Extending ArcGIS Server capabilities through customization - A technology perspective

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Abstract:

To consume ArcGIS Server services a range of client applications and developer frameworks and APIs like ArcGIS Desktop, rich Internet applications such as the ArcGIS API for Microsoft Silverlight/WPF, and Web Mapping applications such as the Web Application Developer Framework (ADF) for Microsoft .NET / Java and Server Object Extensions, are provided by ESRI. Besides, ArcGIS Server provides a wide range of fine grained application programming interfaces (APIs) built on standards that permit almost every client application to interact with and use the mapping, data management, and spatial analysis service of ArcGIS Server.

Nevertheless, there are occasions which necessitate extending ArcGIS Server services by adding functionality that is not explicitly available with the existing service capabilities. This paper would bring insight in to how ArcGIS Server capabilities can be enhanced by building custom web services or business specific Server Object Extensions.

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Introduction

On many occasions customization of off the shelf software becomes a necessity because no software is offered as a "one size fits all" product and developing such a product is difficult, time consuming and prohibitively expensive. Customization can enhance the value of off-the-shelf software, letting the company add more value for their customers — both internal and external.

The objective of this paper is to bring insight in to how the capabilities of ArcGIS Server, the web application product from ESRI, can be enhanced by building custom web services or business specific Server Object Extensions. To consume ArcGIS Server services, a range of client applications and developer frameworks and APIs like ArcGIS Desktop, rich Internet applications such as the ArcGIS API for Microsoft Silverlight/WPF, and Web Mapping applications such as the Web Application Developer Framework (ADF) for Microsoft .NET / Java and Server Object Extensions, are provided by ESRI. ArcGIS Server also provides a wide range of fine grained application programming interfaces (APIs) built on standards that permit almost every client application to interact with and use the mapping, data management, and spatial analysis service of ArcGIS Server. Nevertheless, there are occasions which necessitate extending ArcGIS Server services by adding functionality that is not explicitly available with the existing service capabilities.

ArcGIS Server and its current capabilities (Technology Overview):

About ESRI

ESRI is a software development and services company providing Geographic Information System (GIS) software and geodatabase management applications. The headquarters of ESRI is in Redlands, California. The name ArcGIS refers to the suite of GIS software products from ESRI, which operate on desktop, server, and mobile platforms. ESRI leads the industry in providing general-purpose commercial off the-shelf (COTS) geographic information system (GIS) software applications and toolkits. ESRI is the largest and most experienced commercial GIS software organization in the world. ESRI has the largest customer base in the geoprocessing industry. It offers a stable and mature product line, providing software that is already used extensively for all GIS applications. ESRI also offers a total enterprise solution across a range of platforms with a unified and commercially proven architecture and aggressively improves and extends software products. Moreover, ESRI employs a common software code baseline based on its ArcObjects™ architecture, and these objects are exposed for use by application builders.

ArcGIS Server

ArcGIS Server is a comprehensive platform for delivering enterprise GIS applications that are centrally managed and support multiple users. ArcGIS Server provides the framework to build and deploy centralized GIS applications and services to meet a variety of needs using a variety of clients. Organizations use ArcGIS Server to distribute maps and GIS capabilities via Web mapping applications and services to improve internal workflows, communicate vital issues and engage stakeholders. The intuitive web maps strengthen the business and resource decisions with real-time location intelligence, geographically enable IT investments and a centrally managed geodata, provides better data security and integrity for information assets.

With ArcGIS Server, one can:

- Provide browser-based access to GIS
- Deliver advanced GIS Web services throughout the organization
- Develop custom applications using .NET or Java to meet specific user needs
- Integrate GIS and other IT technologies using industry-standard software
- Provide centrally managed, multiuser editing capabilities
- Perform focused spatial analysis operations on a server
- Extend GIS to mobile workforce
- Simplify access to large volume of imagery resources

The need for customization:

Most of the software packages accomplish most of the needs of a customer and the remaining business specific needs may require customization. In other words, most of the off the shelf products need to be tweaked to fit within any particular business environment without losing too much money in the bargain. However, enhancing a product to satisfy core business needs may be necessary regardless of costs.

The off the shelf software cannot meet the requirements of every industry. It would be time consuming to develop applications that accommodate all the requirements of a specific industry. Also, the cost of such an application would be prohibitively expensive. Hence industry specific offerings are rare. This is where the customization comes into play. A good customization of software applications of course requires a thorough understanding of customer requirements and expectations.

Software customizations can span the entire project life cycle and are driven by the requirements of the customer. It mainly involves changing existing functions as well as creating new modules for the applications. Custom software solutions give the greatest flexibility possible since the product is tailored to specific requirements. Such solutions will save a lot of time and allow for a much greater productivity in the long run. This will ensure greater success either with users or in business process.

ArcGIS Server - Opportunities are many for customization:

The ArcGIS family of products--ArcGIS Desktop, ArcGIS Engine, and ArcGIS Server--is all built from ArcObjects. ArcGIS server by default provides several options to further customize the services to suit specific requirements. The standard customization features of the product are explained briefly below.

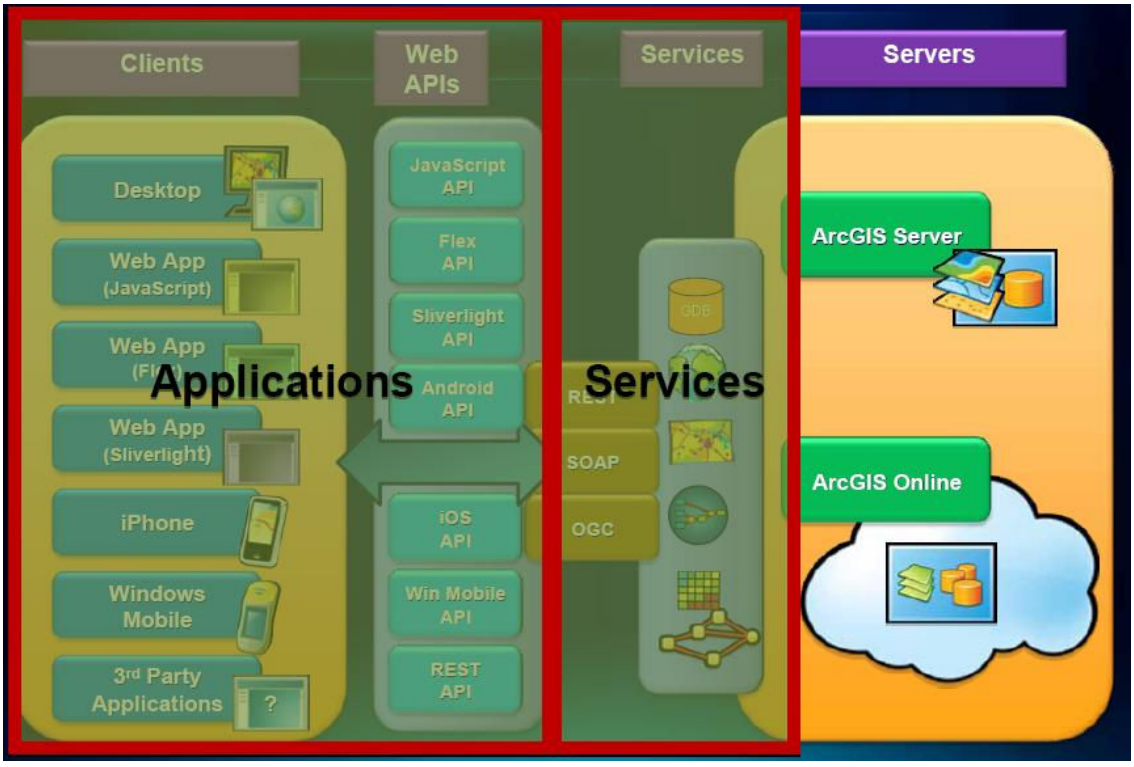

Fig:1 – Developer Opportunities **Source: ESRI Developer Summit presentation**

i. **ArcGIS Server Manager**

ArcGIS Server Manager is the application used to work with the GIS server. The Manager can be used to create and edit Web mapping applications that showcase the geographic information running on the server. The application-building interface of Manager is intended for people with little or no Web development experience. A wizardlike interface is available that takes user through the process of creating a Web application. The ArcGIS Server Manager can be used to create and deploy a fully functional Web mapping application. Manager steps you through the process of selecting which services to display, configuring tasks, and choosing the look and feel of your Web application. For advanced customizations, the application can be opened in an integrated development environment (IDE) such as Microsoft Visual Studio.

Through Manager, the Web application is built and tailored to the needs of the people who will use it. It allows us to configure the machines and directories in the server system and troubleshoot the server using its logs. We can choose the data we want to show, select map elements such as North arrows and scale bars, select tools for working with the application, and configure the map layout.

The main capabilities of ArcGIS Server Manager includes:-

- Adding or removing new services
- Publishing services
- Administering the GIS server
- Creating Web applications
- Publishing ArcGIS Explorer maps on the server

ii. Server side customization through Web ADF, SOE

Web ADF provides tools and ready-to-use templates for developing Web applications. ArcGIS Server comes with two ADFs, one for leveraging JEE and the other for .NET platform. The Web mapping application deployed directly from Manager can be extended further by importing it into the developer IDE. In some cases, it is required to use the code or files included with the Web mapping application as a guide.

The ADFs also include controls such as maps and toolbars, which we can drag and drop to design an application. For advanced applications, we can use the ADFs' libraries to fully automate the process of connecting to servers and performing GIS tasks.

The Web ADF is architected to support connections to multiple types of GIS services in Web applications and Web services. These include:

- ArcGIS Server (local and Internet) services
- ArcIMS services
- ArcWeb Services
- OGC WMS services

Server object extensions (SOEs) allow us to extend the base functionality of ArcGIS Server.

For some specific business logic to perform that is not easily accomplished using the ArcGIS APIs, SOEs can be created. They have the following great advantages:

- An SOE can be exposed as a Representational State Transfer (REST) and/or Simple Object Access Protocol (SOAP) Web service, allowing clients built on top of the ArcGIS application interfaces (APIs), to easily invoke them. In fact, the SOEs will be shown in the ArcGIS Services Directory and can expose the typical object types that the ArcGIS APIs understand.

- When we build an SOE, we're providing coarse-grained methods that perform work on ArcGIS Server, rather than making a large number of calls from the client to the server. SOEs encapsulate ArcObjects™ logic very efficiently, providing an ideal environment to execute the calls quickly.

iii. Web Client APIs

ArcGIS Web Mapping APIs are a collection of APIs to build and embed interactive maps in the website. We can mash-up online services, GeoRSS and social media feeds, tools and widgets to create custom web maps.

The following are the major Web Mapping APIs:

- ArcGIS API for JavaScript
- ArcGIS API for Flex
- ArcGIS API for Silverlight/WPF

These APIs do not use local connections at all. Instead, they only hook into the server through Web services. All these APIs invoked GIS functions through stateless REST-ful Web services. As of today, most ArcGIS Server development is happening through these APIs.

The ArcGIS API for Android enables us to build applications that utilize the powerful mapping, geocoding, geoprocessing, and custom capabilities provided by ArcGIS Server using Java and deploy them on Android devices.

ArcGIS for iOS extends the reach of GIS to the field. It includes an application for Apple iPhone, iPod touch, and iPad devices. Using the ArcGIS API for iOS, we can develop focused applications for iOS devices that can be deployed within the enterprise or to the public via the Apple App Store.

ArcGIS for Windows Mobile helps organizations deliver GIS capabilities and data from centralized servers to a range of mobile devices. We can use ArcGIS for Windows Mobile to deploy intuitive and productive mobile GIS applications to increase the accuracy and improve the currency of GIS data across the organization. Easy-to-use ArcGIS for Windows Mobile applications would enable field staffs to do Mapping, Spatial query, Sketching, GPS integration and GIS editing.

iv. Communication Infrastructure

Built on a single code and in compliance with information technology standards, ArcGIS unifies the enterprise applications by providing a scalable, high-performance communication infrastructure.

The ArcGIS Server SOAP API is an XML-structured language for communicating with ArcGIS Server services based on the SOAP standard. It is designed to make stateless use of ArcGIS Server services. Web services provide the ability for applications to communicate using messaging over many different protocols.

The ArcGIS Server REST API short for Representational State Transfer provides a simple, open Web interface to services hosted by ArcGIS Server. All resources and operations exposed by the REST API are accessible through a hierarchy of endpoints or Uniform Resource Locators (URLs) for each GIS service published with ArcGIS Server.

The REST API is used in other APIs available with ArcGIS Server, including the stand-alone ArcGIS Server JavaScript API and the ArcGIS JavaScript Extension for Google Maps.

Open Geospatial Consortium, Inc. (OGC) Web services provide a way that we can make the maps and data available in an open, internationally recognized format over the Web. OGC has defined specifications for making maps and data available on the Web to anyone with a supported client application.

ArcGIS Server allows to publish three types of OGC services:

- Web Map Services (WMS) for serving collections of layers as map images
- Web Feature Services (WFS) for serving data as vector features
- Web Coverage Services (WCS) for serving data as raster coverages (not to be confused with ESRI's ArcInfo coverages)

Understanding out of the box services:

While publishing a GIS resource to the server, the administrator can enable capabilities that define the various ways clients can use the service. The person who uses these services will view these capabilities as separate services.

Table 1 : Out of the box services

Service	What it does
Geocode services	Provides access to an address locator.
Geodata services	Provides access to the contents of a geodatabase for data query, extraction, and replication. Creates a service compliant with the Open Geospatial Consortium, Inc. (OGC) Web Coverage Service (WCS) specification
Map services	Geodata Access, Geoprocessing, KML, Access to content of map document, Mobile Data Access, Network Analysis, WCS, WMS
Geometry services	Provides an engine internal to the applications for performing geometric calculations such as project and densify.
Geoprocessing services	Provides access to geoprocessing models from either a toolbox or tool layer.
Globe services	Provides access to the contents of a globe document.
Image services	Provides access to the contents of a raster dataset or ArcGIS Image Server service.

Table 2 : Understanding Capabilities

	View	Query & Find	Edit & or Replication	Analysis	Comments
Map	X	X	X		Editing through WFS-T capability
Image	X	X			
Globe	X	X			
Geocode		X			
Geodata			X		
Geoprocessing				X	
Network				X	Capability of Map Service
Mobile	X	X	X		Capability of Map Service
Geometry					Geometry manipulation

Extending ArcGIS Server Capabilities:

ESRI ArcGIS Server provides fine grained APIs as ArcObjects™ and coarse grained features as SOEs / Web ADF templates. Server object extensions allow us to extend the base functionality of ArcGIS Server. Most SOEs do this by using ArcObjects™ code to work with geographic information system (GIS) data and maps.

i. Advantages of SOEs:

- SOE can be exposed as a REST or SOAP Web service, allowing clients to build on top of the ArcGIS application interfaces (APIs), for example, JavaScript, Flex, Silverlight, and so on, to easily invoke them.
- When building an SOE, we are providing coarse-grained methods that perform work on ArcGIS Server, rather than making a large number of calls from the client to the server. SOEs encapsulate ArcObjects™ logic very efficiently, providing an ideal environment to execute the calls quickly.

When do you need an SOE?

SOEs require extensive development, and must be deployed on each server in configuration. Before developing a server object extension, the following alternatives need to be considered.

ii. Geoprocessing services as an alternative to SOEs

Some GIS applications run a specific series of geoprocessing tools to perform some business logic. In many cases, these processes can be expressed in ArcGIS Model Builder, where we can graphically "chain" tools together. We can expose these models as geoprocessing Web services, to be consumed in the applications.

Geoprocessing services benefits

Using a geoprocessing service can save a lot of coding, because we are often just dragging and dropping tools in Model Builder. Also, we can leave an asynchronous geoprocessing job running on the server while doing other things, then check later to get the results. Geoprocessing services are handy for long-running and complex processes.

Along with offering hundreds of out-of-the-box tools, ArcGIS geoprocessing allows the user to develop custom tools. The simplest way is to write Python scripts that can be run in a stand-alone manner or integrated with other tools within a model. A great example is the arcpy.mapping module which is recommended for creating print-quality maps through the Web.

We can also create custom geoprocessing tools with C#, Visual Basic .NET, or C++. This allows embedding our own fine-grained ArcObjects™ logic within our tools and models. We can also re-use these custom tools in non-ArcGIS Server workflows, since they behave like any other tool.

Drawbacks of geoprocessing services

Geoprocessing services have a large memory footprint and often run slower than SOEs. If we are running a process only a few times a day, this might not be an issue. However, if we are running a process many times a day, or with many concurrent users, it might be worth investing the time to build an SOE.

iii. Geometry Services:

Before building a geoprocessing service or an SOE, it is good to see if the geometry service offers the methods that we need. A geometry service can perform basic GIS operations such as buffering, determining spatial relationships, measuring lengths and areas, and so on. Calling a series of methods on a geometry service and combining them with the query capabilities of map services is simpler and faster than using a geoprocessing service.

Considerations while choosing the technologies:

Adopting any technology in a project should be assessed for its suitability. Some of the aspects that need to be considered include:

- Skills and Passion
- Level of complexity
- Other constrains (like corporate standard, legacy applications…)
- Security
- Functionality
- Costs and Benefits
- Environmental constraints
- User Acceptability
- Available infrastructure

Case Study – Develop Pipeline Isolation Functionality for a US Water Utility

i. Background

The project scope was to design and develop a GIS web application using ArcGIS Server and ArcGIS API for Silverlight/WPF technologies. The web application's primary function is to support basic information needs for responding to a water main break, or any other issue that would require isolating a part of the water distribution system.

ii. Application Development

The Norfolk county data used by the application is published through ArcGIS Server services and accessed using map / geometry services. The application development included the basic navigation functionalities, search functionalities, select, zoom and highlight features and query & display of water network data. The highlight of the project was developing the required functionalities for pipeline isolation and finding affected water customers.

Pipeline Isolation

In a typical case, the user will select a water main of interest and perform a directional trace on connected features in the water network using the custom developed tool. The application will then highlight the first encountered closable valves in all directions and the associated data would be displayed in a tabular form. The user selected water main and the traced network between the closable valves would also be highlighted in a different graphics.

Finding Affected Customers

Further, all parcels affected due to valves shut would be highlighted. Geocoded points that intersect the highlighted parcels would be selected and printable lists of customers would also be generated. Alternatively the user can define a geographic area by drawing a polygon over the parcel dataset to select the customers falling in the area. The user has a provision to add or remove set of customers from the list interactively.

iii. Challenges

The application required extensive use of network solvers for performing the find connected, upstream / downstream traces and displaying the results on the map. Also it is required to use closable valves as barriers. However, the ArcGIS Server APIs for Silverlight doesn't have default capability for performing the utility network functions. Hence we had to depend on a custom solution to cater our needs.

iv. Solution

A customized solution for tracing functionality was implemented. The solution was to create and host a web service using the ArcGIS Server ADF for .NET which has rich and extensive network utility functions. Upon receiving requests from the client application, the web service will use the ADF objects and interfaces to process the request and return the query results as a list of junctions and edges back to the client. The ADF based custom web service will communicate to the Silverlight client application using SOAP technology. The client application need not worry about the network tracing features which will be explicitly performed by the web service using the web ADF methods. The Silverlight client using its API will create a request with the selected water main, pass the request to the web service, and then simply will get the response and draw the result on the map.

During the implementation, the web service was found to be slow in responding to the pipeline isolation requests. This happened because adding closeable valves as barriers for the trace need to be done one after another and a huge collection of valves were available on the network. This was resolved by a workaround by creating the barriers at the time of application initialization which run as a separate thread without interrupting user actions. This list will be persistent till the service is restarted again. Another bottleneck encountered was while displaying the trace results in Silverlight client. Finding corresponding feature details of edges and junction were slow. So the search was restricted to a buffered extent of the trace results through a custom spatial filter. With these implementations, the functionalities of the system became highly responsive providing a feel of rich interactive application.

Conclusion:

ESRI ArcGIS Server has very rich built-in capabilities. A rich set of Client APIs for Silverlight, Flex & JavaScript provides developer friendly choice of technology. The Mobile APIs for iOS, Windows and Android can make the developers take GIS everywhere. ArcGIS Server provides access to fine grained APIs and can cater development of business specific capabilities and through industry standard platforms. GIS is becoming influential integration technology for Enterprises. Using the combination of options and technologies as mentioned in this paper, ESRI ArcGIS Server can fulfill the needs of a variety of deployment scenarios needed in this technology advanced time. .

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