Architecting the ArcGIS Platform: Best Practices

April 2016

Patterns & Practices

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Architecting the ArcGIS Platform: Best Practices

April 2016

Maximize the value of the ArcGIS platform, in the context of organizational goals, through the application of guidelines presented in these best practices and implementation approaches.

Introduction

The ArcGIS platform connects maps, apps, data, and people in ways that help organizations make more informed and faster decisions, extending the reach of GIS across the enterprise. ArcGIS accomplishes this by making it easy for everyone in an organization to discover, use, make, and share maps from any device, anywhere, anytime. Furthermore, ArcGIS is designed to be flexible, offering these capabilities through multiple implementation patterns and approaches.

This document presents some implementation guidelines in the form of a conceptual reference architecture diagram and associated best practice briefs. Organizations can use these guidelines to maximize the value of their ArcGIS implementation and meet their organizational objectives.

Conceptual Reference Architecture

The ArcGIS Platform Conceptual Reference Architecture diagram found on page five of this document illustrates platform capabilities combined with best practices and patterns of business use.

The diagram depicts three distinct computing environments—*production*, *staging*, and *development*—which together represent a best practice known as *environment isolation*. There are four main components within each environment, with each section displayed in a different color to highlight the function. Figure 1 identifies those components by number, where the number one represents the Apps section, number two represents the Portal section, number three represents the Infrastructure section, and number four represents the External Systems and Services section. The components are described in following paragraphs.

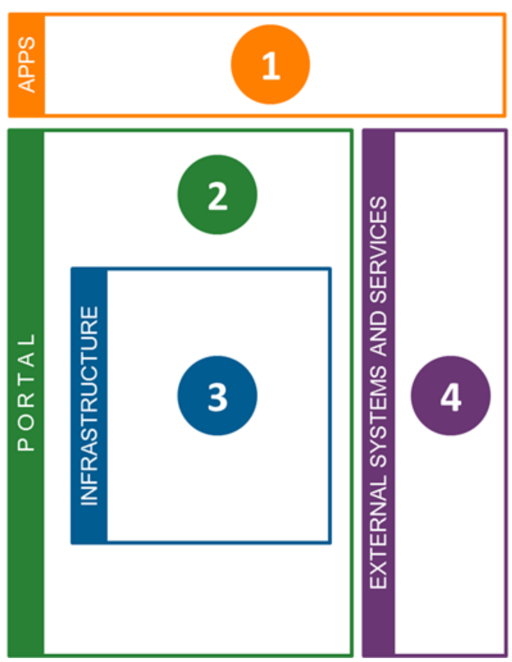


Figure 1: Components of the ArcGIS Platform Conceptual Reference Architecture: 1-Apps (orange), 2-Portal (green), 3-Infrastructure (blue), and 4-External Systems and Services (purple).

The **Apps** section illustrates the components of the platform that most users interact with, including end-user applications such as ArcMap, ArcGIS Pro, Collector for ArcGIS, and Operations Dashboard for ArcGIS. Apps are typically used in workflows that follow one or more of the six *essential patterns of a location strategy* (location enablement, constituent engagement, decision support, field mobility, analytics, and, data management). For example, the *location enablement* pattern extends geospatial capabilities to everyone in the organization with a destination (website and simple apps) for knowledge workers, executives, and field workers to discover, use, make, and share maps. A person capturing damage assessment data in the field with Collector for ArcGIS is following the *field mobility* pattern. The decision maker using Operations Dashboard to observe the real-time information created by field workers is following the *decision support* pattern. Apps connect people and their business workflows to the platform.

The **Portal** component of the platform organizes users and connects them with the appropriate content and capabilities based on their role and privileges within the platform. The portal uses a person's identity to deliver the right content to the right person at the right time. From a product perspective, the portal is either Portal for ArcGIS (on-premises solution) or ArcGIS Online (cloud-based solution). The portal provides access controls, content management capabilities, and a sharing model that enables users to share information products across the organization.

The **Infrastructure** component includes the hardware, software, services, and data repositories that are the core of the ArcGIS platform. Numerous best practices—including load balancing, high availability, workload separation, and publication strategies—are linked from and associated with the platform infrastructure. Follow the links from each best practice label on the Conceptual Reference Architecture diagram to learn more about how these strategies affect infrastructure decisions.

The **External Systems and Services** components include other systems that either provide services to ArcGIS or consume ArcGIS services to geospatially enable their capabilities. The ability to easily geo-enable other enterprise business systems is a key capability of ArcGIS.

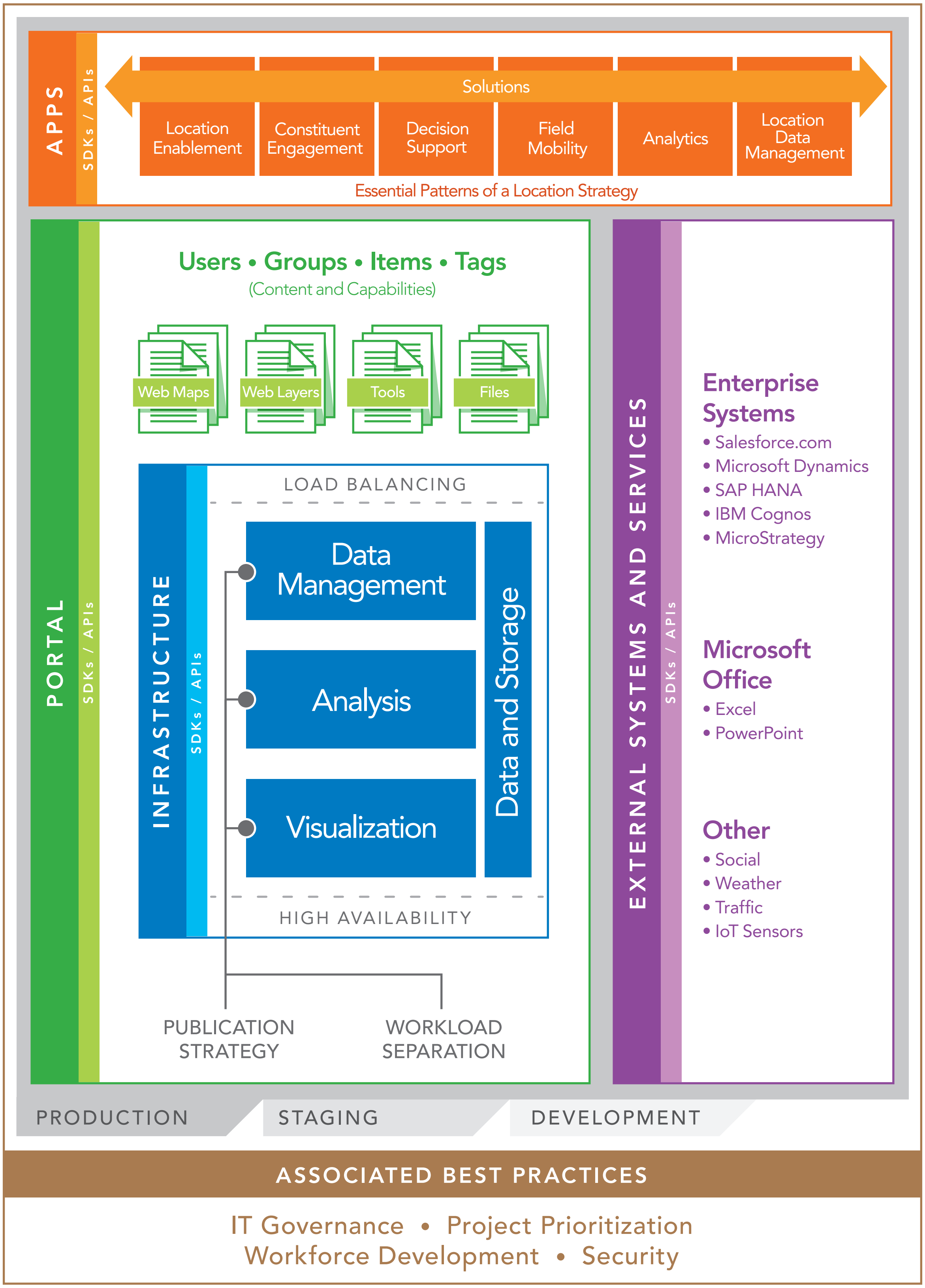
Best Practices

There are fourteen best practice briefs associated with the ArcGIS Platform Conceptual Reference Architecture diagram. Eight of these briefs—including *High Availability*, *Load Balancing*, *Publication Strategy*, *Environment Isolation*, *Security, Portal Implementation, Enterprise Integration*, and *Workload Separation*—reference technology practices that provide high-level implementation guidelines based on business needs. Following these best practices will help organizations meet requirements for performance, security, and availability. The best practice briefs for *Identity, Project Prioritization, Workforce Development, Application Development Approaches,* and *Essential Patterns of a Location Strategy* focus on people and how they should interact with ArcGIS. Finally, the *IT Governance* brief offers a complementary process guideline that suggests ways to minimize risk, improve quality, and increase productivity around ArcGIS solutions.

How to Use This Document

The ArcGIS Platform Conceptual Reference Architecture diagram is a clickable graphic that contains links to each best practice brief. You can use the diagram to explore how the individual briefs relate to the platform, or to visualize how the ArcGIS platform will support organizational business needs.

ArcGIS Conceptual Reference Architecture



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Application Development Approaches

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Custom applications can be expensive to create and maintain over time. While the ArcGIS platform provides a myriad of out-of-the-box templates and applications, the capabilities included with the platform may not always adequately address your business needs. You can extend ArcGIS with custom business logic by leveraging the platform's application frameworks and templates, which provide you with a sustainable and cost-effective approach to application development.

Introduction

ArcGIS provides a robust platform for discovering, creating, using, and sharing maps and applying the power of geography to workflows throughout an organization. To do their work, users interact with the platform in the form of applications, which are delivered at the right time on the right device. While a myriad of platform capabilities and applications exist, you might need to extend the capabilities of the platform through the development of custom applications to meet your organization's business and user needs.

Creating custom applications can be a significant investment of resources, and the decision to develop versus configure should not be made casually. Developing applications takes time and requires highly developed skills, which are typically expensive to nurture or hire. Maintaining custom applications is also an ongoing commitment of resources and is often overlooked in total cost of application ownership. In addition, user expectations have shifted with the consumerization of information technology, causing people to demand easy-to-use applications and rapid and frequent updates, further compounding the resources needed to develop and maintain custom applications.

Recommendations

The ArcGIS platform includes a wealth of out-of-the-box applications and solutions that can be configured for a specific use. Most project needs can be met by simply configuring these apps. Organizations should adopt a "**Configure First**" approach to avoid often unnecessary and costly programming projects, where COTS application properties are set to reflect user/business requirements without the need for more invasive customization or code changes.

However, when custom application programming is necessary to extend the ArcGIS platform to meet business needs, three main approaches include:

1. **Extending existing applications** by encapsulating new functionality in modules or widgets that fit into existing apps and frameworks. Several ArcGIS apps (like the ArcGIS Web App Builder and Operations Dashboard) provide a modular or widget-based framework. Developers can save time and effort by developing new widgets with unique business logic that plug into these existing applications.
2. **Adding functionality to existing templates** made available by Esri, such as those on arcgis.com and github.com/esri. These templates follow best practices and are focused apps designed to solve specific problems. Developers can extend these apps by adding discrete enhancements, or they can use these apps as starting points for other apps.

3. **Building new custom apps** using the available SDKs and APIs, which handle basic mapping functionality and allow the developer to focus on business logic. Best practices for this approach include leveraging the identity of the user to provide appropriate content, and leveraging web maps and web scenes to manage and provide content for apps across the entire platform. These concepts help keep development effort to a minimum without requiring constant updates to the application code.

When it is necessary to extend the ArcGIS platform by developing custom functionality, provide focused applications that solve a specific problem. By adhering to the approaches described above, developers can maximize the unique business value provided to users, minimize risk, and reduce overall cost.

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ArcGIS Portal Implementation Considerations

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Whether you use ArcGIS Online, Portal for ArcGIS, or both, a geospatial portal is an integral component of the ArcGIS platform, fully enabling web GIS. The portal component of ArcGIS provides an organization with user access controls, a sharing model, content management, and capabilities that empower everyone in the organization to easily discover, use, make, and share maps from any device, anywhere, anytime. The decision to implement one or more portals, either on-premises and/or on the Esri cloud, may vary from organization to organization and depends on specific business needs and requirements.

Introduction

Many organizations want to deliver the authoritative geographic content/knowledge they have been so invested in creating and maintaining in a way that reaches their entire workforce. They want a "System of Engagement"- a system that empowers every employee and contractor to easily discover, use, make, and share maps from any device, anywhere, anytime. This System of Engagement is delivered through a web GIS pattern. A web GIS pattern is typified by users (and their applications) connecting to a geospatial portal, using their identity to create, consume, and distribute appropriate information products for their particular role. Web GIS is the next evolutionary phase of GIS implementations and represents the direction that the ArcGIS Platform is taking. Web GIS uses server and desktop GIS patterns as a foundation, integrating with a geospatial portal to deliver a contemporary System of Engagement.

Geospatial portals allow organizations to manage their GIS platform, facilitate sharing, and provide access to content and capabilities—empowering the right user with the right information and tools at the right time. Typically, an organization must first determine whether to deploy a portal within their existing infrastructure (on-premises with Portal for ArcGIS) or on Esri's cloud infrastructure (ArcGIS Online). Some organizations must also decide whether to deploy a single instance of a geospatial portal for their entire organization or multiple portals to address distinct challenges or business requirements.

The decision to deploy the portal on-premises or on the Esri cloud is influenced by several factors, including security, strict Service Level Agreements (SLA), and restricted Internet access. For example, a Department of Health and Human Services may want to implement a department-specific, on-premises portal to support internal mapping and analysis functions with protected health data. In this example, the intent, data security requirements, and business needs are so strict that implementing a separate on-premises portal is appropriate.

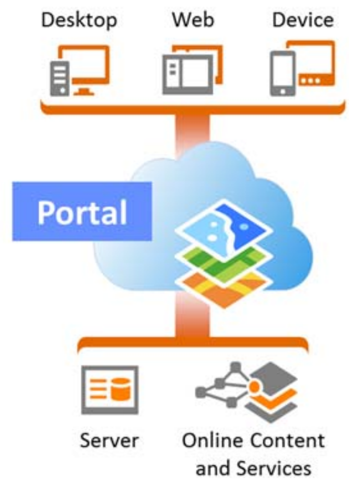

Figure 1: The portal component of ArcGIS allows organizations to manage their GIS platform, facilitate sharing, and provide access to content and capabilities.

Organizations must also decide whether to support their business needs with one portal or multiple portals. A single portal implementation (either on-premises or on the Esri cloud) is often sufficient. But in some situations, an organization may want to implement multiple portals for different purposes—for example, an on-premises portal to meet department-specific business requirements, and an Esri cloud-hosted portal for constituent engagement, including the delivery of open data. In the case of a geographically distributed organization with poor network connectivity between offices, the organization may need to deploy multiple GIS server instances and portals to enable web GIS across all of their distributed locations.

Recommendations

A geospatial portal is an integral component of the ArcGIS platform and is critical for deploying a System of Engagement. Determining whether to implement one or more geospatial portals will depend on the specific characteristics and requirements of an organization's business workflows. A single organizational portal, whether on-premises or on the Esri cloud, is appropriate for most organizations that can centralize and govern their portal. Multiple portals can be appropriate when organizations have a mix of sensitive and public content, are geographically distributed, or have distinct business requirements that demand multiple portal instances.

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Enterprise Integration: Application Patterns

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Workflows that support end-to-end business processes often require collaboration between different types of users and applications. A variety of enterprise application patterns exist, each enabling collaboration between enterprise business systems, whether in terms of the information flows between them or the services they offer. Enterprise applications that integrate ArcGIS with other business systems increase effective decision making by enabling the use of location across workflows, directly and positively impacting business outcomes.

Introduction

Enterprise application integration (EAI) is an approach for connecting and coordinating multiple, disparate information technology systems across an organizational enterprise. EAI applications and solutions seek to create critical business linkages between heterogeneous enterprise systems in a unified manner, which helps the organization better achieve business goals and outcomes. EAI applications and solutions for the ArcGIS platform typically appear as one of three enterprise application patterns: geocentric, geoenabled, and composite.

Geocentric applications are typically map-centric. They are characterized by a predominance of geospatial content and capabilities, with secondary content and capabilities being delivered from other business information. This enterprise application pattern typically uses a traditional GIS application as the hosting framework. Geocentric applications are best suited for staff trained in and comfortable with using GIS applications. An example of this application pattern would be the SAS® Bridge for Esri extension to ArcGIS for Desktop—an approach that empowers GIS users to leverage SAS analytic and business intelligence capabilities within a GIS application environment.

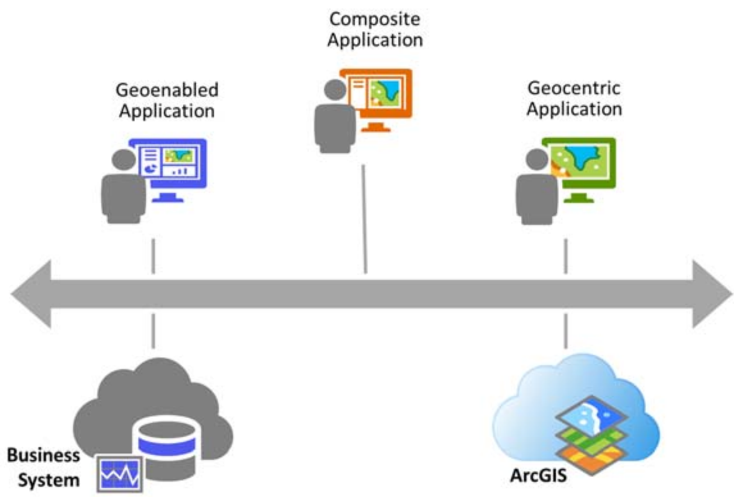

Figure 1: Enterprise application patterns for the ArcGIS platform.

Geoenabled applications are typically not map-centric. Instead, they are characterized by a predominance of business system content and capabilities, with secondary content and capabilities being delivered from GIS. This application approach typically uses the traditional business system application as the hosting framework. Geoenabled applications are best suited for staff trained in and comfortable with using the business system's application. An example of this would be the SAP applications within Flexible Real Estate (RE/FX)—these applications, which are used to support the entire commercial real estate life cycle, are enhanced with mapping and analytical capabilities from GIS.

Composite applications are built by combining multiple existing capabilities and functions from various systems into a new application, without relying on an existing hosting framework. Typically, composite applications are built using web services and incorporate logic from multiple systems to produce new, derived functionality. Conceptually these applications are comparable to mashups and represent a contemporary trend in enterprise application development. As with all new applications and workflows, staff training may be required. An example of a composite application is the CitySourced Mobile Service Request application, a mobile civic engagement app that utilizes services from ArcGIS as well as work order management systems such as Microsoft Dynamics or IBM Maximo.

Recommendations

Enterprise application patterns vary and are dependent on use cases supporting business goals. Select the application pattern that delivers the required business capabilities while preserving and leveraging existing information technology systems. Regardless of application pattern (geocentric, geoenabled, or composite), Esri recommends a COTS first approach to application selection, prioritizing the use of COTS technology before developing custom applications, extensions, or middleware. This approach will help reduce total costs of application ownership by minimizing both short- and long-term expenditures associated with application programming, maintenance, and support staff. It is further recommended to seek applications from Esri or from the Esri Partner Network, which includes more than 1,900 organizations providing expertise, solutions, and services to the global ArcGIS community.

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Environment Isolation

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Isolating computing environments is a recommended approach that contributes to system reliability and availability by creating separate and distinct systems for operational, testing, and development activities. Environment isolation reduces risk and protects operational systems from unintentional changes and negative business impacts.

Introduction

It is highly undesirable for an operational system to fail to deliver the functional or performance capabilities that customers expect, whether because of resource contention, system failures, outages, or other issues that could have been avoided. Environment isolation plays a crucial role in system design because it insulates the different computing environments from unmanaged change, helping maintain the functionality and performance that users expect in the system.

Recommendations

System changes are inevitable. It is a recommended practice to manage these changes in isolated computing environments, which helps mitigate the risks associated with change and contributes to the delivery of stable, extensible, and high performing business capabilities. Risk needs to be defined and documented in a contract or Service Level Agreement (SLA) between technology service providers and business stakeholders. Within this contract, expectations for system reliability, in measureable terms, will guide how environment isolation and its governance will support those expectations. Implementing at least three isolated, computing environments (production, staging, and development) is an important element to meeting SLAs and is an essential practice for enterprise systems management (Figure 1).

A production environment is the "live" system that supports end users. Uptime requirements are defined by an SLA and are supported by appropriate change management and governance. Software, application, configuration, or network changes should never be made to the production environment without first being tested and evaluated in a staging environment.

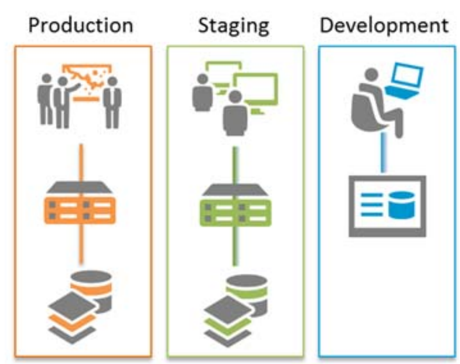

Figure 1: Three recommended computing environments.

A staging environment is a mirror of the production environment, and it provides a venue to vet system changes and ensure system quality before deploying changes to production. User acceptance testing, load testing, and training[i] are often performed in the safety of a staging environment without the risk of negatively impacting the production system.

A development environment is a workspace where developers and analysts can innovate, manage content and make changes without impacting a large audience. This dedicated server environment is typically used for unit testing, constructing business workflows, or creating new capabilities such as applications, services, data models, or geoprocessing models. Any group or organization that is developing new capability should have a development environment for these activities. The size and complexity of the environment will depend on the level of risk generated by changes, the number of creators, and the potential impact of system outages and downtime.

Implementing separate computing environments enables organizations to deliver a stable, extensible, and high performing system. SLAs should be created and publicized to support stakeholder expectations. The proper execution of change management between computing environments helps shield the system from unexpected failure and associative business disruption.

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[i] Many organizations may choose to implement each of these activities in separate computing environments instead of in a single staging environment. Many risk adverse organizations will have upwards of four, five and six different computing environments to support their IT delivery needs.

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Essential Patterns of a Location Strategy

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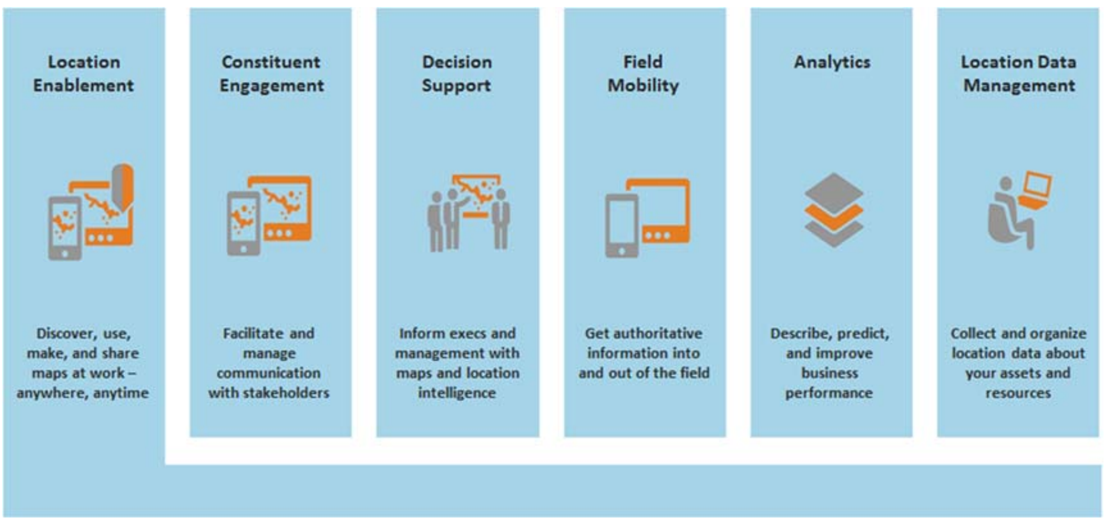
The essential patterns describe common geospatial functions that re-occur across various organizational business models and environments. Patterns include location enablement, constituent engagement, decision support, field mobility, analytics, and location data management. These patterns offer organizations a categorical framework for tracking both current and future GIS utilization in a business context.

Introduction

A common set of usage patterns exist across industries, whether an organization works in government, utilities, commercial business, energy, public safety, healthcare, non-profit, etc. These patterns describe essential usages that occur independent of business models or environments. The patterns are typically mapped against the ArcGIS platform's capabilities, providing a framework for understanding how Esri's platform aligns with specific organizational business needs. Organizations that comprehensively implement all of these GIS business patterns typically reap the greatest business benefits from their GIS investments.



Location Enablement extends the reach of your location platform, providing everyone in your organization with the ability to discover, use, make, and share maps. This pattern also includes the ability to infuse geospatial capabilities into external systems and services accessed by conventional business users.

Constituent Engagement consists of harvesting and disseminating information to and from external constituents. This process helps the organization engage communities of interest and make more informed decisions.

Decision Support is concerned with visualizing data and information on a map or dashboard to better understand organizational activities, projects, and operations. From a technology perspective, this pattern involves combining both data and analytical layers, organizing them in a map, and publishing that map over the network or the web for consumption in applications.

Field mobility is the process of storing and optimizing actionable information for the mobile environment and making this information widely available. The goals for this pattern are to improve visibility into the operational aspects of an organization, enhance workforce scheduling, eliminate issues of data currency, and provide field personnel with the information they need for their out-of-office tasks.

Analytics transform data into actionable information and are extremely powerful when applied to describe, predict and improve business performance. Accurate and actionable analytics are reliant upon solid location data management practices.

Location Data Management includes the collection, organization, and exchange of geographic data. Optimal data management involves the persistence of spatial data in the geodatabase—an object relational information model and data management framework for the ArcGIS platform.

Recommendations

Leverage the six essential patterns as a categorical framework to track both current and future GIS utilization in a business context. If gaps in pattern adoption are identified, consider implementing the ArcGIS platform to fill those gaps and to maximize the value of the GIS investment.

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High Availability

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High availability is a design approach that helps a system meet a prearranged level of operational performance over a specific period of time.[i] To achieve high availability, factors such as hardware, software, and governance need to be addressed. When solutions are architected properly, customers are provided with a reliable, redundant, and high performing environment that meets or exceeds their business requirements for service delivery.

Introduction

When GIS was merely a small, project level system for organizations, it was often satisfactory (though undesirable) if GIS capabilities were sometimes offline and unavailable. However, today GIS is engrained within the fabric of an enterprise and part of critical business operations and workflows; failure and downtime is no longer permissible. IT Managers and Architects should consider high availability designs for their GIS deployments to mitigate the risks incurred from a system/component failure.

Recommendations

Before architecting a solution for high availability, it is necessary to determine an organization's acceptable level of system downtime – typically described in a Service Level Agreement (SLA). An SLA is quantified by the percentage of required service uptime (also known as the "number of nines"). For example, an organization may want to have their systems available annually at a rate of 99.9% (three nines). This percentage equates to 8.76 hours of downtime annually or 10.1 minutes weekly. Minimizing an organization's downtime can be accomplished by reducing the number of single points of failure, adequately testing the system, and monitoring the system to catch issues early.

Reducing single points of failure within an ArcGIS platform implementation can be accomplished through duplication and load balancing (Figure 1). Duplication involves implementing multiple instances of a particular system component. Load balancing is a technique for distributing client workload traffic requests across multiple system components.

Test plans should be developed and executed regularly to evaluate a systems ability to meet a prearranged level of operational performance. These plans should include, but not be limited to, stress, performance and failover functions/activities. It is further recommended that one or more test plans be developed and executed before going "live." All testing plans and associative activities should be part of the overall system governance.

A key part of maintaining a highly available system involves monitoring the health of the system and having a plan in place to correct problems before they cause a widespread or unrecoverable outage. A variety of system monitoring tools are available from Esri as well as third-party vendors.

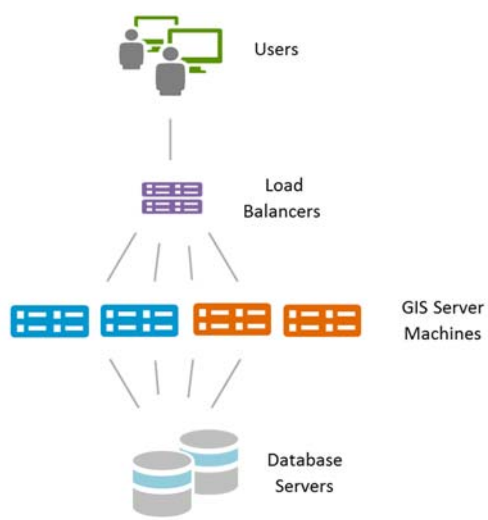

Figure 1: System design with duplication and load balancing.

High availability is a set of approaches or strategies that are meant to minimize service downtime. The effective implementation of these strategies (reducing single points of failure, adequate testing, and system monitoring) helps maximize uptime and provides redundant, reliable, and high performing service delivery.

[i] High Availability (HA) while related to, should not be confused with Disaster Recovery (DR). Generally, HA strives to retain operational service delivery, whereas DR focuses on data retention and system restoration. DR is the process by which a system is restored to a previous, acceptable state after a disaster. While DR plans are executed it is typical for service delivery to be disrupted until the system has been restored.

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Identity

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Identity information is used to uniquely and securely describe user access to maps, apps, data, and analysis within the ArcGIS platform. A person's ArcGIS identity can be managed with built-in security by ArcGIS or with a third-party identity management system. Regardless of the approach, effective management of user identities and associative credentials is necessary for successfully implementing the ArcGIS platform.

Introduction

An ArcGIS identity allows a person to participate in the platform; access, create, or share items as part of one or more groups; and use the platform to play a more collaborative role in the organization (Figure 1). Identities may be managed within the ArcGIS portal, or they may be federated as part of an enterprise identity provider. People access the platform through a role and set of privileges configured by an administrator. Roles can be tailored to individual users and their organizational responsibilities (examples include: viewer, editor, publisher, analyst, field technician, and administrator). The privileges associated with these roles ultimately permit people to join groups, access their own resources (data, maps, apps, and capabilities), and access resources that have been shared with them.

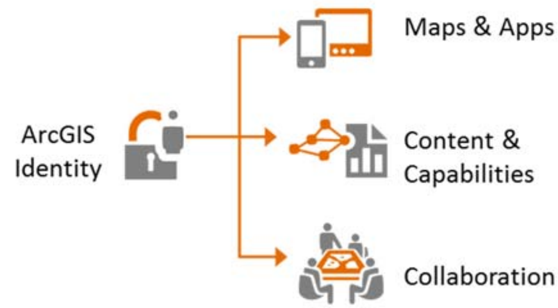

Figure 1: Identity defines a user's role and associative privileges within the ArcGIS platform.

A user's identity is managed as a named user credential within the platform. This credential associates the user with ArcGIS privileges no matter where they are. They can sign in to any app, on any device, anytime, and have access to all the maps, apps, data, and analysis they're entitled to. Named users can access a comprehensive suite of apps and maps that they can use in their day-to-day work. As people log in to apps with their named user credentials, their identity gives them access to their maps and other items, allowing them to be immediately productive.

Identities are grouped together within a sharing model. A group is a collection of items (such as maps, apps, and named users) typically related to a specific area of interest (such as a business unit, initiative, or team). Groups are useful for organizing content and controlling access. If a group is private, only members will see the group and its content.

Recommendations

Depending on the needs of the organization, ArcGIS identities can be managed using the built-in security provided by ArcGIS, or using an organization's third-party identity management system.

For small implementations, an ArcGIS administrator will want to leverage the built-in security of the ArcGIS portal to manually add and configure or batch import users. The administrator would then use a simple web interface to manage these users, the roles they assume, and the privileges they are granted.

For larger implementations, enterprise identities and groups (managed external to ArcGIS) will be used by the ArcGIS portal to control access to the platform.[i] These implementations can leverage enterprise credentials from an existing Lightweight Directory Access Protocol (LDAP) server, an Active Directory server, and identity providers that support Security Assertion Markup Language (SAML) 2.0 Web Single Sign On.

Regardless of the implementation approach, proper management of user identities is necessary for ensuring users have the software and privileges necessary to accomplish their business objectives.

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[i] Differences in enterprise identity and group support between Portal for ArcGIS and ArcGIS Online exist. Please reference Portal for ArcGIS and ArcGIS Online documentation for details.

IT Governance

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Information technology (IT) governance is a subset of the greater corporate governance framework focused specifically on IT systems, their performance, and risk management. IT governance ensures that solutions are built and managed properly within the IT landscape. This brief provides an overview of IT governance as it relates to ArcGIS platform implementations as well as guidelines that will help ArcGIS solutions deliver clear benefits and achieve long-term success.

Introduction

Conceptually, governance is a framework, a cultural orientation, and a set of owned responsibilities that ensure the integrity and effectiveness of the organization's use of IT. Implementation governance involves monitoring, managing, and steering a business, information system, or IT landscape to deliver required business outcomes. Since the GIS domain is part of the IT landscape, IT governance should be applied to GIS, including the ArcGIS platform and the solutions built on it. One way to help the ArcGIS platform remain effective to an organization is to employ an IT governance strategy that includes software change management, data governance, and workforce development.

Recommendations

Making changes to enterprise systems always introduces risk to business operations. Minimize risk by employing a software change management strategy. This strategy should include planning for upgrades to any enterprise system, including any part of the ArcGIS platform. Planning should include the testing of new software versions in one (or more) staging environments (ideally, ones that mirror the production environment) to ensure the business continuity of client applications and workflows. Testing should include, but not be limited to, functional testing, performance testing, and user acceptance testing. When testing is complete and the new software works as expected, the software upgrade to the production environment should be scheduled in advance. During the upgrade process itself, be sure necessary staff are available and that they have the permissions necessary to complete their assigned tasks. Document the upgrade process in case there is an unforeseen issue and the upgrade needs to be paused. It's also recommended to have a rollback strategy in the event of an unrecoverable error in the change or upgrade process.

Data governance involves exercising positive control over data quality, availability, usability, and security across an enterprise. It is recommended that spatial data be included within an organization's data governance and not treated separately. Furthermore, it is recommended that spatial data be maintained by data stewards within the business units and served to the rest of the organization's enterprise from centrally managed databases. Responsibilities for data quality and usability must be upheld by the departmental data stewards, and accessibility and security responsibilities must be upheld by IT, the recommended "implementation managers" of the GIS platform.

Workforce development and training is essential to the long-term success of any enterprise system implementation. A modern GIS enables ubiquitous access to maps and spatial data throughout an organization, with knowledge workers continuously contributing to and leveraging GIS capabilities. It is recommended that the organization invest in workforce development and training in order to benefit both individual employees and the organization as a whole. Flexible programs should be available for staff to acquire focused GIS training on a routine basis. GIS training programs are needed to:

1. Increase productivity and efficiency in GIS operations so knowledge workers can accomplish more with fewer resources.
2. Prevent costly mistakes in new GIS implementations and system updates.
3. Enable staff to recognize opportunities for GIS to help increase operating efficiencies, save money, and provide better government services.

Exercising IT governance within the GIS domain is critical for long-term organizational success and enables the ArcGIS platform to truly grow within the enterprise with limited risk. It is important to note that software change management, data governance, and workforce development are some key elements of an IT governance strategy; however, other elements, roles, and responsibilities (not covered in this brief) may also be necessary.

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Load Balancing

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Load balancing is a technique for distributing client workloads across multiple computing resources (such as physical servers, virtual servers, or clusters). Load balancing, either by software or hardware devices, is a recommended best practice to balance system utilization, reduce risk, simplify service delivery and growth, and improve the security of backend servers.

Introduction

With load balancers in place, client workload traffic can be optimized and distributed to server-based resources to ensure the best performance and utilization possible. Load balancing algorithms, used to dispatch client requests, can vary from simple round-robin approaches to more complex algorithms that consider factors such as current connection counts, host utilization, or real-world response times. From a scalability perspective, a properly load balanced system supports the addition and subtraction of machines without having to modify or remove client applications from use. For example, machines may be added in response to increased client demand, or machines may be removed for maintenance purposes. Also, with load balancing in place, typically only one IP address is externally exposed to the internet/intranet, which greatly reduces security risks, because the internal topology of the network and systems is hidden, and the number of breach points are reduced in case of attack. This method also simplifies service delivery and consumption by providing a single access point (e.g., a URL).

Recommendations

The ArcGIS platform is designed to be scalable and can accommodate both small and large deployments. As the number of users increases, so will the deployment size and the number of GIS servers. The ArcGIS platform supports a variety of load balancing techniques and technologies to accommodate this growth efficiently and effectively. In its simplest configuration, a multiple machine site is configured by setting up a pool of two or more GIS servers fronted by the ArcGIS Web Adaptor running on a web application server. In more complex configurations, third-party load balancers may be deployed in front of multiple GIS servers (Figure 1).

The ArcGIS Web Adaptor is a software application that runs in an existing website and acts as a proxy to registered GIS servers. Client workload traffic is directed by the ArcGIS Web Adaptor via a round-robin technique to currently participating GIS servers. Because it is easy to install and configure, the ArcGIS Web Adaptor is an option that is very appealing to many customers.

Third-party load balancers, with their advanced control features and tools, are commonly used by more advanced site and network administrators. Third-party tools typically offer a variety of special capabilities including asymmetric load management, priority queuing, added http security, SSL offload and acceleration, and TCP buffering. Much like the ArcGIS Web Adaptor, client workload traffic is directed to the third-party load balancer and then in turn forwarded to available GIS servers. The additional special features of the third-party load balancer are typically leveraged to address specific and more advanced organizational and technical needs and requirements.

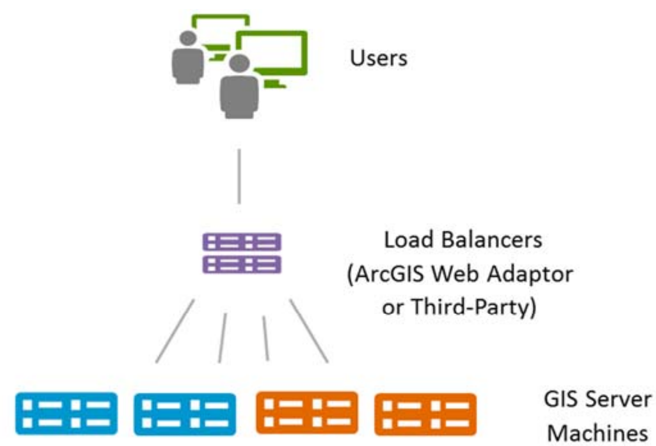

Figure 1: System design with multiple load balancers in a High Availability configuration.

The ArcGIS platform supports a variety of load balancing techniques for distributing client workloads across multiple computing resources. It is a recommended best practice to implement load balancers to balance system utilization, reduce risk, simplify service delivery, and improve security of backend GIS servers.

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Project Prioritization

April 2016

You can apply a simple method of project selection, prioritization, and sequencing to improve your overall return on investment with the ArcGIS platform. This method will help you mitigate implementation risks by balancing project difficulty/challenge with business benefit/value. You should focus on implementing high-value, easy-to-implement projects, and avoid projects that are difficult or risky and deliver little business value. Organizations new to the platform may wish to experiment and learn with low-risk, less challenging projects, while more experienced organizations may cautiously pursue projects that present significant challenges/difficulty and high benefit. Organizations that embrace project selection, prioritization, and sequencing methods are typically rewarded with the continuous delivery of high business value and high returns on their platform investment.

Introduction

One way that organizations capture value from their technology investments is by prioritizing projects using a benefit-versus-challenge matrix. The *benefit* aspect relates to the value derived from completing the project (such as increased productivity through better distribution of assets, reduced costs through more effective routing, or more informed decisions through improved situational awareness). The *challenge* aspect focuses on the level of effort or risk required to finish the project (including considerations like technology skillsets, time to delivery, and level of difficulty). By plotting potential projects on a matrix, such as the one offered in figure 1, you can evaluate potential projects and pursue those with the appropriate mix of value and risk.

Recommendations

In figure 1, the green oval is labeled *aggressively embrace* because it represents projects that provide clear benefits and are relatively easy to accomplish (for example, COTS configurable templates that deliver a focused set of valuable results). Seeking out these projects and developing a cadence of delivery will produce ongoing value to the organization.

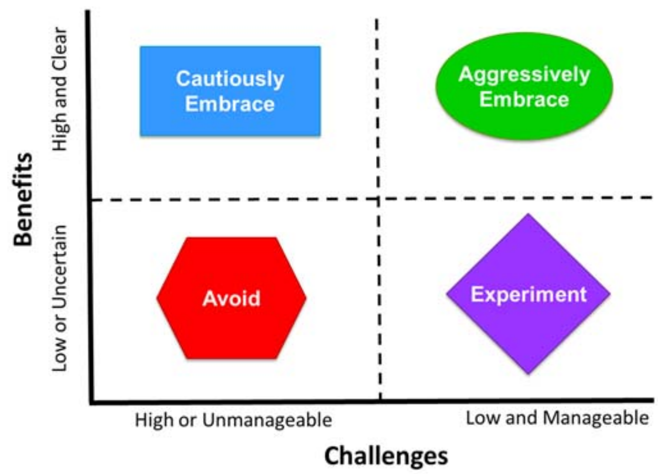

Figure 1: Project prioritization matrix evaluating benefits verse challenges.

Cautiously embrace projects, represented by the blue rectangle, are more challenging and valuable. These are typically long-term projects that require careful planning to deliver high value to the organization. They may require additional resources, planning, or mitigation actions to achieve the desired benefits. The additional effort to manage risks may also lengthen the project duration, delaying the instant gratification boost that less challenging projects can achieve with more regularity. These more challenging projects should produce clear benefits that are not otherwise achievable.

The purple diamond is labeled *experiment* because it represents projects that are good for developing skills, thanks to low and manageable challenges. You can use these projects to learn new technology or try new things in a safe environment (the isolated development environment). Experimentation will lead to greater understanding, which will help to reduce future risk.

The red hexagon represents the type of project that you should generally *avoid*, as these projects are difficult/challenging and offer little known business benefit. Trying to implement these types of projects will be costly and distracting from the overall platform value delivery.

A benefit-versus-challenge matrix may help you qualify projects based on their value and risk to the organization. To deliver rapid value to your organization, plot projects on this matrix and prioritize the ones that offer the greatest benefit with the lowest risk. As new skills are learned through experimentation, challenges will be reduced and benefits will be easier to achieve. Develop a delivery cadence of easy, high-value projects, and take time to plan more challenging projects. Avoid low-value, high-risk projects altogether. Organizations that employ this simple but effective project prioritization method derive high value from their technology investments and achieve greater success in their platform implementation.

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Publication Strategy

April 2016

Publication is the act of delivering content (data, services, and applications) to appropriate consumers. One or more techniques may be required to prepare content (e.g., publication geodatabases, map caches, and geoprocessing output) for delivery. Defining and executing a proper publication strategy is necessary for creating and delivering content to consumers in a timely, secure, and reliable manner.

Introduction

An effective publication strategy addresses performance, security, and reliability, ensuring that content is delivered in a manner that is suitable for consumers to use. Expectations for content delivery are managed with Service Level Agreements (SLAs), which are contracts between technology service providers and business stakeholders. It is necessary for architects and system designers to define and implement proper publication techniques to fulfill SLAs and business needs.

Recommendations

The specific techniques for preparing content for publication will depend on the type of information products being created and distributed, the number of users expected to access those products, and factors specific to the customer's business architecture. It is important to consider how information products will be consumed as well as expectations regarding performance and availability. Develop a strategy that includes techniques for geodatabase publication, map caching, and efficient geoprocessing – understanding that some level of data transformation may be necessary.

One of the most common and recommended publication techniques involves the creation and use of a publication geodatabase. A publication geodatabase is a unique instance and version of a transactional enterprise geodatabase that is primarily used to support the dissemination of geographic data, services, and applications. Publication geodatabases are a recommended best practice as they improve performance, contribute to high availability, and enhance security. Typically, publication geodatabases are created (e.g., using one way replication techniques, scripts, or Extract Transform and Load (ETL) tools) and then persisted in a file geodatabase or as a hosted feature service. (Figure 1).

Another recommended publication strategy involves map caching. A map cache is the most efficient way to deliver relatively static content—such as aerial imagery, roads, or basemaps—that does not change more quickly than the cache itself can be generated. Map caches are created by one or more GIS servers and consist of numerous, pre-rendered images (like png or jpg) at several scales. Pre-rendering images makes the delivery of complex maps more efficient than having a GIS server render a map on demand. Isolating a set of GIS servers is recommended to support the process intensive tasks associated with map cache creation and maintenance. Map cache creation and maintenance tasks are typically run in a development environment, tested in a staging environment, and finally deployed to a production environment for consumption and use.

Geoprocessing tasks are typically resource intensive and should be planned accordingly. While sometimes geoprocessing tasks need to be performed on demand, often these tasks can be preprocessed or executed in advance, resulting in output that can be readily incorporated into maps, services and applications. Preprocessing is a very effective geoprocessing publication technique and should be executed in a way that does not negatively disrupt other applications and services. Whether geoprocessing tasks are preprocessed or not, the recommendation is to isolate geoprocessing workloads from other potentially conflicting workloads such as visualization and data management.

Developing a publication strategy that embraces best practices (such as publication geodatabases, map caches, and preprocessed geoprocessing tasks) will ensure the timely, secure, and reliable delivery of content in a manner that supports the needs of the business.

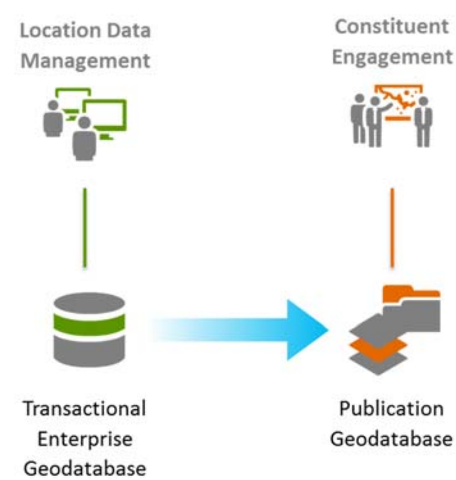

Figure 1: A Publication geodatabase created from a transactional enterprise geodatabase to support the dissemination of geographic information.

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Security

April 2016

The topic of securing the ArcGIS platform should be addressed early in the design process, especially since the techniques and approaches needed may vary depending on business needs and environment. Information stored and delivered securely will improve the appropriate availability of information and reduce the risk of compromise. ArcGIS supports common security frameworks and should be configured to work within the organization's established security model.

Introduction

ArcGIS can meet the security and privacy challenges of organizations through a secure, enterprise solution. Typically, the security configuration involves integrated functions within Esri products, third-party solutions, and implementation approaches. Some key technical security mechanisms to consider in an ArcGIS implementation are user authentication and authorization, filters, encryption, and logging/auditing. Regardless of the security mechanisms embraced, organizations should—early in their ArcGIS platform design process—consider and identify the appropriate security measures needed to meet their enterprise business requirements and security/privacy needs.

Authentication involves verifying credentials to confirm the identity of a person attempting to access the system. The authentication process confirms the user's identity and then directs them to the items and datasets they have access to via **authorization**. To help organizations secure resources through a single sign-on experience and reduce the number of user credentials that need to be managed, ArcGIS can leverage centralized authentication stores like Lightweight Directory Access Protocol (LDAP), Active Directory (AD), or Security Assertion Markup Language (SAML).

Filtering hardware and software aims to intercept invalid or attack requests before a web or application server can execute them. Firewalls can prevent unauthorized access to private resources; they can also be configured to inspect packets and accept or reject them based on defined rules around the acceptable level of risk. Reverse proxies obscure details of the internal network and should be configured to perform content filtering, URL rewriting, and load balancing. The ArcGIS Web Adaptor is an application that forwards client requests to GIS server machines in a site, obscuring machine and port information and filtering access to ArcGIS Server Manager and Administrator directories.

Encryption of data in transit is an industry-recognized best practice to enforce the security and privacy of data. To prevent the interception of secure data communications, ArcGIS should be configured to use Transport Layer Security (TLS) protocol. Furthermore, strong encryption methods like Advanced Encryption Standard (AES) and Secure Hash Algorithms (SHA) should be employed to encode the data and detect whether it has been tampered with or modified.

Auditing system and application logs regularly is recommended to provide a baseline understanding of the ArcGIS platform's use in regular operations. Anomalies in the baseline can then be used to identify security incidents or to provide information on system problems or unusual conditions. Application logs can also provide event-level details around specific security incidents and policy violations within the enterprise.

It is important to acknowledge security throughout the design and implementation phases of an ArcGIS platform deployment. It is best to leverage existing security techniques and mechanisms, and then extend them as dictated by the organization's business requirements and appetite for risk.

Recommendations

Authentication and authorization should use an organization's existing centralized identity management system to simplify user access and secure the environment by reducing each user's number of login credentials. Filtering hardware and software, such as the ArcGIS Web Adaptor, should be used to inspect requests and obfuscate internal network components. Data encryption in transit and at rest should use the most secure methods possible in relation to the acceptable level of risk, while application and system logs can provide an understanding of baseline operations and be used to identify anomalies. Auditing logs regularly can help identify any potential risks or threats. Most importantly, security must be considered early in the process to confirm that risk assumptions and architecture decisions align. For more information, please visit Trust.ArcGIS.com – the most up to date resource for security, privacy, and compliance information regarding the ArcGIS Platform.

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Workforce Development

April 2016

Workforce development is meant to equip an organization's most valuable asset—its people—with the knowledge and experience needed to effectively use and expand the reach of the ArcGIS platform. Devoting resources towards workforce development will help an organization achieve greater value and a faster return on investment from ArcGIS.

Introduction

Organizations use ArcGIS to execute day-to-day operations, engage with customers and constituents, and create products and services that improve outcomes. Often, organizations are unable to fully leverage ArcGIS because their staff is not current on the latest technology advancements. This can make it difficult for organizations to meet business demands, and it may cause them to use inefficient legacy workflows or rely on consulting services to accomplish goals. These organizations can utilize Esri's training resources to better equip their workforces and achieve their strategic goals. Workforce development is critical to a successful platform implementation because it improves awareness of contemporary workflows and methodologies, encourages the use of appropriate methods and approaches for solving problems, and reduces reliance on external resources.

Recommendations

Workforce development should be a part of every ArcGIS platform implementation. Customers can work with Esri to build a plan to develop their workforce. Esri offers a wide variety of learning methods including online courses, instructor-led training, conferences and user groups, professional services, and business partner knowledge transfer. With expertise developed through workforce training and practice, organizations are better suited to utilize ArcGIS platform capabilities.

As technology evolves over time, new workflows and processes are developed within those technologies to improve efficiency and productivity. Esri training helps an organization's employees understand these more efficient modern workflows, which in turn offsets the cost of training.

Workforce development also teaches organizations to use appropriate methods and approaches that minimize wasted time and unlock the ArcGIS platform's full value. While there are multiple ways to achieve desired outcomes, knowing when and where to use the right tools and workflows allows organizations to reach their goals more quickly and more efficiently.

Organizations often need to use third-party consultants to assist in developing new capabilities. Consultants will be more efficient and more effective if the resources managing those consultants have the proper expertise. Because trained employees are more capable of leading the new team, the organization retains better control over consultants' activities. In addition, these employees are better positioned to experience knowledge transfer from the supplemented team, which makes them more likely to be able to take ownership of the consultants' work.

Esri recommends that organizations invest in workforce development to meet their business needs. Even though training often receives a smaller portion of funding in an overall location strategy, organizations that invest in workforce development achieve greater value and return on investment from the ArcGIS platform. With a trained workforce, organizations will be able to use ArcGIS efficiently and effectively, set and achieve their goals, and build a culture of self-reliance and expertise.

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Workload Separation

April 2016

Workload separation is a design approach that enhances performance and reliability by aligning the technical implementation with organizational business requirements. With this approach, the organization considers its different business workflows to understand how each workflow impacts compute resources, and then uses segregated and preplanned resource allocation to ensure the needs of each workflow are met.

Introduction

By allocating workloads to appropriate server resources organized by business function, organizations can reduce risk, improve service delivery, and improve security. By implementing geospatial function isolation, organizations can reduce the risk that high-intensity processes will consume cycles needed to support critical applications, or that an abnormal spike in requests will disrupt service for all users.

Service delivery is improved when service requests are directed to appropriate compute resources in a way that optimizes hardware and reduces resource contention. Service requests that are known to be central processor unit (CPU) intensive, such as complex analysis tasks, can be directed to a GIS server site containing machines with faster processors and directed away from sites/machines that support critical applications. This approach will ensure that GIS server machines are used in the most effective manner and will protect critical tasks from resource contention.

Security is enhanced when workloads and associated GIS server machines are isolated within a site. Separating workloads and GIS server machines by a site ensures that if one machine gets compromised or malfunctions, it cannot affect other machines in the environment. User requests are routed to the appropriate sites through load balancers, and results are securely and transparently delivered to users.

An example of workload separation involves the isolation of analytic tasks from decision support tasks. Back-office analytics are typically CPU intensive, executed sporadically, and maintained by lower Service Level Agreements (SLA). Because analysts use geoprocessing tasks in an ad hoc fashion, the CPU may sit idle for long periods, but then spike when several tasks are executed. On the other hand, decision support activities often simply consume map-based information products to drive operational business decisions. They are typically less CPU intensive, executed more consistently, and maintained by higher SLAs. Because the characteristics of these tasks and workflows are so different, it would be appropriate to use workload separation to accommodate each set of activities.

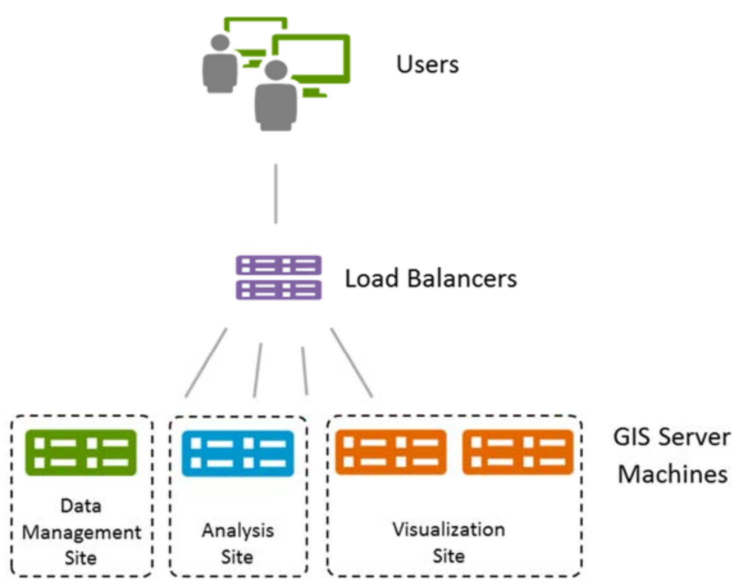

Figure 1: GIS Server machines organized within sites which are separated by business function.

Recommendations

Organizations should implement workload separation to reduce risk, improve service delivery, and enhance security. Hardware allocation around core GIS capabilities, including data management, analysis, and visualization functions, is recommended (Figure 1). Some organizations may have more detailed separation needs around specific business functions (e.g. imagery, real-time, caching, etc.), hardware characteristics, or SLA definitions. Finally, use GIS patterns, SLAs, and performance expectations to determine how to best direct workloads to appropriate compute resources.

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Esri inspires and enables people to positively impact their future through a deeper, geographic understanding of the changing world around them.

Governments, industry leaders, academics, and nongovernmental organizations trust us to connect them with the analytic knowledge they need to make the critical decisions that shape the planet. For more than 40 years, Esri has cultivated collaborative relationships with partners who share our commitment to solving earth's most pressing challenges with geographic expertise and rational resolve. Today, we believe that geography is at the heart of a more resilient and sustainable future. Creating responsible products and solutions drives our passion for improving quality of life everywhere.

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