjects is composed of platform-neutral C++ software objects that can run on both Windows® and UNIX® platforms and have multiple developer application programming interfaces (APIs). These include COM, .NET, Java, and C++. Developers can use these APIs to build applications that make use of ArcObjects functionality. ArcObjects is at the core of all the ArcGIS products—ArcGIS Desktop, ArcGIS Engine, and ArcGIS Server—providing a common developer experience across all ArcGIS products.

There is a wide range of possibilities available when developing with ArcGIS. Developers can

- Configure/Customize ArcGIS Desktop products.
- Extend the ArcGIS architecture and data model.
- Embed maps and GIS functionality in other applications with ArcGIS Engine.
- Build and deploy custom desktop applications with ArcGIS Engine.
- Build Web services and applications with ArcGIS Server.

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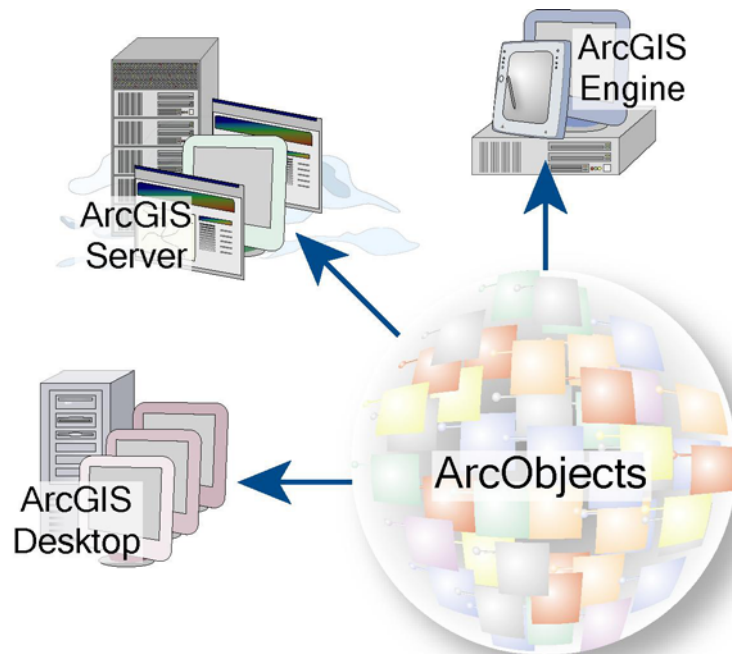
ArcObjects is the underlying component technology for ArcGIS products.

ArcGIS Engine provides new and improved tools for developers as well as new deployment options and resources. ArcGIS Engine is a set of the core ArcObjects components packaged together for developers to build custom GIS and mapping applications. These objects are platform neutral and can be called from various APIs. Developers can extend the object libraries and have complete control over the look and feel of their applications' user interfaces.

Introduction to ArcGIS Engine
ArcGIS Engine is a complete library of embeddable GIS components and tools packaged together for developers to build new or extend existing custom desktop applications. Using ArcGIS Engine, developers can embed GIS functions into existing applications, such as custom industry specific products, and commercial productivity applications, such as Microsoft Word and Excel, as well as build focused custom applications for delivering GIS to many users in their organizations.

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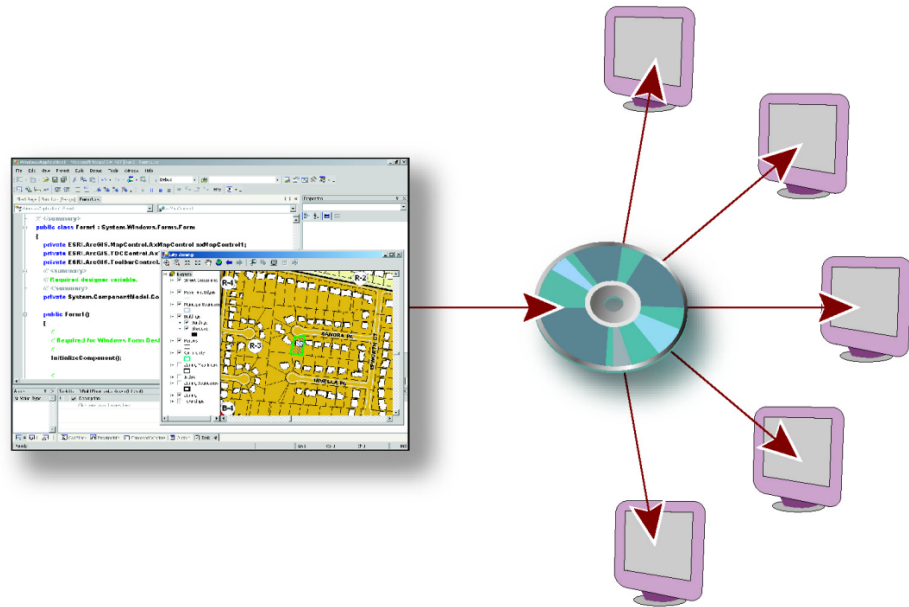
Applications built with ArcGIS Engine are licensed and distributed to end users.

ArcGIS Engine consists of two products: a software development kit to build and a redistributable runtime to enable execution of the completed applications. The ArcGIS Engine Developer Kit is a component-based software development product for building custom GIS and mapping applications. The ArcGIS Engine Developer Kit is not an end user product but rather a toolkit for application developers, suitable for building basic mapping and comprehensive, dynamic GIS applications for Windows, UNIX, or Linux® users. The ArcGIS Engine Runtime is the product that contains the core ArcObjects components to enable the execution of the end user application and will be installed on each computer that is running an ArcGIS Engine application.

Why Use ArcGIS Engine?

Many users require focused, industry specific access to GIS from within familiar software applications. They need much less than the general GIS products, yet they may require access to sophisticated GIS logic in their applications. In cases in which users need customized access to GIS, ArcGIS Engine provides an alternative to general software applications.

ArcGIS Engine is used to

- Embed GIS logic in custom applications.
- Efficiently build and deploy GIS applications.
- Provide access to advanced GIS logic from simple applications.
- Embed GIS logic and maps in other applications.
- Build cross platform applications with C++ or Java.

What Developers Can Do With ArcGIS Engine

As a developer, you can implement these and many other functions in programs built with the ArcGIS Engine Developer Kit.

- Display a map with multiple map layers such as roads, streams, and boundaries.

- Pan and zoom throughout a map.

- Identify features on a map by clicking them.

- Search for features on a map.

- Display labels with text from field values.

- Draw images from aerial photography or satellite imagery.

- Draw graphic features such as points, lines, circles, and polygons.

- Draw descriptive text.

- Select features along lines and inside boxes, areas, polygons, and circles.

- Select features within a specified distance of other features.

- Find and select features with a Structured Query Language (SQL) expression.

- Render features with thematic methods such as value map, class breaks, and dot density.

- Dynamically display real-time or time series data.

- Find locations on a map from a street address or intersection you provide.

- Transform the coordinate system of your map data.

- Perform geometric operations on shapes to create buffers; calculate differences; or find intersections, unions, or inverse intersections of shapes.

- Manipulate the shape or rotation of a map.

- Create and update geographic features and their attributes.

- Interact with personal and enterprise geodatabases.

ArcGIS Engine is suitable for building basic mapping to advanced GIS applications.
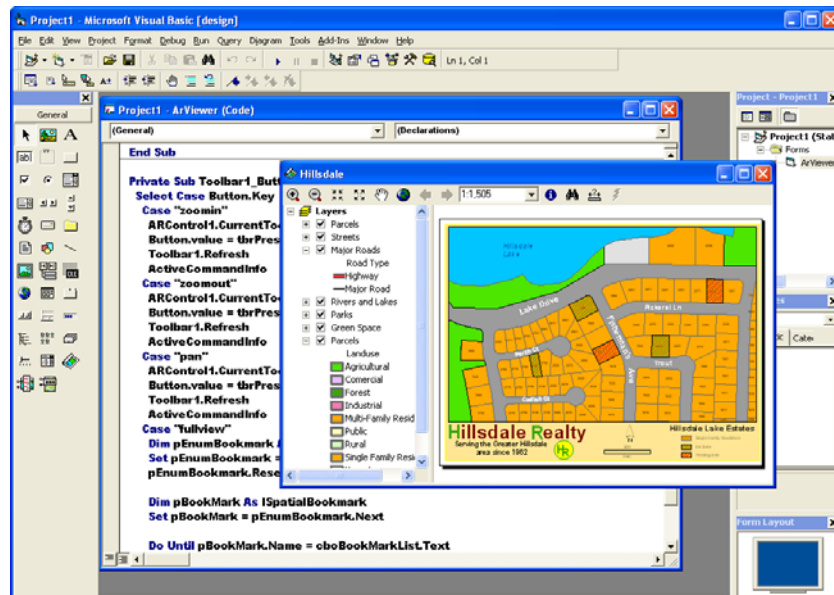
Building an ArcGIS Engine Realty Application in Visual Basic

Key Features of ArcGIS Engine

Standard GIS framework: ArcGIS Engine provides a standard framework for developing GIS applications. The world's most popular GIS software products (ArcView, ArcEditor, and ArcInfo) are built from this same set of software objects. ArcGIS Engine is both robust and extensible, and its rich functionality allows developers to concentrate on solving organizational problems, not building GIS functionality from scratch.

Cost-effective deployment: ArcGIS Engine Runtime is licensed per computer. This allows multiple ArcGIS applications to run on the same computer, incurring the cost of only a single runtime license.

Developer controls: ArcGIS Engine provides a common set of developer controls that allow developers to easily deploy well-crafted applications with a common look and feel. A common user experience leads to a short learning curve for users, so returns on the applications are quickly realized.

Cross platform functionality: ArcGIS Engine and all of its associated objects and controls are available on a wide variety of platforms including Windows, Linux, and UNIX. Custom GIS applications will fit within standard computing environments; there is no need to change or add operating environments to the present computing infrastructure.

Cross developer languages: ArcGIS Engine supports a variety of developer languages for its use including COM, .NET, Java, and C++. This allows the objects to be programmed using a wide range of tools and should not require the programming staff to learn a new or proprietary language.

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ArcGIS extension functionality: The ArcGIS Engine Developer Kit includes the extended functionality to update and create a multiuser geodatabase as well as the functionality of ArcGIS 3D Analyst™, ArcGIS Spatial Analyst, and ArcGIS StreetMap™ USA products.

Developer resources: The ArcGIS Engine Developer Kit provides a help system, along with object model diagrams and sample code, to help developers get started. Several developer tools and utilities are also included in ArcGIS Engine Developer Kit to facilitate development with ArcGIS Engine.

ArcGIS Engine Developer Kit

The ArcGIS Engine Developer Kit software is a set of mapping components that enables programmers to add dynamic mapping and GIS capabilities to existing applications or build custom mapping and GIS solutions. With the ArcGIS Engine Developer Kit, programmers have unprecedented flexibility for creating customized interfaces for maps and spatial analysis. One can use several industry-standard programming environments to create unique applications or combine the ArcGIS Engine components with other software components to take advantage of the synergistic relationship between maps and the information that users collect and manage.

The ArcGIS Engine Developer Kit includes all the developer resources to support comprehensive development tasks. An integrated help system is provided for several APIs (COM, Java, .NET, and C++) along with object model diagrams and samples for each part of ArcGIS Engine.

The ArcGIS Engine Developer Kit is not an end user product. It is strictly for people who are developing applications. Developers will build applications based on ArcGIS Engine and deliver those programs to end users. An important feature of ArcGIS Engine is that the map displays can be either an incidental or central element in the application. This feature makes ArcGIS Engine particularly well-suited to vertical market applications. If, for example, the focus of the application is a database with information about available business property for lease, using ArcGIS Engine, the program can display a form with a map highlighting the business location of interest when the end user performs a query on that database. Going a step further, the application could display images of the building, floor plans, parking structures, and demographic information about the surrounding neighborhood.

The ArcGIS Engine Developer Kit provides access to a large collection of ArcObjects components but also includes several visual developer controls for creating a high-quality mapping user interface. ArcGIS Engine includes the following visual components to assist with application development:

- Map Control
- Page Layout Control
- Toolbar Control
- Reader Control
- Globe Control
- Scene Control
- Table of Contents Control
- Collection of commands and tools for use with the Toolbar Control
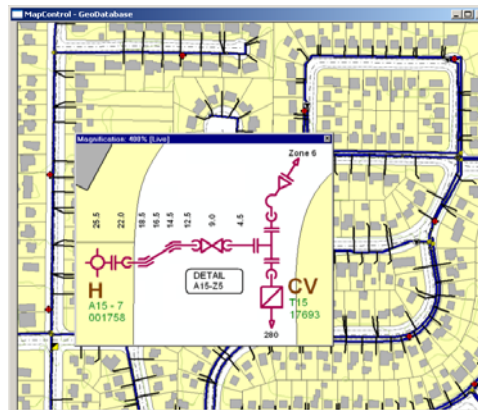
Map Control

Page Layout Control
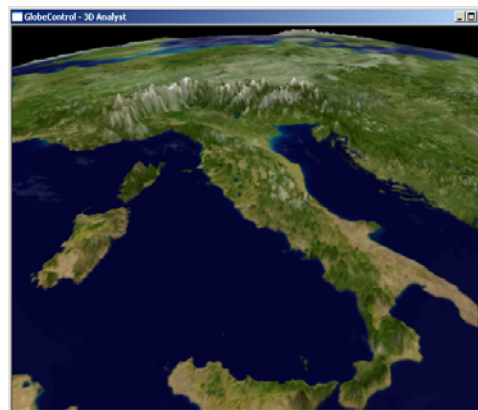
Globe Control
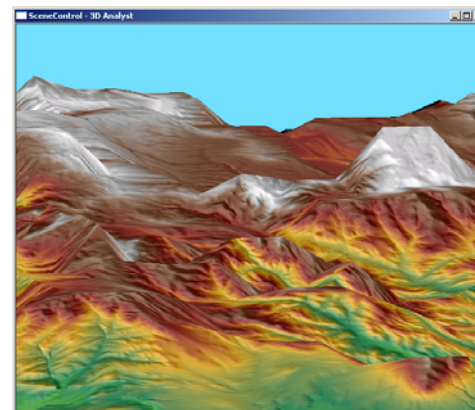
Scene Control

Examples of the ArcGIS Engine Visual Controls

These visual components are available as ActiveX® controls, JavaBeans™, .NET Windows controls, and Motif widgets. The ArcGIS Engine Developer Kit controls can

be combined with other controls and components to create customized user interfaces, displays, and reports.

Developing With ArcGIS Engine

Framework/ Architecture

ArcGIS Engine developers have access to a set of several controls that permit the use of many properties, events, and methods. Although a simple application can be built with just the high-level controls, practical applications of ArcGIS Engine require knowledge of the different object libraries that compose ArcGIS Engine.

Object libraries are logical collections of ArcObjects components, ranging from fine-grained objects (e.g., individual geometry objects) to coarse-grained objects, which aggregate logical collections of functionality. When implementing ArcGIS Engine applications, programmers use their choice of several standards-based APIs (COM, .NET, Java, and C++). The following are brief descriptions of the libraries available when programming with ArcGIS Engine.

ArcGIS Engine Object Libraries

System
: The System library is the lowest level library in the ArcGIS architecture. The library contains components that expose services used by the other libraries comprising ArcGIS.

SystemUI
: The SystemUI library mainly defines types used by user interface components in the ArcGIS system.

Geometry
: The Geometry library contains the core geometry objects, such as point, polygon, polyline, and so forth, along with geometry types and definitions.

Display
: The Display library contains the components that support drawing symbology to an output device.

Server
: The Server library contains the objects used to obtain a connection to ArcGIS Server. The connection is managed via the objects in this library.

Output
: The Output library contains the objects required to generate output, most commonly from maps or page layouts, to both printers and plotters as well as export to files.

Geodatabase
: The Geodatabase library contains types for all definitions relating to data access.

GISClient
: The GISClient library contains objects for working with remote GIS services. Either ArcIMS or ArcGIS Server can provide these services.

DataSourcesFile
: The DataSourcesFile library contains the workspace factories and workspaces for vector data formats supported by the geodatabase API.

DataSourcesGDB	The DataSourcesGDB library contains the workspace factories and workspaces for vector and raster data formats supported by the geodatabase, which are stored within an RDBMS.
GeoDatabase Distributed	The GeoDatabaseDistributed library contains the objects required to perform checkout from/check-in to operations supporting distributed geodatabase.
DataSourcesOleDB	The DataSourcesOleDB library provides workspaces for working with object linking and embedding database (OLE_DB)-based data sources.
DataSourcesRaster	The DataSourcesRaster library contains the workspace factories and workspaces for file-based raster data formats.
Carto	The Carto library contains the objects for displaying data.
Location	The Location library contains objects related to working with location data. Location data can typically either be route events or geocoding locations.
NetworkAnalysis	The NetworkAnalysis library supports the creation and analysis of utility networks.
Controls	The Controls library contains controls for application development including commands and tools for use with the controls.
GeoAnalyst	The GeoAnalyst library contains core spatial analysis operations that are used by both the Spatial Analyst and 3D Analyst extensions.
3DAnalyst	The 3DAnalyst library contains objects for performing 3D analysis of data, along with the support for displaying 3D data. A control is available in this library for developers to use. A 3D Analyst extension license is required to work with objects in this library.
GlobeCore	The GlobeCore library contains objects for performing analysis of globe data along with the support for displaying globe data. A control is available in this library for developers to use. A 3D Analyst extension license is required to work with objects in this library.
SpatialAnalyst	The SpatialAnalyst library contains objects for performing spatial analysis on raster and vector data. An ArcGIS Spatial Analyst license is required to work with objects in this library.
ArcGIS Engine Tool Set	The ArcGIS Engine Developer Kit provides several prebuilt tools and commands that can be used in conjunction with the Toolbar Control to rapidly add basic mapping functionality to an application. Here are some of the frequently used elements.

Feature Selection for
Use With Map Control
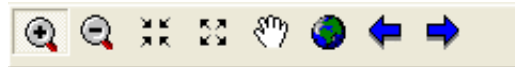or Page Layout

- Select Features
- Select by Graphics

- Select Features on Screen
- Clear Selected Features
- Zoom to Selected Features

Graphic Elements for Use With Map Control or Page Layout

- Select Elements
- New Rectangle
- New Polygon
- New Circle
- New Ellipse
- New Line
- New Curve
- New FreeHand

Map Navigation for Use With Map Control or Page Layout

- Zoom Out
- Zoom In
- Fixed Zoom In
- Fixed Zoom Out
- Pan
- Full Extent
- Go to Previous Extent
- Go to Next Extent

Page Layout for Use With Page Layout
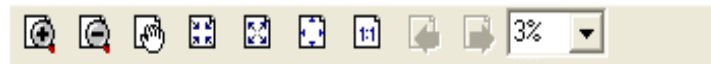
- Zoom Out
- Zoom In
- Pan
- Fixed Zoom In
- Fixed Zoom Out
- Zoom Whole Page
- Zoom to 100%
- Go Back to Extent
- Go Forward to Extent
- Zoom Control

Building Applications With ArcGIS Engine

Developers build ArcGIS Engine applications in their chosen integrated development environment (IDE) such as
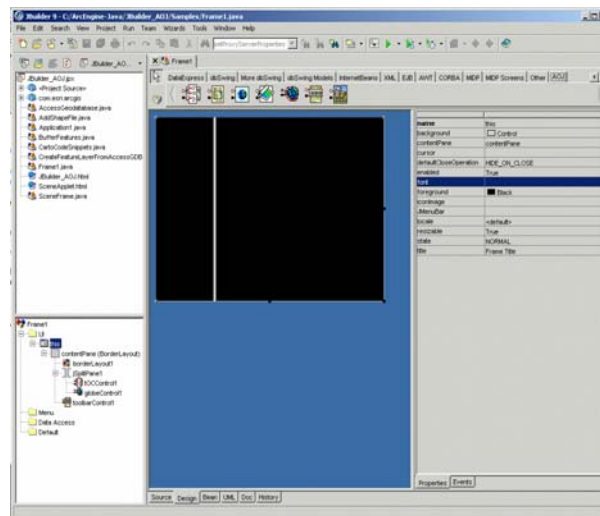
■   Microsoft® VisualStudio® and Delphi® for Windows developers
■   Eclipse, Sun™ ONE Studio, and Borland® JBuilder™ for Java developers

Developers register the ArcGIS Engine Developer Kit components with their IDE, then create form-based applications, adding ArcGIS Engine components and writing code to build their applications.

Building an ArcGIS Engine Application in JBuilder, a Java IDE

For example, a Java developer can build a focused GIS mapping application by adding a Map Control, a Table of Contents Control, and selected toolbars to his/her application.

The developer can associate an ESRI ArcMap™ map definition file (.MXD), ArcScene™ file (.SXD), or ArcGlobe™ file (.3DD) with the control and can program additional buttons and other functions for focused tasks. The finished application can then be installed on any ArcGIS Engine Runtime seat (including ArcGIS Desktop seats) to deploy the application.

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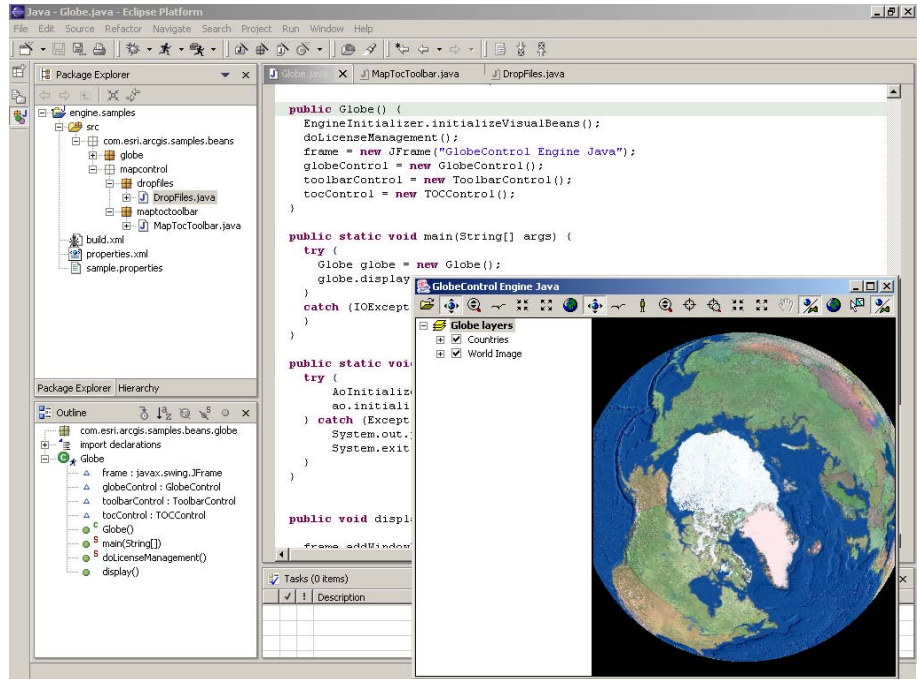
View of the User Interface Built Above

In addition to the above application that displays mapping data in a "globe" context, here are several other examples of the types of applications that benefit from ArcGIS Engine technology.

A city government department may want to build a series of focused parcel review applications that access information from the GIS database, integrating it with other critical enterprise work orders for permitting, taxation, planning review, and so forth.
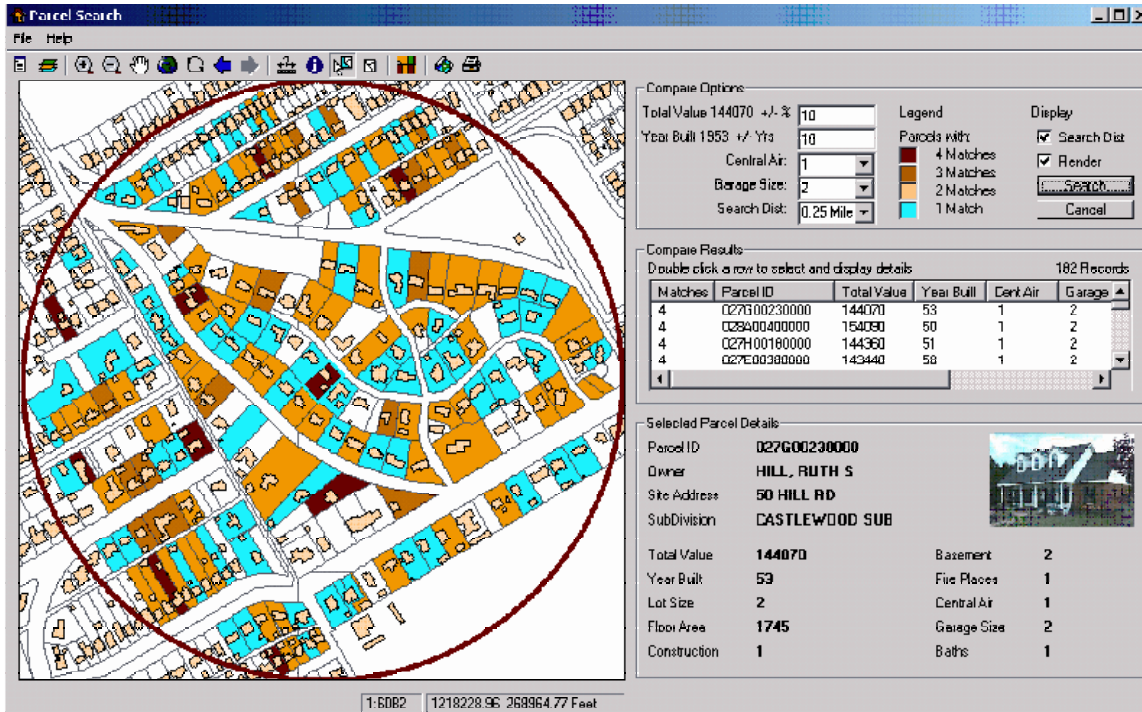
Parcel Review Application Built in ArcGIS Engine

ArcGIS Engine components can be embedded in Microsoft Word documents to help make connections between text and tabular information with spatial data.
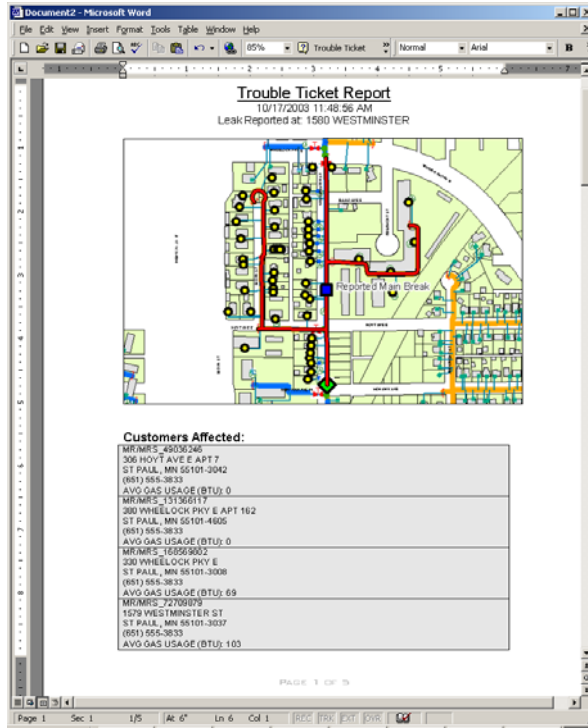
Trouble Ticket Report in Microsoft Word With Embedded ArcGIS Engine Map

ArcGIS Engine Runtime

All applications built with the ArcGIS Engine Developer Kit will need ArcGIS Engine Runtime or an ArcGIS Desktop product (ArcView, ArcEditor, or ArcInfo) with the appropriate level of license to execute successfully.
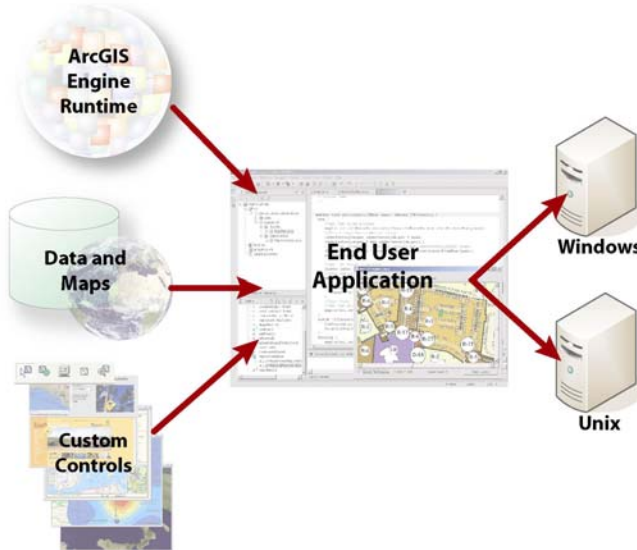
Components That Make Up an ArcGIS Engine Application's Deliverables

The standard ArcGIS Engine Runtime provides the core functionality of all ArcGIS products. The standard ArcGIS Engine Runtime can be enhanced with full read–write access to a multiuser geodatabase along with advanced functionality for 3D visualization, spatial analysis, and detailed U.S. street data.

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The Geodatabase Update option to ArcGIS Engine Runtime provides developers with the necessary ArcObjects components to build solutions that deal with data automation and compilation and the construction and maintenance of complex geodatabase features. This includes the ability to work with schemas and versioned multiuser geodatabases. The ArcGIS Engine Geodatabase option provides the capability to programmatically create personal or enterprise geodatabases with geometric networks, relationship classes, subtypes, feature-linked annotation, dimension classes, and custom behavior.

ArcGIS Engine developers with access to a DBMS via ArcSDE will be able to build and deploy solutions that deal with the editing and maintenance of multiuser geodatabases. This includes access to the ArcObjects components necessary for version management of the geodatabase.

The Spatial option to ArcGIS Engine Runtime provides a powerful set of functions that allows users to create, query, and analyze cell-based raster data. Using the Spatial option to ArcGIS Engine Runtime, users can derive information about data, identify spatial relationships, find suitable locations, and calculate the accumulated cost of traveling from one point to another.

ArcGIS Engine Runtime 3D option enables the creation of applications that effectively visualize data in 3D and globally. This option supplements ArcGIS Engine with components for examining a surface from multiple viewpoints and determining what is visible from a chosen location.

ArcGIS Engine Runtime can also be extended with the StreetMap USA option. The StreetMap USA option provides U.S. street-level mapping and address matching. StreetMap layers automatically manage, label, and draw features such as local landmarks, streets, parks, and water bodies. All data comes compressed on CD–ROM.

The end user or the developer of the ArcGIS Engine application can configure a software license file that controls the availability of the options' functionality.

Deploying and Licensing ArcGIS Engine Applications

Deploying ArcGIS Engine Runtime

An ArcGIS Engine application requires ArcGIS Engine Runtime software to be installed on the end user's machine. To ensure that ArcGIS Engine Runtime is on the machine, a developer can have the user run the ArcGIS Engine Runtime setup directly and install the license key or include the ArcGIS Engine Runtime setup in the application's setup program.

The ArcGIS Engine Runtime setup can be accomplished in an application's installation using a number of methods that are detailed in the *ArcGIS Engine Developer Guide.*

Deployment Methods

There are two recommended methods for deploying ArcGIS Engine Runtime.

- Install the ArcGIS Engine Runtime setup directly from the CD. The ArcGIS Engine Runtime setup can be redistributed on the application's CD. Developers may copy the contents of ArcGIS Engine Runtime CD images and create additional CDs or contact ESRI to obtain additional ArcGIS Engine Runtime CDs.

- Incorporate the ArcGIS Engine Runtime setup to run within the application's setup program. ArcGIS Engine can be installed without a user interface by running the setup using Windows Installer command line parameters. This method streamlines installation of the final end user product.

Licensing ArcGIS Engine Runtime

Each stand-alone application developed using ArcGIS Engine must initialize itself with a suitable license to ensure it runs successfully on any machine on which it is installed. License initialization is performed by an application at application startup, before any ArcObjects components are accessed. If license initialization is performed after ArcObjects components are accessed, application errors will result.

License files are provided by ESRI Customer Service to the party who purchases ArcGIS Engine Runtime—either the developer who is producing the application or the end user who has received an application from a developer who expects the end user to be responsible for purchasing the runtime from ESRI and enabling the license file. The *ArcGIS Engine Developer Guide* provides detailed instructions for the developer that includes the license file with a packaged application and for the end user who needs to install the license file independent of the developer.

ArcGIS Developer Resources

The following topics describe some additional resources available to ArcGIS developers. These include books, guides, and various help systems available to ensure success with all aspects of building and deploying ArcGIS Engine applications.

ArcGIS Developer Help System

The ArcGIS Developer Help system is an essential resource for both beginning and experienced ArcGIS Engine developers. It contains information on developing with ArcObjects including sample code, technical documents, and object model diagrams. In addition, it serves as a reference guide, containing information on every object within ArcObjects. ArcGIS Developer Help is designed for Visual Basic®, .NET, Java, and C++ developers and is placed on the hard drive during the ArcGIS Engine Developer Kit installation.

The ArcGIS Developer Guide Series

Each part of the ArcGIS system—Desktop, Engine, and Server—has a developer guide to help developers get started with ArcObjects and the different supported APIs. The *ArcGIS Engine Developer Guide* provides information for developers who wish to create and deploy custom applications based on ArcGIS Engine and the different developer controls and components. The *ArcGIS Desktop Developer Guide* is for developers who want to customize or extend one of the ArcGIS Desktop applications such as ArcMap or ArcCatalog™. Developers can use Visual Basic for Applications (VBA) to customize and Visual Basic, Visual C++®, or .NET to extend the applications. The *ArcGIS Server Developer Guide* is for developers who want to use ArcGIS Server to build custom server applications. Server developers can build Web services and Web applications that do simple mapping or include advanced GIS functionality. Each book

provides several scenarios that illustrate with code examples some of the different types of applications that can be developed using one of the ArcGIS Developer Kits.

ArcGIS Developer Online

ArcGIS Developer Online is the Web-based equivalent of the ArcGIS Developer Help system and contains the same information. The site can be found at http://arcgisdeveloperonline.esri.com.

The online site has several advantages, including being accessible via a Web browser on computers without ArcGIS installed, and is updated frequently with new material such as samples, technical documents, and corrections. Use the online site to get the most up-to-date information available for ArcGIS developers.

ESRI Support Center

The ESRI Support Center, at http://support.esri.com, contains software information, technical documents, samples, user forums, and a knowledge base for all ArcGIS products. ArcGIS developers can take advantage of the forums, knowledge base, and samples sections in particular to aid in the development of their ArcGIS applications.

Training

ESRI offers a number of instructor-led and Web-based training courses for ArcGIS developers. These courses range from the introductory level for VBA to the more advanced courses in component development for ArcGIS Desktop, ArcGIS Engine, and ArcGIS Server with specific APIs. For more information, visit www.esri.com/training.

Conclusion

ArcGIS Engine is a new addition to the ArcGIS family of products. ESRI customers and prospects have expressed a strong interest in the ability to develop desktop applications on the ArcGIS ArcObjects framework with the capability to build custom, industry specific user interfaces.

The right platform on which to effectively host a GIS development effort is a cross platform, standards-based component framework that will allow solution providers or an organization's internal developers to rapidly build industry specific applications. A GIS development framework provides the necessary comprehensive spatial functionality for applications and allows the software developer to focus efforts on building application specific logic. ArcGIS Engine is that GIS framework, created in response to requests that ArcObjects and supporting developer resources be packaged for fast, comprehensive, and cost-effective delivery of GIS and mapping applications that reach beyond the traditional GIS user.

For more information about ArcGIS Engine, please visit www.esri.com/arcgisengine.