



ESRI
EXTERNAL

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Architecting the ArcGIS System: Best Practices

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What's New (February 2023)

This update includes minor corrections and clarifications, with some substantive updates to the “Enterprise Integration” article and a new article on “IT Infrastructure Monitoring.”

Modifications

The “Enterprise Integration” article was updated to clarify the recommended techniques when considering system integration with ArcGIS, and to clarify recommendations for achieving greater return on investment made on the integrations themselves.

A new article, “IT Infrastructure Monitoring,” provides an overview of the practice of identifying and diagnosing system and software issues. It also offers considerations for proactively responding to current or emerging infrastructure issues to prevent or minimize business interruption.

We also reviewed and made minor updates to the remaining best practices to align with the latest Esri messaging. The content of most of the best practices, including their recommendations, remains unchanged.

Introduction

You can maximize the value of ArcGIS in the context of your organization’s goals, by applying the guidelines presented in these best practices and implementation approaches.

Architecting ArcGIS

ArcGIS is a system that connects maps, apps, data, and people in ways that help organizations make more informed and faster decisions. 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. Together, these capabilities and flexible approaches make it easier for you to extend the reach of GIS across the enterprise.

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

Conceptual Reference Architecture

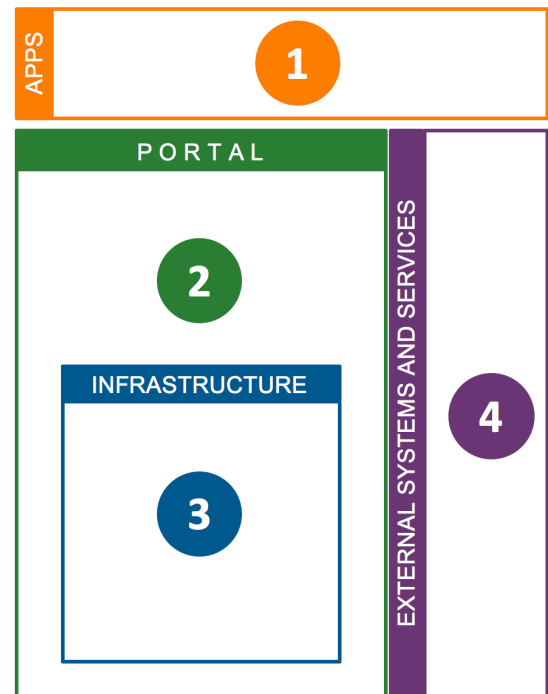
The [ArcGIS Conceptual Reference Architecture](#) diagram (found on page 6) illustrates the capabilities of ArcGIS combined with best practices.

The diagram depicts three distinct compute environments—*production*, *staging*, and *development*—which together represent a best practice known as *environment isolation*. Each environment has four components, with each section displayed in a different color to highlight the function. The figure to the right identifies those components by color and number.

The **Apps** section illustrates the components of ArcGIS that most users interact with, including clients such as ArcGIS Pro, mobile native apps, and web applications. Apps connect people and their business workflows to ArcGIS. Apps are typically used in workflows that follow one or more of the *patterns of use* (mapping & visualization, data management, field mobility, monitoring, analytics, design & planning, decision support, constituent engagement, and sharing & collaboration). For example, the *sharing & collaboration* pattern extends geospatial capabilities to everyone in the organization by providing a destination (website and simple apps) where knowledge workers, executives, and field workers can access information and capabilities. A person capturing data in the field is following the *field mobility* pattern. A decision-maker observing the real-time information created by field workers is following the *decision support* pattern.

The **Portal** component of ArcGIS organizes users and connects them with the appropriate content and capabilities based on their role and privileges. 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 ArcGIS Enterprise (software) or ArcGIS Online (Software as a Service, or SaaS). The portal provides access controls, content management capabilities, and a sharing model that enables users to share information within and/or between organizations.

The **Infrastructure** component includes the hardware, software, services, and data repositories that are the core of the ArcGIS system. Many best practices—including *load balancing*, *high availability*, *workload separation*, and



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

publication strategies—offer key considerations that may affect your infrastructure decisions. Follow the links from each best practice label on the Conceptual Reference Architecture diagram to learn more about how these strategies affect infrastructure decisions. Additional information is also available in the [Infrastructure](#) best practice brief.

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

Best Practices

There are 21 best practice briefs associated with the ArcGIS Conceptual Reference Architecture diagram.

Twelve of these briefs—*Automation, Collaboration, Enterprise Integration, Environment Isolation, High Availability, Infrastructure, IT Infrastructure Monitoring, Load Balancing, Publication Strategy, Real-time GIS Strategy, Security, 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 *Application Implementation Strategy, Capability Delivery, Communicating Success, Geospatial Strategy, Managing Identities, Patterns of Use, Prioritization Approach, and Workforce Development* focus on people and how they should interact with ArcGIS.

Finally, the *Governance* brief offers a complementary process guideline that suggests ways to minimize risk, improve quality, and increase productivity around ArcGIS solutions.

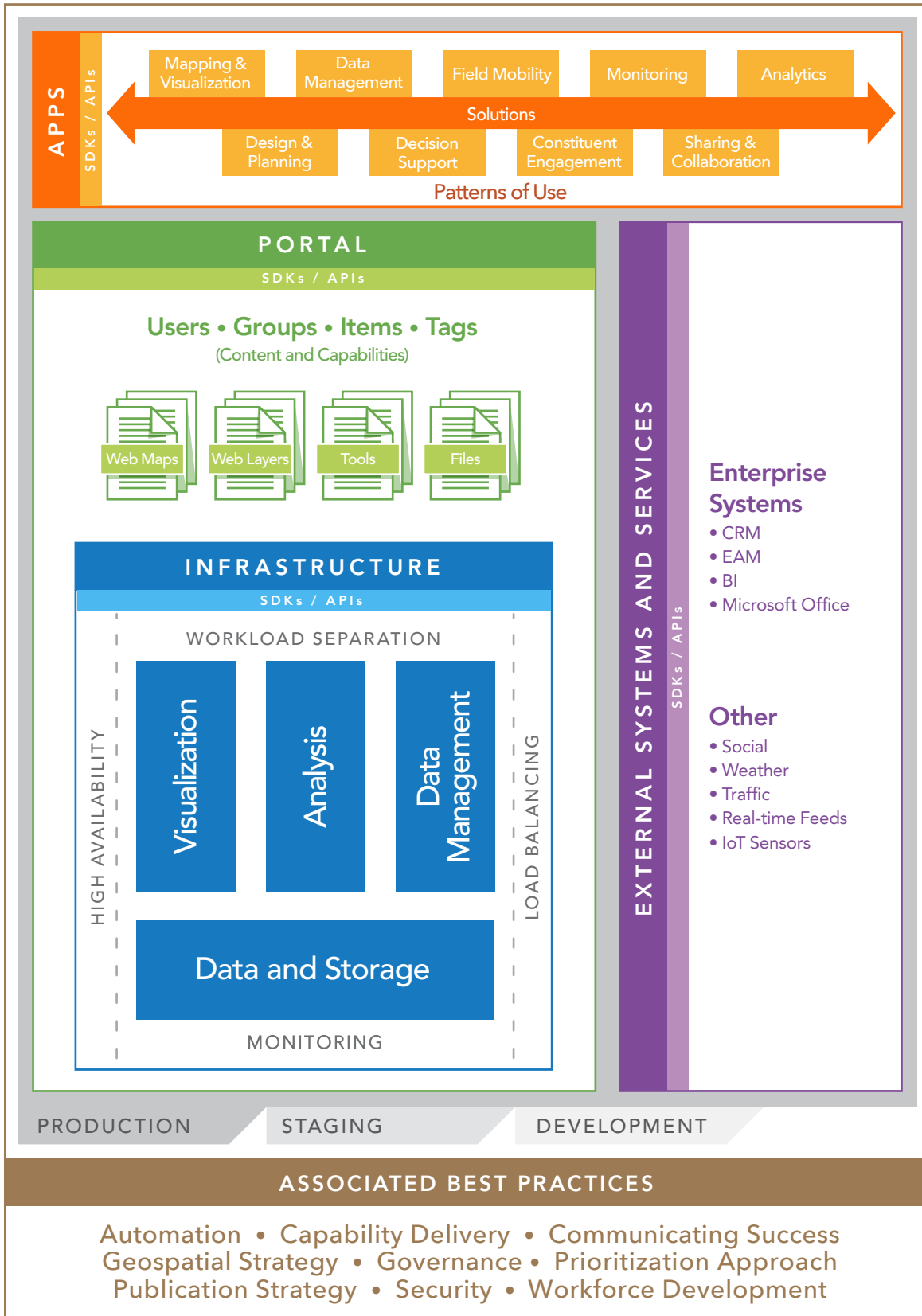
How to Use This Document

The ArcGIS 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 ArcGIS, or to visualize how ArcGIS will support organizational business needs.

Comments and Suggestions

Any comments or suggestions regarding this document can be emailed to SA@esri.com.

ArcGIS Conceptual Reference Architecture



Application Implementation Strategy

An application implementation strategy is an approach to delivering capabilities that meet your business needs with technology. An ideal strategy will minimize cost and optimize the use of development resources. By applying a “configure first” philosophy that prioritizes commercial off-the-shelf (COTS) apps and least-effort design patterns, you can reduce the cost and effort needed to deploy and maintain applications for your users.

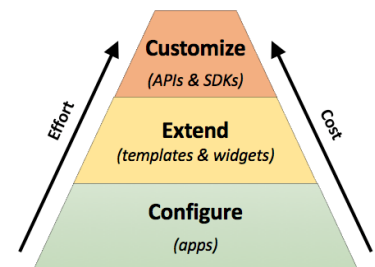
A Flexible System for Implementing Location-Enabled Apps

ArcGIS lets you apply the power of geography to improve workflows throughout your organization. Apps provide the user experience that makes ArcGIS capabilities available at the right time on the right device, so users can work more efficiently. Implementing apps, however, can require different approaches, depending on whether the capabilities you need are available out of the box. ArcGIS helps you deliver these capabilities by supporting multiple approaches to application implementation (as shown in the figure below), while also helping you minimize cost and effort.

There are many factors to consider when deciding the best way to deliver new capabilities through apps. These factors include resourcing, initial development effort, ongoing app maintenance, user training, and technical support. In addition, users now expect frequent updates to their apps, which increases demand for resources to develop and maintain custom apps. As a result, it’s best to select the approach that delivers the capabilities you need with the least cost and effort.

Depending on your specific requirements, you can:

1. **Configure COTS apps** to meet your business needs. ArcGIS provides many configurable COTS apps that support key workflows out of the box. Using COTS apps requires the least effort and the lowest ongoing cost.
2. **Extend existing apps**, either by modifying templates or by creating widgets for COTS apps. Esri offers app templates at arcgis.com and github.com/esri that provide focused solutions for specific problems; you can modify the source code for these templates to add discrete capabilities. In addition, several ArcGIS COTS apps use modular frameworks that let you create custom widgets and plug them into the apps. Extending existing apps lets you develop only the additional functionality you need, saving money and effort.
3. **Customize apps** using ArcGIS APIs and SDKs. These APIs and SDKs provide objects like the Identity Manager to manage credentials within custom apps that expose ArcGIS capabilities (such as secure web maps). Because you don’t have to code those parts yourself, you can build business-focused apps to take advantage of ArcGIS COTS capabilities, reducing the overhead for app development and maintenance.



Configure first for the lowest cost and least effort, then extend and customize as needed.

A configure-first philosophy helps you avoid unnecessary cost and effort associated with custom app development, maintenance, and training. Organizations that adopt a configure-first philosophy start by configuring COTS apps, then extend and customize apps only when needed. Using this least-effort approach in your application implementation strategy lets you deliver capabilities faster and reserve your development resources for more complex tasks.

Recommendations

To establish an effective application implementation strategy for your organization:

1. Adopt a configure-first philosophy, configuring COTS apps when possible to deliver the capabilities you need.
2. If you have a requirement that cannot be met with configuration alone, extend existing apps with discrete capabilities and widgets.
3. When you need capabilities that you can’t provide by configuring and extending existing apps, customize apps using ArcGIS APIs and SDKs.

Automation

Automation is the orchestration of tasks, processes, and compute resources to function automatically and efficiently. Automation allows you to streamline administrative workflows and repetitive tasks to improve efficiency, consistency, and productivity, reducing risk and increasing the value of your GIS.

Increasing the Value of ArcGIS Through Automation

Repetitive tasks are common when using GIS to support data management, analysis, map production, and infrastructure deployment and operations. Repetitive manual tasks take a lot of time, effort, and focus; decrease overall productivity; and increase risk. These impacts are compounded as the number of tasks grows.

You can mitigate these impacts through automation. Automation allows technology to create and maintain infrastructure and programmatically execute the steps of a well-defined workflow while limiting human interaction. Common tools for automation include APIs and scripts.

Automation maximizes your investment in ArcGIS by improving:

Efficiency. Information is most useful to the decision-making process when it is delivered in a timely manner. Because automating tasks and resource allocation improves efficiency, work can be completed faster and new information can be delivered to stakeholders sooner. This boost in efficiency allows ArcGIS to return greater value to the business.

Consistency. When tasks are executed manually, errors are more common and outcomes can be inconsistent, unreliable, and costly. Once developed and properly tested, automated processes are highly dependable and can be replicated with identical and predictable results. Automated processes save time, minimize duplicated efforts, and increase confidence in business operations.

Productivity. Automation can improve all areas of a GIS including deployment, administration, and end-user workflows. By using automation to execute more GIS tasks and complete them faster, you can increase overall productivity. This lets you apply ArcGIS to additional business initiatives (such as strategic projects, research and development efforts, and other high-value projects) that might otherwise go unfulfilled.

With automation, you can improve administrative workflows and process data more efficiently, consistently, and routinely. This improves operational efficiency and the effectiveness and timeliness of decision-making, freeing resources for other tasks and boosting the value of ArcGIS in your organization.

Recommendations

To maximize the benefits of automation and reduce risk in your organization:

1. Automate tasks where human error can impact reliability and consistency in outcomes.
2. Automate lengthy tasks so processes can be completed in less time.
3. Schedule automated tasks so they run continuously within set time windows, without human interaction.

Automation Tames the Internet of Things (IoT)

As the volume and velocity of IoT data increases, automation becomes both more necessary and more valuable to the business.

Working manually, staff often struggle with processing the high volumes of data produced by IoT devices and scaling infrastructure accordingly. This delays the transformation of data into insight, which in turn reduces the organization's efficiency and makes its decisions less responsive and less effective.

With automation, you can process IoT data efficiently, consistently, and routinely. For example, you can automatically allocate compute resources to your infrastructure to scale up and down as data volume and processing needs fluctuate. This keeps IoT data flowing to key workflows and business systems, improving efficiency and supporting better, faster decisions.

Capability Delivery

Delivering capabilities that support key requirements, goals, and initiatives helps you improve business outcomes. By working with stakeholders to define the capabilities you deliver, you can better align your solutions with real business needs. In addition, establishing a regular cadence for capability delivery lets you continuously improve your maps, apps, services, and information products, so they can provide additional value and meet evolving requirements.

A Business-First Approach to Delivering New Capabilities

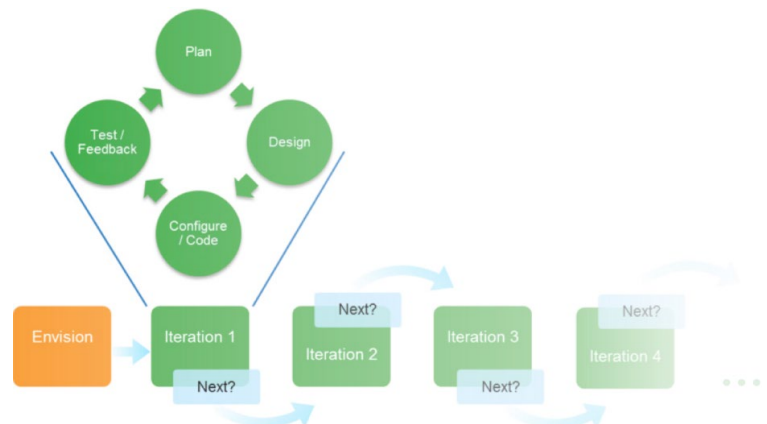
Delivering capabilities that support your business requires smart resource investments. Organizations that spend years on expensive, complex development projects often end up with solutions that are difficult to use or that don't align with current requirements. To maximize the value of your investments and better support the evolving demands of your business, you can work with stakeholders to identify areas where you can provide the most value in the least time. This business-first approach helps you establish a cadence for rapidly delivering high-impact capabilities and information products that meet business needs.

For effective capability delivery, you should:

Collaborate with business stakeholders to envision their capability needs. Engaging stakeholders early in the planning process helps you identify the business value a capability will provide, balance value against risk, and set development priorities. You can then apply a configure-first approach, deploying low-effort capabilities first. This delivers value quickly and builds toward long-term success. Once you have a final product, you can invite stakeholders to test it and offer feedback.

Iterate rapidly on existing solutions so you can deliver new value quickly and often. By focusing on incremental enhancements that provide clear value, you can avoid spending development time on functionality that adds unnecessary complexity. A rapid release cycle should be 30 days or less, with each iteration producing a usable deliverable. To meet this short release schedule, you can keep requirements simple and focused, and leverage COTS and configurable solutions when possible. With each new release, you can solicit stakeholder feedback to drive the next iteration.

Adhere to a capability delivery lifecycle with a regular cadence, like the lifecycle shown in the figure above. This helps you continue iterating on your solutions as long as the business gains new value from each iteration. Once you satisfy your stakeholders' needs, you can suspend further iterations, then resume them if future business needs require additional enhancements. When a solution no longer provides value, its lifecycle is complete. Deprecating these legacy solutions lets you avoid consuming resources unnecessarily.



Capability delivery follows a cadence and terminates when the solution no longer provides value to the business.

Recommendations

To deliver capabilities that maximize business value and make effective use of development resources:

1. Collaborate with business stakeholders to define, prioritize, and test new capabilities.
2. Keep iteration cycles short and focus on supplying incremental business value with each new release.
3. Establish a regular cadence for new iterations until you satisfy all identified business needs, and deprecate solutions that no longer provide value.

Collaboration: Enable People to Work Together

Collaborations enable people from multiple ArcGIS organizations to work together and share content through trusted and secure workflows. By implementing one or more collaborations, you can more effectively leverage authoritative data, foster engagement and communication, and glean insights from data. Collaborations let you preserve departmental control over data and workflows while supporting the needs of the entire organization.

A Modern Approach to Sharing Information

ArcGIS supports two types of collaboration for an improved type of sharing. A distributed collaboration is a configuration between ArcGIS Enterprise and/or ArcGIS Online, while a partnered collaboration works between ArcGIS Online organizations. With this integrated approach, each department controls access to their shared items, while enabling authorized people to contribute edits or access authoritative information, promoting more interactive and integrated data maintenance workflows and information sharing. The result is a truly collaborative environment—an integrated set of deployments working toward shared goals.

For example, an organization might have multiple business units, each with its own GIS deployment supporting different business functions. In a city, the police department, fire department, public works department, and municipal water utility might each deploy their own GIS to support their individual workflows. By configuring collaborations, you can connect those organizations so people across departments or outside the organization can work together to create, maintain, and use authoritative data. The figure to the right illustrates these relationships using both a distributed collaboration and a partnered collaboration. Together, these collaborations enable people to work better together.



Preserve control and access within individual departments while supporting the broader needs of the enterprise and cross-departmental workflows.

Collaborations expand a modern GIS by making its capabilities and data easier to access across the enterprise without sacrificing security. You can now configure an organizational network where content can be shared in a simple and controlled manner. This enables business units to share, update, or sync select information with the broader enterprise while maintaining control of sensitive data.

Each organization within a collaboration maintains its own maps, apps, services, and data. Each participating organization chooses which content to share with members of the collaboration; updates can be shared either in real time or at scheduled intervals. Importantly, a collaboration uses each organization's existing security model.

With collaboration enabled, you can achieve larger organizational goals through distributed and partnered collaborations, well-defined sharing processes, and automation, all within ArcGIS.

Recommendations

To fully leverage collaboration within your own organization:

1. Model your ArcGIS system after your organization's structure.
2. If you have departments or business units that need to control sensitive data, allow each to work in its own GIS deployment as part of a trusted collaboration.
3. Establish collaborations between organizations based on business need and workflows, enabling the right people to update and/or have access to the authoritative content they need.

Communicating Success

Communicating successful outcomes motivates and incentivizes people in your organization to support GIS. By reinforcing the business value of GIS, you can build stakeholder support and encourage people to build new GIS capabilities that solve business problems and help the organization achieve its goals.

Communication: One Action, Three Outcomes

Communication is key to building and sustaining GIS investments. Organizations recognize the need for effective communication when they are defining their geospatial strategy, but often they don't realize that communication is equally important when they are executing that strategy.

After you deliver a geospatial solution that solves a business problem, you should communicate your success with stakeholders throughout the organization. Doing so produces three positive outcomes:

Awareness: Good communication informs stakeholders that real business value was created from their investment in GIS. Without communication, stakeholders may not know that GIS is providing value to their business processes. They may not understand how GIS is contributing through spatial analysis, mobile workflows, decision support, or information sharing. They may see expenditures without realizing the benefits. By publicizing your success to stakeholders, you can help them better understand the power of geospatial technology and make them aware of the value it's providing. This is crucial for GIS to be seen as a good investment that helps the organization meet its goals.

Incentive: Good communication encourages other people in the organization to think about how GIS can help them. When people can see what is possible with GIS, they are more likely to want to participate in new GIS projects. This builds demand and expands the pool of resources that can use GIS. As a result, you can leverage your GIS technology investments more fully to deliver the most value possible to the organization.

Acknowledgment: Good communication celebrates and motivates the people that deliver geospatial solutions for the organization. Timely and authentic employee recognition builds trust and helps you foster a positive culture. In turn, this helps you encourage the people responsible for building solutions, so you can continue to deepen the value of geospatial technology to the organization.

Together, these outcomes will help you sustain your GIS program, advocate for additional resources, and increase your impact.

Recommendations

After you deliver a new solution, you should:

1. Communicate your success to promote greater awareness of GIS, incentivize potential users, and acknowledge the hard work of your teams.
2. Communicate the business impact of your success by highlighting new workflows that save time, reduce costs, or improve effectiveness; by showing how business units are using GIS to work together or improve their operations in tangible ways; and by illustrating more informed decision-making thanks to geospatial technology.

Enterprise Integration

Enterprise integration is an approach to interconnecting disparate business systems, exchanging data, and providing people with timely and accurate information that enables more effective operations.

Integration as a Force Multiplier

Integration multiplies the value of business systems by combining information and capabilities to provide users with insights that are otherwise difficult to derive. An enterprise geographic information system (GIS) compounds those benefits by integrating location data with all types of descriptive information and content from other systems. Whether the result is visualization, analytics, or data management/exchange capabilities, maps and location help provide context that can transform massive quantities of data into consumable information.

Integrating Enterprise Capabilities

The recommended, contemporary approach to integrating content and capabilities between enterprise systems is through well-defined application programming interfaces (APIs) and/or web services. ArcGIS is designed to be open, interoperable, and secure, and it offers APIs and web services that deliver mapping and visualization, analytic, and data management/exchange capabilities. Integrators can bring external business system capabilities into ArcGIS or bring ArcGIS capabilities into another business system.

Mapping and visualization capabilities highlight locations in the context of their surroundings, where one or more layers (i.e., groups of similar features, such as schools, fire hydrants, or pipelines) can be combined in the context of a base map and/or aerial imagery. Locations can be static, like a building, or dynamic, like a GPS-equipped vehicle streaming its location. Simply visualizing locations on a map often helps people gain the understanding they need to make a good decision.

Analytic capabilities provide organizations the ability to understand how places are related, to find best locations and paths, to detect and quantify patterns, and to make predictions based on location. For example, how many assets are likely to be impacted by an approaching hurricane? Analytic capabilities help people discover, quantify, and understand geographic phenomena and determine what actions to take.

Data is an enterprise asset used to make better-informed decisions across a variety of workflows and business processes. Data management/exchange capabilities enable organizations to maintain data accuracy (spatial and attribute) and exchange data bi-directionally between systems. For example, a field engineer can quickly and accurately update the location and characteristics of an asset using the GIS, so a user of the customer information system (CIS) can inform potential customers of service availability. Organizations benefit when data across systems is current, accurate, and available to everyone that needs it.

Enterprises rely on content and capabilities from multiple business systems. Combining those systems often produces information that would otherwise be unavailable. Enterprise integration with GIS connects and exposes content, improving understanding and enabling people to gain insights through the lens of location and geography.

Recommendations

1. Identify ways your organization will benefit from integrating key systems with your enterprise GIS.
2. Understand the integration methods, tools, and capabilities ArcGIS and your other enterprise systems provide so you can choose the best approach for your integration.
3. Add context and transform business data into information that enables people to make more informed decisions.

Environment Isolation

Isolating computing environments is an approach to maintaining system reliability and availability. This approach involves creating separate systems for production, testing, and development activities. Environment isolation reduces risk and protects operational systems from unintentional changes that negatively impact the business.

Deploying Isolated Environments to Safeguard Operational Systems

Unintentional system changes can cause operational systems to fail to deliver the capabilities and performance that users expect. Environment isolation insulates different computing environments from the risk of unmanaged change, helping you better maintain their functionality, stability, and performance.

Users within your organization have expectations for system reliability. In some cases, your users' expectations may be documented in a Service Level Agreement (SLA), a contract between business stakeholders and technology service providers that defines the level of reliability expected by stakeholders. You should consider your users' expectations when you decide on the level of environment isolation and governance required to manage system changes.

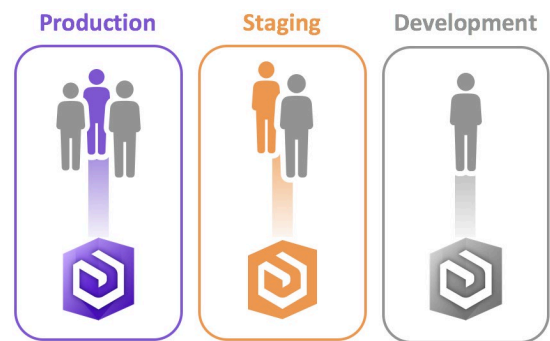
To effectively manage enterprise systems and meet expectations for system reliability, organizations typically implement at least three isolated computing environments (as shown in the figure below):

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

A **staging environment** is a mirror of the production environment that lets you vet system changes before deploying those changes to production. You can perform user acceptance testing, performance testing, load testing, and training in a staging environment to avoid risk to your production system. If needed, you can even implement multiple staging environments for different testing and training activities.

A **development environment** is a workspace where developers and analysts can 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. 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 these isolated computing environments helps you deliver a stable, extensible, and high-performing system. By leveraging these environments to support effective change management, you can shield your system from unexpected failure and avoid disruptions to business operations.



Recommended (minimum) compute environments.

Recommendations

To best maintain system reliability and availability for your users:

1. At a minimum, implement isolated production, staging, and development environments.
2. Test system changes in a staging environment before making changes to the production environment.
3. Use a development environment to develop new capabilities without impacting users in other environments.

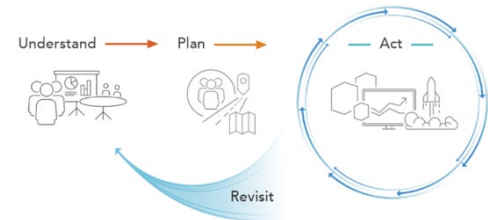
Geospatial Strategy

A geospatial strategy is a business-oriented plan that defines how an organization will align GIS to support its business. Organizations that develop and execute a geospatial strategy are able to connect and align technology to their business, deliver quick value based on priorities, and define and implement sustainable solutions that solve business challenges.

A Business-First Approach for Maximizing the Impact of GIS

Many successful organizations maximize the impact of GIS in their business by developing and executing a geospatial strategy. A geospatial strategy gives organizations a way to align their geospatial capabilities and technologies to their underlying business needs. By executing on this business-first strategy, organizations can use GIS to reach their goals and improve outcomes throughout the business.

Employing a geospatial strategy requires a passionate team of leaders that want to solve business challenges within their organization and improve the way their organization works. Successful teams include a champion that believes in the value of geospatial solutions, an executive sponsor that provides resources and funding, and a technical sponsor that provides resources to implement and maintain sustainable solutions. With this team, you can develop and execute a geospatial strategy, following a four-phase approach (illustrated in the figure above).



A four-phase approach to a geospatial strategy.

In the **Understand** phase, the team engages with stakeholders across the organization including departmental and functional area executives, key business unit directors, and GIS users and managers. Through these meetings, the team learns what is driving these stakeholders and develops a shared understanding of the organization, its goals, and its challenges. The outcome of the Understand phase is clear and shared knowledge of the organization including its mission, goals, business challenges, and more.

In the **Plan** phase, the team defines the targeted future state that will allow the organization to overcome its challenges and meet its goals, and then identifies the gaps between existing capabilities and what is needed. By comparing the current and future states, the team can define the technology, data, workflows, and skills necessary to establish sustainable solutions that address business needs. This phase concludes with a road map, which is a prioritized and sequenced set of activities.

In the **Act** phase, the team executes a series of implementation cycles consisting of activities defined in the road map. Each implementation cycle should result in one or more tangible outcomes.

In the **Revisit** phase, the team adapts and updates the plan as leadership goals change, business priorities shift, and technology evolves. The plan should be revisited regularly—especially after each implementation cycle—to ensure it is maximizing the impact of GIS on the organization.

This approach supports an incremental implementation guided by a geospatial strategy. It allows the team to develop and execute a plan that aligns geospatial technology to the needs of the business and delivers continuous value.

Recommendations

To define and execute your own geospatial strategy:

1. Review Esri's approach to developing a geospatial strategy, and then form a team that includes a motivated champion, an executive sponsor, and a technical sponsor.
2. Develop and execute your geospatial strategy by engaging stakeholders across your organization, identifying business challenges, developing a plan that addresses the needs of the business, implementing solutions through an incremental process, and revisiting your plan over time.
3. Leverage best practices to maximize the impact of your geospatial strategy and GIS within your organization.

Governance: The Policy and Practice of Enablement

Governance is a formal approach to decision-making consisting of policies and procedures that enable positive change within an organization. Information and technology (IT) governance guides the implementation and management of IT systems to maximize their value, reduce risk in technology investments, and help the organization accomplish its goals. By applying IT governance to ArcGIS, you can deliver clear benefits and achieve long-term success with ArcGIS solutions.

Key Characteristics of Effective IT Governance

Because change within every organization is inevitable, it's important that IT systems have a way to change along with business needs. Effective IT governance enables IT systems to change by reducing the friction between technologists and business users. It maximizes the business benefits of technology investments by increasing stakeholder engagement and optimizing risk and resources.

By applying the key characteristics of IT governance (below), you can better align your GIS technology investments to high-priority business and stakeholder needs. Leveraging these characteristics can help you lead and manage change so you can design, implement, and use GIS to maximize the impact on desired business outcomes.

Business Benefits: Technology investments are maximized when outcomes are well aligned to the business needs of the organization—when the technology is used to deliver something of value, such as increased revenue, reduced costs, or improved safety. This means the intended outcomes and the value to the organization should be clearly understood before undertaking activities that require your organization's resources or funds. The evaluation of business benefits is best accomplished by engaging with stakeholders who understand and can communicate the value of new capabilities.

Risk Optimization: Recognizing that while big, transformational change is sometimes required, organizations that want to optimize risk focus on implementing small changes that deliver continuous value over time. They reduce risk by choosing capabilities that are sustainable and then iteratively improve them to stay current with updates in performance, security, reliability, and efficiency. They favor solutions that minimize technical debt, choosing configurable solutions over customization, preferring best of breed technology, and avoiding purchases where weaker solutions deliver overlapping capabilities. They leverage their existing capabilities to maximize their value.

Resource Optimization: When an organization understands its business priorities, it can more effectively optimize its resources and assets to support its needs. Within this context, governance guides which solutions get developed and who does the development, based on skills and availability. An important aspect of governance is getting the right people to create the right capabilities.

Stakeholder Engagement: A key component of IT governance is the involvement of stakeholders. By engaging stakeholders more broadly, organizations are more likely to maintain focus on business priorities, reduce risk, and optimize resources. Stakeholders should include representatives from the executive team, line of business managers, enterprise IT, GIS, and other subject matter experts as needed.

Effective IT governance drives greater outcomes for the business through the adoption of technology that is tailored to its business and stakeholder needs. This helps the organization maximize the value of its technology investments.

Recommendations

When planning and making decisions about your organization's use of ArcGIS, you should:

1. Leverage the characteristics of IT governance to enable change that leads to positive outcomes.
2. Use IT governance to guide technology choices so you maximize the value of GIS in your organization.
3. Align technology to overcome business challenges and amplify the value of your GIS.

High Availability

High availability is a design approach that helps a system meet a prearranged level of operational performance over a specific period.¹ Highly available systems provide customers with a reliable, high-performing environment that meets or exceeds their business requirements for service delivery.

Strategies for Maximizing System Performance and Reliability

Organizations implement ArcGIS in a highly available configuration to prevent data loss and work interruptions. But there is no one-size-fits-all, optimal high-availability design. Rather, high-availability designs fall on a spectrum based on your organization's tolerance for cost and unplanned interruption. First, determine your organization's specific business needs for availability. This can be a formal contract (like a Service Level Agreement) or an informal service level expectation. Next, weigh the costs associated with increasing availability, and focus on capturing the actual business needs of the system.

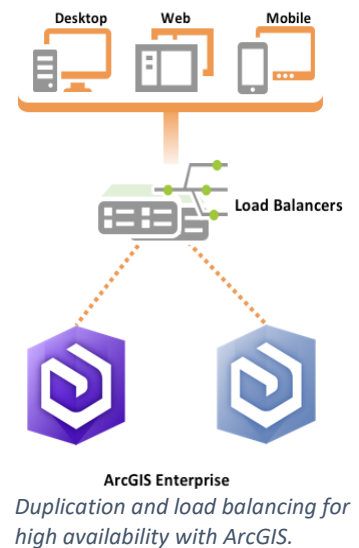
Consider the following at the data, software, hardware, people, and process tier:

Backups: Creating backups of your ArcGIS deployment is the easiest way to avoid data loss and reduce downtime. This allows you to recover items that existed at the time the backup was created, and significantly reduces the time to operation.

Duplication and redundancy: Implement multiple instances of specific system components, potentially including geographic redundancy, to reduce single points of failure (see the figure to the right). Consider the skills required to maintain the system as well—a person can also be a single point of failure.

Test plans and system monitoring: Evaluate the system's ability to meet the needed service level by testing stress, performance, and failover functions. All testing plans and associated activities should be part of your overall system governance. Continually monitor the system to correct problems before they cause a widespread or unrecoverable outage.

By designing your ArcGIS implementation for high availability, you can improve performance and reliability, meet your SLA commitments, and satisfy your users' expectations for service availability.



Recommendations

To implement a high-availability design for ArcGIS:

1. Create backups of your ArcGIS deployment regularly.
2. Refer to ArcGIS documentation on duplication and redundancy to reduce single points of failure.
3. Test and monitor the system regularly to assure that it can meet performance requirements.
4. Address other key best practices that enable high availability: Automation, Collaboration, Load Balancing, Publication Strategy, and Workload Separation.

¹ High availability (HA), while related to disaster recovery (DR), is a separate concept. Generally, HA is focused on avoiding unplanned downtime for service delivery, whereas DR is focused on retaining the data and resources needed to restore a system to a previous acceptable state after a disaster. When DR plans are executed, it is typical for service delivery to be disrupted until the system has been restored.

Infrastructure

GIS infrastructure is GIS technology deployed on standard IT infrastructure components. The server-side infrastructure components of the ArcGIS system let you deliver, access, and use data and capabilities wherever and whenever they're needed.

An Infrastructure for Serving Data and Capabilities to Users

ArcGIS system capabilities are delivered by server-side infrastructure components, represented conceptually in the figure to the right and described below. You can host these components on premises or in a cloud environment like Amazon Web Services or Microsoft Azure. By leveraging these components, you can expose GIS content and capabilities as web services and consume those services in your apps. This enables users to access and apply useful GIS resources in their work.

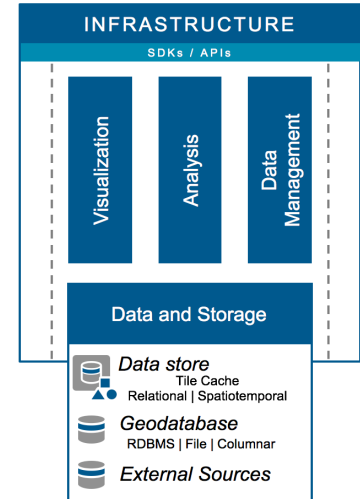
SDKs/APIs let developers build custom capabilities for specific needs. At the infrastructure level, they reference objects and interfaces for your GIS servers, allowing you to extend, consume, and manage GIS services. For example, you can use ArcGIS Enterprise SDKs to add new operations to map services and extend the functionality of ArcGIS. In addition, with Esri's other SDKs and APIs, many client and server technologies can be integrated with the ArcGIS system.

Data Management represents server-side capabilities, exposed as web services that allow end users to create, maintain, and transform geographic data. For example, you can use a mobile app to access a web service for data editing, allowing you to gather location data in the field. Key server-side data management capabilities include short and long transaction editing, data replication, and extract, transform, load (ETL) procedures.

Analysis represents web services for performing GIS analytics. These analytics can range from simple geometric functions (like point-in-polygon) to complex geoprocessing models for site selection. You can run analytics on many kinds of data including vector data, raster data, linear networks, imagery, 3D data, real-time data, and big data.

Visualization represents web services for creating and consuming visual information products like 2D maps and 3D scenes. These products can be dynamically generated on demand, or pre-rendered and cached.

Data and Storage represents the stored geographic information leveraged by GIS servers. ArcGIS supports multiple storage models for various data types, formats, and uses. One storage model is the *data store* managed by ArcGIS. There are several data store types, including relational data stores (for vector data), tile cache data stores (for map and 3D scene caches), and spatiotemporal big data stores (for big data). Another model is the *geodatabase*, an object-relational model for storing geographic data in a relational database management system (such as Microsoft SQL Server, IBM DB2, or Oracle), a file-based structure (a file geodatabase), or an in-memory columnar system like SAP HANA. A third model is to connect to *externally managed data sources* like Hadoop, IBM Netezza, and Teradata.



ArcGIS infrastructure components.

Recommendations

To make the most of your ArcGIS system infrastructure:

1. Store and connect to your data using the storage models that best support your data and business needs.
2. Expose data management, analysis, and visualization capabilities as web services so people can access and use those capabilities in their daily work.
3. Use ArcGIS apps, SDKs, and APIs to incorporate ArcGIS capabilities and services in your apps and systems.

IT Infrastructure Monitoring

IT Infrastructure Monitoring (ITIM) is the practice of capturing the performance, availability, and resource utilization of your enterprise GIS components to detect and resolve problems, with the intent to minimize negative business impacts.

The Value of ITIM

To maintain the health of their enterprise GIS, organizations leverage ITIM tools and practices to identify, diagnose, and respond proactively to issues to prevent or minimize business disruption. ITIM tools and practices can provide early problem detection and notification. Early warning improves the chances of avoiding an outage by alerting staff to address resource saturation and make adjustments that prevent disruption. Above all, ITIM is intended to help critical infrastructure continue supporting business operations.

Identify and Diagnose Issues

Identifying issues often begins with capturing operational data about hardware and software resources and being notified if resources are operating outside their normal range. Common elements monitored include CPU, memory, network utilization, local disk, storage, and system logs. Monitoring data can be used to identify issues, such as increasing memory consumption or CPU usage. ITIM can offer insights into hardware or software issues, especially when IT staff are trained in interpreting ITIM content. There are numerous ITIM tools, including ArcGIS Monitor, for holistic system monitoring of your enterprise GIS and its underlying infrastructure. These tools can help you understand and diagnose issues, potentially even before they impact the business.

Diagnosing an issue involves a variety of approaches to determine contributors to the problem. ITIM tools may provide insight automatically, or a system administrator may need to manually interrogate system and software logs. For example, an ITIM tool may automatically alert administrators when available disk space drops below a certain threshold, so administrators can determine a resolution. Automated alerts and processes should be leveraged whenever possible to reduce the time needed to diagnose issues.

Responding to Issues and Operationalizing ITIM

Once administrators become aware of a problem or impending issue, they need the skills and resources to respond. Operationalizing ITIM requires human and technology resources to enable a swift and adequate response aimed at minimizing costly business interruption. As resource utilization patterns emerge, these patterns can be used to inform the future design of the system. For instance, hardware may be scaled up (add more CPU to the machine) or scaled out (add additional instances of the machine) to accommodate higher volume. In some cases, adjustments to the design result in reduced operational expenses when utilization patterns show the system is over-provisioned, and servers can be downsized or decommissioned.

ITIM is a well-accepted practice of capturing performance, availability, and resource utilization of IT components, including your enterprise GIS. When properly applied, ITIM tools and practices help reduce costs and minimize negative business impacts. To identify and diagnose utilization issues, a team needs the knowledge and skills to monitor, assess, and triage both hardware and software to understand when or why the system isn't performing as expected.

Recommendations

1. Monitor system performance, preferably in real time, leveraging tools that provide automated alerting.
2. Work with IT to understand and diagnose components of the ArcGIS system.
3. Use ITIM outputs to inform future designs.
4. Train administrators on ITIM tools and the systems they monitor.

Load Balancing

Load balancing is a technique for distributing client workloads across multiple computing resources, such as physical servers, virtual servers, or clusters. Load balancing helps you balance system utilization, reduce risk, simplify service delivery and growth, and improve backend server security.

Technology for Optimizing System Resource Utilization

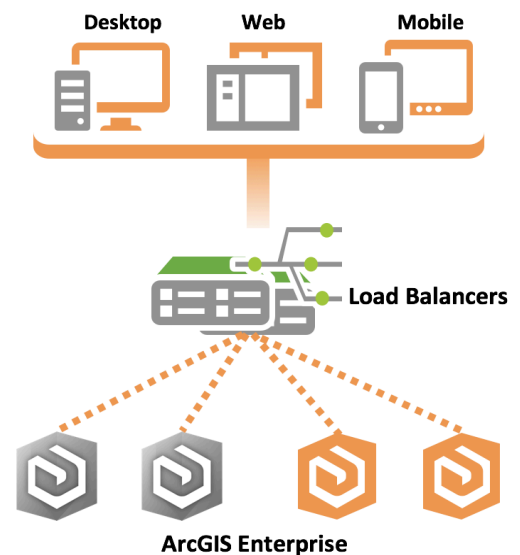
The ArcGIS system can scale to support both small and large deployments. As the number of users increases, so will the deployment size and the number of GIS servers. To accommodate this growth effectively, ArcGIS supports load balancing techniques and technologies. With load balancers in place, you can distribute client workload traffic across multiple server-based resources to optimize performance and resource utilization. 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.

A properly load-balanced system improves scalability by allowing you to add and subtract machines without modifying client applications or removing those applications from use. Also, with load balancing in place, typically only one IP address is exposed to the internet or intranet. This greatly reduces security risks because the internal topology of the network and systems is hidden, and the number of breach points is reduced in case of attack. This method also simplifies service delivery and consumption by providing a single access point (such as a URL).

In its simplest configuration, a single-machine ArcGIS Enterprise base deployment uses two ArcGIS Web Adaptors to manage traffic to the ArcGIS Enterprise portal and to the ArcGIS Server. In more complex configurations, you can deploy third-party load balancers in front of your ArcGIS Servers (as shown in the figure to the right).

ArcGIS Web Adaptor is an application that integrates ArcGIS Server with an existing web server. It also serves as a load balancer, providing a single endpoint that distributes incoming requests and enables web-tier authentication. Client traffic is forwarded to your ArcGIS Servers via a round-robin algorithm. ArcGIS Web Adaptor is easy to install and configure, and it is required for an ArcGIS Enterprise base deployment.

Third-party load balancers are often used by more advanced site and network administrators. As with ArcGIS Web Adaptor, client traffic is directed to the load balancer, then forwarded to available servers or ArcGIS Web Adaptors. However, third-party load balancers also offer special capabilities including asymmetric load management, priority queuing, added HTTP security, SSL offload and acceleration, and TCP buffering. These additional features help organizations address advanced business and technical requirements.



Multiple load balancers in a high-availability configuration.

Recommendations

To optimize system performance and resource utilization for your GIS deployment:

1. Implement load balancing to distribute client workload traffic across multiple computing resources.
2. If you have a simple ArcGIS configuration or require web-tier authentication, use ArcGIS Web Adaptor as your load balancer.
3. If you have advanced load balancing requirements, use a third-party load balancer that provides the capabilities you need (along with ArcGIS Web Adaptor, if you also need web-tier authentication).

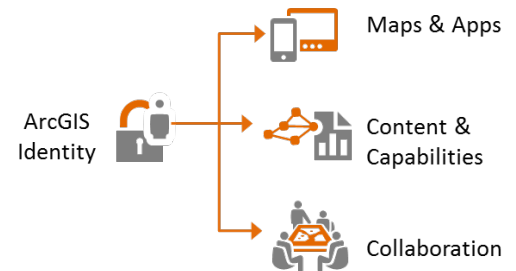
Managing Identities

An ArcGIS identity provides a unique credential that lets a user securely access maps, apps, data, and analysis tools. You can manage ArcGIS identities using the built-in security features in ArcGIS or using a third-party identity provider. By effectively managing ArcGIS identities for your users, you can enable people across your organization to access, use, and participate in the ArcGIS system.

Delivering the Right Content and Capabilities to Every User

An ArcGIS identity allows a person to participate in the ArcGIS system. With an ArcGIS identity, users can access, create, and share GIS content and capabilities. This enables them to collaborate with others across the organization.

Each ArcGIS identity is managed as a named user credential. With this credential, users can sign into ArcGIS on any device, at any time, and access the maps, apps, and capabilities they have permission to use (as shown in the figure above). For example, they can access their saved maps and items, content and apps that have been shared with them, and data from other participants. The named user model allows you to securely extend geospatial capabilities to everyone who needs them.



An ArcGIS identity defines each user's role and privileges within the ArcGIS system.

Administrators can configure roles that define the privileges users have in ArcGIS. You can tailor roles to individual users and their responsibilities. The privileges associated with these roles govern the capabilities the user can access.

Users can also join and participate in groups. A group is a collection of maps and apps that is typically related to a specific area of interest (such as a business unit, initiative, or team). Groups help you organize content and control access. If a group is private, only members will see the group and its content. Members of a group can update maps and apps that have been shared with the group. You can also create public groups that are viewable by anyone.

Depending on the needs of the organization, ArcGIS identities can be managed within ArcGIS or with a third-party identity management system. For small implementations, administrators can leverage their ArcGIS portal's built-in security to add and configure users. They can then use a simple web interface to manage these users, the roles they're assigned, and the privileges they're granted. For larger implementations, organizations can use externally managed identities and groups to control access to ArcGIS.¹ These implementations can integrate enterprise credentials from a Lightweight Directory Access Protocol (LDAP) server, an Active Directory server, or any identity provider that supports Security Assertion Markup Language (SAML) 2.0 web single sign-on.

Recommendations

To effectively manage ArcGIS users in your organization:

1. Provide an ArcGIS identity to everyone in the organization that needs to use GIS content and capabilities.
2. Create roles and groups to control who can access specific capabilities and content.
3. If you don't need to integrate ArcGIS with existing enterprise credentials, use the built-in security in ArcGIS; otherwise, use an external identity provider.

¹ Specific capabilities related to identities and groups differ between ArcGIS Enterprise and ArcGIS Online. The [ArcGIS Enterprise](#) and [ArcGIS Online](#) help topics provide details about these differences.

Patterns of Use

The patterns of use describe common geospatial functions that re-occur across organizational business models and environments. These patterns give you a framework for tracking current and future GIS utilization in a business context.

Understanding and Planning Your Use of ArcGIS

A common set of GIS usage patterns exists across industries, independent of business models or environments. Because these patterns describe both geospatial capabilities and business capabilities, you can use them to understand how ArcGIS aligns with your needs. Organizations that apply all the patterns in their location strategy reap the greatest business benefits and return on their GIS investments.



The common GIS usage patterns that exist across organizations.

Mapping & Visualization is how people understand locations and relationships through visual representations. 2D and 3D maps and charts bring data to life and provide context, so people can share and understand information.

Data Management is how people collect, organize, and maintain accurate locations and details about assets and resources. It is important to persist spatial data within storage models optimized for its unique characteristics. Storage models include the geodatabase, spatiotemporal big data store, relational data store, and tile cache.

Field Mobility includes managing and enabling a mobile workforce to collect and access information in the field. This lets you improve visibility into the operational aspects of an organization, enhance workforce scheduling, reduce issues caused by stale data, and empower personnel with information needed to perform tasks while on the move.

Monitoring allows people to track, manage, and monitor fixed and mobile assets and resources in real time. This lets organizations tap into, analyze, and display streaming data from many sensors, devices, and social media feeds.

Analytics involves applying analytical techniques to transform data into actionable information. You can use analytics to discover, quantify, and predict trends and patterns to empower decision-making and improve business outcomes.

Design & Planning enables people to evaluate alternative solutions and create optimal designs. This supports the design workflow by enabling users across organizations and communities to collaborate on design decisions.

Decision Support involves combining data, metrics, and operational and analytical layers on a map or dashboard to better understand activities, projects, and operations. This produces valuable information for decision-makers.

Constituent Engagement includes two-way sharing of information with the public, partner agencies, or other external stakeholders. By improving engagement and collaboration with communities of interest, you can promote more informed decision-making.

Sharing & Collaboration provides self-service capabilities, so people can discover, use, make, and share maps. This lets you extend the value of location information to the entire organization or community.

Recommendations

To better understand how GIS capabilities can meet your current and future business needs:

1. Apply the patterns of use as a framework for tracking your use of GIS in a business context.
2. If you identify gaps in pattern adoption, consider leveraging ArcGIS capabilities to fill those gaps and maximize the value of your GIS investment.

Prioritization Approach

You can maximize the value of ArcGIS by prioritizing easy and manageable activities that deliver high business value.

Deliver Ongoing Value to Your Organization

When implementing new GIS capabilities, organizations should apply a simple method of selection and prioritization to improve their overall return on investment. The goal should be to mitigate implementation risks and improve adoption by balancing challenges with business benefits. By embracing this approach, you can continuously deliver high business value and high returns on your GIS investments.

One effective prioritization approach uses a matrix to plot both business value and ease of launch. The benefit aspect relates to the value derived from completing an activity (such as increased productivity, reduced costs, or more informed decisions). The ease of launch aspect focuses on the level of effort, challenge, or risk required to deliver a capability (including considerations like the technology skillsets required, time to delivery, and level of difficulty).

You can evaluate potential new capabilities by plotting them on a matrix like the one shown in the figure to the right. You can then pursue the activities with the appropriate mix of value and risk:

The **green oval** represents activities that provide clear benefits and are easy to accomplish (for example, configuring COTS templates). You can embrace these kinds of activities to develop a cadence of delivery that produces ongoing value to the organization.

The **blue rectangle** represents high-value capabilities that are challenging to deliver. Typically, these are long-term projects that require careful planning. They may require additional resources, planning, or mitigation actions. The additional effort to manage risks may also lengthen the project duration.

The **purple diamond** represents tasks that are good for developing skills, thanks to manageable challenges. You can use these types of activities to learn new technologies or approaches in an isolated development environment. Experimentation can lead to greater understanding and help reduce future risk.

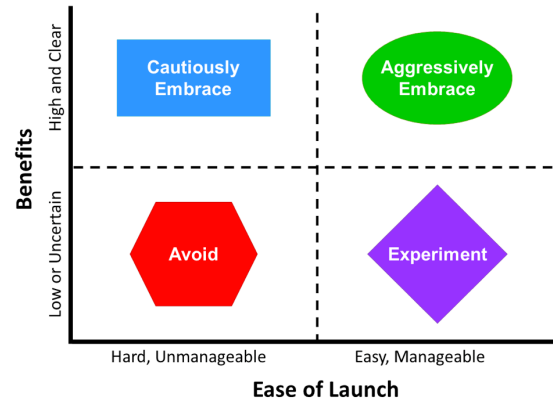
The **red hexagon** represents efforts that are challenging and offer little business benefit. Trying to implement these types of capabilities will be costly and will distract from the overall value of your efforts.

Organizations that employ this simple but effective prioritization approach derive high value from their ArcGIS investments and achieve greater success in their implementation.

Recommendations

When deciding how to prioritize new activities in your organization:

1. Consider using a matrix to help qualify new capabilities based on business value and ease of launch.
2. Prioritize the capabilities that offer the greatest benefit with the lowest risk, so you can deliver rapid value.
3. Develop a delivery cadence of easy, high-value capabilities, and take time to plan more challenging projects.
4. Avoid low-value, high-risk efforts altogether.



Prioritization matrix evaluating benefits and ease of launch.

Publication Strategy: Geospatial Content Delivery

A publication strategy describes how you deliver data, services, and applications to users. By considering the needs of your users, you can identify a strategy that delivers geospatial content in a well performing, reliable, and secure manner.

Give Your Users the Access They Need—Securely

An effective geospatial content delivery strategy must address performance, reliability, and security. By addressing these three areas, organizations can make certain that content will be available and delivered in a manner that is suitable for consumers to use. This strategy should balance user expectations for performance and availability against security and load on the infrastructure. This will mitigate risk while meeting audience needs and expectations.

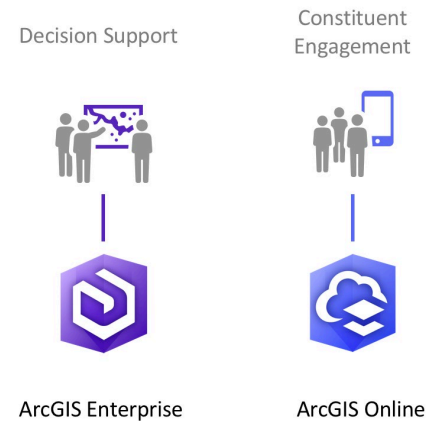
One common publication need involves sharing internal information with people outside the organization—for example, a city sharing land ownership information with the public. A typical strategy involves creating a publication geodatabase (as a hosted service) deployed to a cloud environment, which is separated from internal systems. As discussed below, this strategy addresses the elements of performance, reliability, and security:

Performance is addressed by separating information consumers from operational or transactional systems. In the city’s example, the public consumes information from ArcGIS Online, a cloud-hosted software-as-a-service (SaaS) environment. This approach reserves the city’s internal resources for transactional editing, which in turn reduces resource contention and increases the resources available for editors. In addition, the resources available to consumers can grow in response to demand (for example, to support a suddenly popular map), because the SaaS environment is scalable and more elastic than the city’s internal resources.

Reliability can be expressed as a Service Level Agreement (SLA) or as an expectation of when the system will be available (for example, during work hours, or during a crisis). You can address reliability by following other best practices like [High Availability](#), [Load Balancing](#), [Workload Separation](#), and [Security](#). You can also leverage cloud capabilities to meet reliability expectations. In the city’s example, reliability is addressed for the public, since ArcGIS Online has a 99.9% SLA. The city’s SLA for editors is less strict and doesn’t need high availability.

Security means exposing the right content to the right consumers while protecting the enterprise. In the city’s example, consumers can view published land ownership information but cannot update property boundaries. Because property boundaries should be maintained in a secure system of record and edited only by authorized experts, a separate internal publication environment is appropriate for other departments. The city might also consider a separate internal publication environment for decision support, as shown in the figure to the right.

An effective geospatial content publication strategy addresses performance, reliability, and security. Your strategy should deliver content that meets the needs and expectations of consumers, while minimizing the impact on operations and protecting internal systems and data.



Publish content to the environment appropriate for the audience.

Recommendations

When devising your own publication strategy, consider the following recommendations:

1. For better performance, consider separating information consumers from operational or transactional systems, and consider using a cloud-hosted SaaS environment for scalability and elasticity.
2. To improve reliability, implement the infrastructure necessary to support the SLA expectations of your users.
3. For better security, use separate publication environments to support audiences with different needs.

Real-time GIS Strategy

Real-time GIS allows organizations to analyze and display streaming data from sensors, devices, and social media feeds. With real-time GIS, maps and databases are continuously updated, trends are observed as they form, and key personnel are alerted the moment activity or performance reaches a critical threshold. By embracing location in your real-time capabilities, you can speed up decision-making and responsiveness.

A Core Capability for Operational Awareness and Decision-Making

Real-time location data is increasingly important in modern enterprises. Organizations that treat real-time GIS as a core capability can track the location, performance, and status of relevant assets and environments, as well as manage, analyze, and disseminate this data in real time. This enhances an organization's operational awareness and maximizes the impact of its decisions. Your real-time GIS strategy should allow you to ingest and manage real-time data, transform that data into actionable information, and disseminate the intelligence to the right people.

Ingest real-time data from a wide variety of locations and sources, so decision-makers and operations teams can access information as events occur. You can consume real-time data streams for immediate display and persist the data for later analysis and use. ArcGIS ingests data about the location, performance, and status of teams, assets, products, environments, and services from Internet of Things (IoT) sensors and devices, as well as social media feeds and web APIs. With ArcGIS, you can broadcast live data with stream services for visualization, as well as archive data to a relational database or spatiotemporal big data store.

Filter and analyze incoming data on the fly so decision-makers can address changes as they occur. You can use location-based and attribute-based filters to evaluate high-volume and high-velocity data and determine its relevance and importance. For example, a spatial filter based on a geo-fence can verify if an asset is inside, outside, entering, or exiting an area (see the figure to the right). Additionally, you can analyze and enrich incoming data using mathematical, spatial, and geometric analysis tools. Analysis can make real-time data more relevant and actionable.

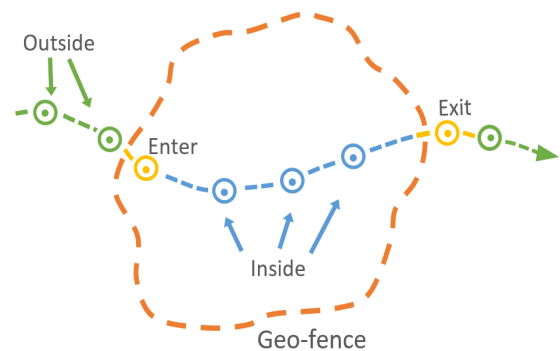
Disseminate actionable information to enhance decision support through notifications, which let you send information to appropriate users, applications, or systems for action. For example, the location of moving assets (like snow plows) or the status change of stationary assets (like radiological sensors) can trigger a notification to key personnel (via text message) and/or to another system (via a web API).

Real-time data from moving and stationary assets can help you optimize business performance and improve decision support. By embracing the location aspect of your real-time data, you can react more quickly to dynamic situations and make faster, more informed decisions.

Recommendations

To maximize the value of your real-time data:

1. Ingest real-time data from a range of locations and sources to deliver better situational awareness to users.
2. Use analysis tools and filters to evaluate incoming data and determine its relevance and importance.
3. Configure notifications so the right users, applications, or systems can respond to incoming data.



Use of a spatial filter to determine the location of a moving asset in relation to a geo-fenced area.

Security

ArcGIS security should be addressed early in the design process, since the techniques and approaches may vary by business need and environment. Storing and delivering information securely will improve availability and reduce risk. ArcGIS supports common security frameworks and can be configured to work within your established security model.

Key Technical Security Mechanisms

ArcGIS can meet an organization's security and privacy challenges through a secure enterprise solution. Typically, the security configuration involves integrated functions within Esri products, third-party solutions, and implementation approaches. Key technical security mechanisms to consider include user authentication and authorization, filters, encryption, logging and auditing, and hardening:

Authentication involves verifying credentials to confirm the identity of an application or user attempting to connect to a system. Once the identity is confirmed, an **authorization** process determines if the application or user has permission to access resources like data, maps, or apps. To help you secure resources using a single sign-on experience (reducing the number of user credentials you manage), ArcGIS supports centralized identity stores like Lightweight Directory Access Protocol (LDAP), Integrated Windows Authentication, and Security Assertion Markup Language (SAML). Based on the identity store, authentication and authorization may require specific technology configurations to enable users and applications to access system resources.

Filtering hardware and software can intercept invalid or attack requests before a server can execute them. You can use firewalls to prevent unauthorized access to private resources, or to inspect packets and accept or reject them based on defined rules based on acceptable levels of risk. Reverse proxies obscure details of the internal network; you should configure them for content filtering, URL rewriting, and load balancing. ArcGIS Web Adaptor can forward client requests to ArcGIS Enterprise machines in a site, obscuring machine and port information and filtering access to ArcGIS Server Manager and Administrator directories.

Encrypting data in transit enforces the security and privacy of data. To prevent the interception of secure data communications, you should configure ArcGIS to use the Transport Layer Security (TLS) encryption protocol. You should also employ strong encryption methods like Advanced Encryption Standard (AES) and Secure Hash Algorithms (SHA) to encode data and detect whether it has been tampered with or modified.

Auditing and analyzing system and application logs on a regular basis can provide a baseline understanding of use during regular operations. You can then use anomalies in the baseline to identify and investigate security incidents, or to provide information about system problems and unusual conditions. Application logs can also provide event-level details about specific security incidents and policy violations.

Hardening is the process of securely configuring a system to mitigate as many security risks as possible. Hardening involves implementing application-level security approaches, removing unnecessary software, disabling unnecessary services, consulting guidelines and policies that are specific to your applications and operating system, and reviewing industry-standard security guidelines.

Recommendations

To address security requirements within your environment:

1. Include user-level authentication in every application and avoid anonymous access.
2. To improve auditing, use ArcGIS Monitor to track what is happening to the system in real time.
3. To improve system hardening, follow ArcGIS Enterprise security best practices (as described in the [help documentation](#)) and leverage the ArcGIS Online [Security Advisor](#).
4. Regularly review ArcGIS security, privacy, and compliance guidance at trust.arcgis.com.

Workforce Development

Workforce development is the investment in an organization’s most valuable assets—its people—so they have the knowledge and skills required to deliver significant business value. Business needs and technology capabilities are ever-evolving, and workforce development is needed to achieve greater value and faster return on investment from ArcGIS.

Achieving a High ROI on ArcGIS Requires a Strategic Investment in People

Through workforce development, GIS teams can acquire the knowledge and skills they need to sustainably deliver high-value solutions, so they can support key business workflows and empower decision-making. But when skills and knowledge aren’t developed within GIS teams, organizations are unable to fully leverage their investment in ArcGIS. Under-developed staff are not aware of technology advancements or contemporary workflows, or they lack the skills required to take advantage of them. As a result, these organizations often rely on more expensive external resources, and staff unable to direct, manage, and monitor consultant work. Esri offers a multitude of resources to equip your staff with skills needed to achieve your organization’s strategic goals (see the figure to the right).



Take advantage of Esri’s training resources to improve workforce development throughout your organization.

Communicate the value of workforce development to your leadership by showing how it contributes to the success of the organization’s business priorities. Document the skills GIS professionals need to implement, administer, or use the technology that supports critical business workflows, so leaders can see how success is tied to these skills. Help them understand that the decision to invest in GIS technology requires an investment in the knowledge and skills of GIS professionals. For example:

1. New workflows and processes are developed as technology evolves, improving efficiency and productivity. Training helps employees become familiar with more efficient workflows, saving them time.
2. Once your staff knows how to use the right workflows and tools, they can deliver new and improved business capabilities, enabling others to work more effectively and gain greater insights into pressing challenges.
3. Third-party consultants help organizations develop capabilities when time and skills are lacking. Trained staff are better prepared to lead teams and can retain better control over consultants’ activities. In some cases, a well-equipped workforce can replace the need for consultative work, reducing overall costs.

Workforce development should be a part of every ArcGIS implementation, because it allows you to continue to develop and deliver high-value solutions. With a trained workforce, you can use ArcGIS efficiently and effectively, set and achieve your organization’s goals, and build a culture of self-reliance and expertise.

Recommendations

To increase the return on investment from your ArcGIS implementation:

1. Invest regularly in workforce development to improve operations and meet evolving business needs.
2. Build a training plan for each GIS role in your organization to develop appropriate expertise.
3. Provide a budget for training and justify it by connecting training resources directly to organizational outcomes.

Workload Separation

Workload separation is a design approach that aligns your technical implementation with your organization’s business requirements. You can use this approach to maximize system performance, reduce risk, and improve reliability.

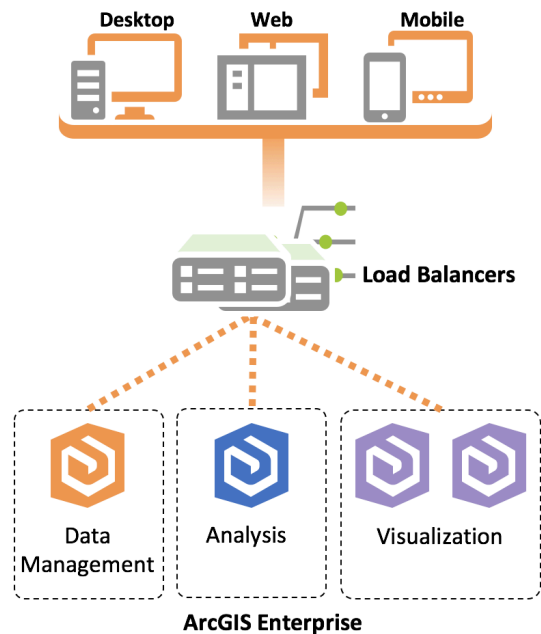
Provide Better, More Reliable Service

Different business functions impact the performance of ArcGIS in different ways. By allocating workloads to appropriate server resources organized by business function, you can maximize performance, reduce risk, and meet business-defined Service Level Agreements (SLAs). By implementing geospatial function isolation, you 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. You should:

Maximize system performance by directing service requests to compute resources in a way that optimizes the use of your hardware and reduces resource contention. For example, you can direct processor-intensive analysis tasks to an ArcGIS Server site containing machines with fast processors, while directing less intensive tasks to more modest machines. This makes the best use of your compute resources to achieve the highest level of performance.

Reduce the risk of service interruption by routing user requests to the appropriate sites through load balancers. This enhances system stability by preventing overloaded machines from affecting other machines, which in turn protects critical tasks from resource contention.

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 SLAs. Because analysts use geoprocessing tasks in an ad hoc fashion, the CPU may sit idle but then spike when several tasks are executed. On the other hand, decision support activities simply consume map-based information products to drive operational business decisions. They are typically less CPU-intensive, are executed more consistently, and demand higher SLAs. Because these tasks and workflows are so different, you can use workload separation to accommodate each set of activities.



Organize your infrastructure components by business function.

Recommendations

To take advantage of workload separation in your environment:

1. Consider different business workflows to understand how each workflow impacts compute resources, and then use segregated and preplanned resource allocation to meet the needs of each workflow.
2. Allocate hardware around core GIS capabilities, as shown in the figure above.
3. Use GIS [Patterns of Use](#), SLAs, and performance expectations to determine how to best direct workloads to appropriate compute resources.
4. Direct CPU-intensive service requests to sites containing machines with faster processors, and direct less intensive requests to more modest machines.



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