[KE-04-017] The Benefits and Costs of Enterprise GIS Implementations

Abstract

Geospatial Enterprise systems are becoming more common with much of the content delivered via Web Service format to Web Browsers and mobile phones. This entry describes the benefits, governance, and costs of deploying a Geospatial Enterprise system within a mid-size (< 100 staff) governmental organization.

Keywords: economic aspects

Author & citation

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Explanation

1. Introduction

The early GIS systems relied on workstations and desktop software packages deployed across an organization that was maintained by just a few geospatial specialists. These staff would perform analysis to support a narrow range of unique business needs and data was typically stored in isolated silos with limited access, resulting in inefficient collaboration and underutilization of the GIS tools and accompanying geospatial data. Contemporary GIS systems have evolved towards a more organized and integrated suite of tools capable of reaching broader audiences resulting in better collaboration, and more efficient use of geospatial data resources.

2. The Benefits of Geospatial Enterprise Systems

Numerous authors have noted how Geospatial Enterprise systems can provide for better control of governance, scalability, integration and compliance with business processes and IT capabilities (Tomlinson, 2013; Peery, 2019). The Geospatial Enterprise system's resources can be distributed as web services across the internet, and anyone using a Web browser or mobile phone can share in this experience. This approach increases collaboration, ease-of-use, availability, and enhanced data interoperability, all at a lower cost.

Contemporary Geospatial Enterprise system deployments range from cloud-based Software-as-a-Service (SaaS) to on-premises GIS Enterprise deployments. Esri's ArcGIS ecosystem provides the most prolific suite of GIS tools commonly found in organizations today (https://gisgeography.com/web-mapping/), therefore the remainder of this discussion will focus primarily on Esri's GIS Enterprise offerings, especially since all the Esri products are readily available as commercial off-the-shelf products (COTS).

Organizations previously working with legacy GIS desktop solutions tend to evolve toward either the ArcGIS Online or ArcGIS Enterprise because these technologies easily scale with an organization's existing relational databases (MS SQL, Oracle) and content management software like Microsoft's SharePoint. The GIS Enterprise's basic architecture consists of an application server which constructs and transforms GIS content, a database server to house the geospatial data, and then a front-end map-centric portal (Figure 1).

Once configured, the Geospatial Enterprise functions as a location intelligence platform resembling a socio-technical hybrid system of people, software, and hardware, all relying on a bottom-up communal holistic structure. This approach contrasts to the older legacy stove pipe or bottlenecked GIS systems where GIS data existed in siloed data repositories and file folders on an organization's file network managed by the IT department. An organization's IT department still plays a vital role in managing hardware and software via the typical top-down approach; however, the control and management of content needs to be facilitated by the organization's collaborators, otherwise there could be bottlenecks limiting the free flow, and efficient use of the geospatial content and data assets.

The benefits of a Geospatial Enterprise system include some or all the following outcomes:

- The availability and lower costs of content accessed from the Cloud and onsite.
- The ease of integration using existing tools (i.e., database and content management).
- The ease of using tools and content via a simple Web Browser.
- The creation and reliance on streamlined processes, including standard workflows and procedures, leading to improved consistency.
- Less overall maintenance versus legacy systems, and improved reliability.
- The free flow of content – the reliance on data layers and the Web leads to fewer bottlenecks.

3. Governance

Governance is all about policies, best practices and standards that help foster a more efficient, cooperative, and cost-effective GIS Enterprise. The GIS Enterprise governance process is dynamic in nature and typically GIS users fall under different work units. It is therefore imperative that these units get into alignment with one another and adapt to the changing nature that various GIS tools and data resources bring to the table. The sooner this happens the quicker the organization will realize an overall benefit. Speaking about data, there are typically three types of data governance models that have been implemented in geospatial organizations: the Centralized, Decentralized, and Federated models.

Organizations that have a dedicated database manager generally utilize the centralized governance data model. However, smaller geospatial units within organizations that had traditionally relied on simple desktop solutions. Today those smaller organizations are tending to migrate away from both the Centralized and Decentralized data governance models to adopt the Federated data governance model in which both IT and non-IT staff can both be involved in the decision-making process. The governance principles include one or more of the following:

- Governance needs to begin with user-based needs and not solutions.
- Focus on user needs and not solutions to promote responsibility and sustainability.
- Create transparency of decisions and action via an “agile” approach that allows users the opportunity to demonstrate authority and accountability.
- Promote independence for members and stakeholders and to help to avoid conflicts of interest.
- Support early adopters – identify staff that understand the benefits and allow transfer of ownership to them.
- Try to adhere to procedures and structures to promote system integrity and security.

4. Project Costs

GIS costs in organizations are typically distributed across multiple projects and this approach may slow or impede the transition from standalone GIS operations towards a successful GIS Enterprise (Cf. Lewin, 2023). GIS Enterprise strategies need to incorporate both direct and indirect costs into the fabric of an organization’s strategic and business plans early on to establish who will be responsible for what.

Since the total cost can be dynamic and spread over multiple years, it is wise to employ some form of project cost forecast. With a forecast one can adjust needs and expectations to control costs and stay within a budget. To better understand what is driving demand, businesses and organizations typically utilize one or other of two approaches:

1. Demand Management – this method looks at historical services data to understand what is driving demand and whether any overprovisioning is occurring.
2. Service Catalog Management – this method utilizes a catalog to identify the most frequently used services.

The chosen approach to use will depend on a clear understanding between IT capacity and a unit’s growth and future goals since cost optimization should be about shared responsibility across any business or organization. These conversations should consider both direct and indirect costs as described below.

4.1 Direct Costs

Direct costs are those costs that are necessary to complete the project and are usually more conspicuous and easier to estimate.

The direct costs likely include: (1) capital (purchase and setup) outlay costs that cover data, software licenses, hardware, implementation, and migration; (2) ongoing operational and maintenance costs associated with software maintenance and support, enhancements (server or data center support), and security; and (3) human (which can be both direct and indirect) costs to cover IT support, administration, and other forms of technical support.

The three subsections below explore examples of the data, software, and hardware costs associated with Geospatial Enterprise deployments (as of July 2023).

Data. Data costs can range from a few hundred to several thousand dollars or more, depending on many factors. For example, some organizations like county assessor offices sell tax lot and parcel data sets to recover the organization cost associated with data analysis, processing and handling which can range between $500 and $1,500, whereas proprietary or commercial data providers often charge higher fees which is especially true when working with imagery data providers. Therefore, organizations need to evaluate their needs, budget constraints, and available options when considering data purchases and use agreements. The geographic extent of the data will influence cost, and real-time data may have higher costs compared to historical or static data and high-quality survey-grade data will always incur higher costs.

The typical types of GIS data include vector (points, lines and polygons, imagery (raster), tabular, 3-D, field/mobile, business, big data, cloud stores, and file-based datasets. While some organizations continue to store data in network file folders or file systems like a File Geodatabase, many organizations now favor architected data which have more fabric and structure.

Organizations that decide to host an RDBMS on-premises will incur costs for hardware, software licenses, and maintenance. Each of these RDBMSs may have different pricing models and they may require purchasing licenses based on factors such as the number of users, data volume, and number of cores or other metrics. Some databases like PostgreSQL are open-source and free-of-charge with no licensing fees, but additional support and enterprise features may come with a cost. Some of the costs associated with proprietary RDBMSs can be avoided because they are offered as a service in the cloud (DBaaS), with pricing models based on factors like data storage, data transfer, and computer resources.

Esri provides an Enterprise Geodatabase (EGDB) that is managed and sits within an RDBMS (https://www.esri.com/news/arcuser/0408/entergdb_101.html). Once the EGDB is connected to web services, organizations can unlock greater data visibility, analysis capabilities and insights. Additionally, Esri's GIS Enterprise software provides a PostgreSQL virtual database that stores all the "hosted files" and services (Lawalin, 2020).

Choosing the best option can be difficult and so organizations might consider using some form of insight model to find their user's needs and experiences, and to help define what variables are important in delivering quality and consistent data (Dalton, 2023). This approach can help staff more quickly conduct daily tasks and lower an organization's total costs.

Software. The software costs will be specific to the products and services used and the examples below focus on Esri's solutions. The ArcGIS Enterprise solutions may be more expensive at first sight but for mid-size and large organizations, the overall cost is lower per user and the platform can reach a broader audience. Costs for MS SQL Server that houses the GIS Enterprise Geodatabases vary tremendously depending on what version (i.e., Standard or Advanced) an organization needs, but they typically start around $1,000 for Standard and $130,000 for two or multi-cores, respectively.

Esri's ArcGIS GIS Enterprise software has two primary version levels with different one-time and perpetual licensing costs depending on product combinations and there may be added costs for "user types" which are annual licenses needed to access and utilize ArcGIS Enterprise (see Table 1 for additional details).

Perpetual licensing refers to the traditional method of purchasing software, where you pay for the license upfront, and you may use the software indefinitely. In addition, you may purchase annual maintenance that covers software updates and technical support. Subscription (or Term) licensing, on the other hand, covers software updates and technical support but will expire if not renewed on an annual basis.

Choosing between the subscription vs. perpetual licensing model depends on needs. The Subscription licenses have a lower initial price but cost more over an extended period and stop working if you do not renew. This approach typically includes premium 24x7 support as well. Perpetual licenses cost more up-front, less over time, and never expire. In addition, Esri also offers software licenses via what they call an Enterprise License Agreement (ELA) where customers commit to a contract for a specified period in exchange for unlimited software and maintenance. An ELA typically includes software updates, technical support, and training, and they may may include unlimited desktop licensing which is important because the Desktop licenses allow the organization's staff the ability to create content that is then shared out to the Enterprise for the staff to collaborate on.

Hardware. The costs for hardware will vary for on-premises vs. cloud deployment. For on-premises deployments, the average costs for server hardware can range from $3,000 to $5,000 depending on the amount of RAM, disk space, etc. The costs for each Windows Server software installation range from $500 to $1,100. Therefore, a simple base deployment for ArcGIS Enterprise might look something like the following:

- 1 Application Server $3,000-$5,000
- 1 Database Management System $3,000-$5,000
- 1 Portal Spatial content management system $3,000-$5,000
- Web Adapters/Load Balancers Included with ArcGIS Enterprise
- Web Server Included with Windows Server

While it is possible to install everything on a single machine, this is not an advisable practice since applications like MS SQL will try and grab as much memory as possible which could result in performance bottlenecks for other applications on the server. Therefore, a good rule-of-thumb for MS SQL is to start with at least 10% of total memory use.

Figure 1 shows Portal (spatial content management) being deployed on one machine, ArcGIS Server (application server) is hosted on another, and ArcGIS DataStore and MS SQL are hosted on a third machine. Each server should have 16-32 GB of memory and 100-200 GB of storage. For those smaller (< 100 staff) organizations that might be operating on a limited budget, this configuration could be reduced to a two-server type of deployment by combining the application and database server on the same machine provided there is sufficient memory; however, the Portal spatial content server should be hosted on a separate dedicated server.

The second cloud hosting option places your Geospatial Enterprise on a group of connected virtual machine servers, and so the system and content is stored in multiple places all at once, providing greater security, flexibility, and reliability and failover – if one server fails then another server can pick up the slack. Should there be a need for greater capacity or resources such as RAM or storage, then this can be adjusted with no downtime or loss of continuity.

Cloud providers offer different pricing models and so it is vital to first understand the system needs before choosing which model best suits an organizations' needs. Some vendors provide canned deployments models for fast and efficient deployment scenarios; however, some organizations might have governing policies and practices that prohibit automatic deployments. In other cloud environments the user is responsible for provisioning and configuring the cloud infrastructure components (virtual machines and networking components such as fire walls and load balancers) using the tools provided by vendors, as illustrated with the examples below.

In the first example, Carto Vista utilizes AWS and offers Geospatial Enterprise deployments via Software as a Service (SaaS). Their monthly costs are straightforward and can range from $89 (professional – 10 GB storage) to $149 (Enterprise – 40 GB storage) per user per month.

In the second example, Esri's ArcGIS Enterprise in the Cloud utilizes both AWS and Microsoft Azure. While it is also possible to deploy using something other than AWS or Azure, the user is then responsible for provision and configuring the infrastructure on their own which creates more complexity and potential cost. With AWS or Azure, there is a plethora of options for deployment and Esri provides specialized tools with the ArcGIS Enterprise Cloud Builder that can help automate the deployment process.

In the third example, Google Cloud's (https://cloud.google.com) infrastructure is set up as a pay-as-you-go pricing structure. There are no up-front fees, no termination fees, and you only pay for the services you use. Pricing varies by product and use levels, and they also provide a cloud cost management dashboard tool to help with your pricing configurations.

In the final analysis, there is no way to know whether cloud hosting or on-premises deployment is the best solution in all cases. Rather, the better approach is to evaluate a given application against a range of criteria including financial and budget considerations, the maturity of the application and your organization's infrastructure. Additionally, an organization will need to consider whether they have the appropriate trained staff that can provide ongoing system support when choosing one or other of the options.

4.2 Indirect Costs

Indirect costs are those costs that do not directly lead to project completion but are still vital for the organization Geospatial Enterprise. These indirect costs are also referred to as overhead expenses which cannot easily be attributed to any single outcome (i.e., a specific product or service) and examples may span: (1) labor costs; (2) building rent; (3) utility costs; (4) equipment depreciation; (5) administrative costs; and (6) the preparation of grant proposals and the administration of grants.

The indirect costs typically vary from one type of organization to another (10-15% for Nonprofits, 50-65% for universities working on federal grants and 100% for private sector enterprises), but this revenue supports a variety of necessary tasks, including: (1) testing and quality assurance; (2) data security and compliance; (3) training; and (4) change management.

The last of these tasks may be crucial because changes in technology tend to happen exponentially (Moore’s Law), whereas human and organizational change typically occurs slowly over time because many people are resistant to change (Martec’s Law). This state-of-affairs suggests that implementing some form of change management process as part of the transition to a Geospatial Enterprise will add value.

Malhotra (2019) described the ADKAR model of change management, and discussed how organizations often use this model, which includes five building blocks, to reach goals with measurable outcomes, as follows:

1. Awareness
    - Understanding the need to change.
    - Demonstrating the capabilities.
2. Desire
    - Are you willing to change?
3. Knowledge
    - Did we provide proper training?
    - Can we transfer skills?
4. Ability
    - Are we able to do this?
5. Reinforcement
    - Can we sustain change; are participants accountable?

5. Summary

While the benefits are compelling, deploying a Geospatial Enterprise system is not always the best choice for every situation since these are multifaceted systems that can be overwhelming and can cost thousands of dollars to implement and support. Many organizations simply do not have the leadership or focus to even begin looking into an endeavor like a Geospatial Enterprise system let alone the shared support and service architecture needed to support one. Some organizations hire consultants or seasoned GIS veterans who have a broad background of IT experience and education to successfully implement and sustain these systems.

This said, the adoption of Geospatial Enterprise systems is burgeoning, and vendors can now quickly integrate established COTS products into an organization’s existing GIS and RDBMS resources. When properly implemented and with trained staff, a Geospatial Enterprise system can help organizations foster a more efficient, productive, and collaborative geospatial environment that leads to better business decisions and lower organization costs.

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