BIOGRAPHICAL INFORMATION

Dan Mahar
Senior Consultant
EMA, Inc.

Specific Responsibilities

Joined EMA, Inc., in 2002. Responsible for:

- GIS Implementation
- Spatial Data Modeling
- Web-based GIS Applications
- Desktop GIS Customization
- Training
- Geodetic Science
- Surveying and Coordinate Reference Systems

Past Experience

Ten years of project-based experience, Dan provides support for spatial technologies, focusing on the design, development and implementation of geographic information systems.

Educational Information

B.S. - College of Engineering, Business Administration and Mathematics, University of Vermont

M.S. - Department of Geodetic Science, The Ohio State University

Professional Memberships

URISA – Board Member, Rocky Mountain Chapter

BIOGRAPHICAL INFORMATION

Jeremy Wolfe
Senior Consultant
EMA, Inc.

Specific Responsibilities

Joined EMA, Inc in 2002. Responsible for...

- Programmig
- Software Engineering
- Web Development
- Database Architecture/Development
- Business and Data Modeling
- Enterprise Information Integration
- System, Data and Organizational Requirements and Design
- Geospatial Information and Technology Solutions
- Infrastructure Management Applications

Past Experience

Uses programming language(s) and operating system(s) to accomplish assigned tasks. Learns new languages and technologies quickly. Focuses on development of efficient, timely, application delivery.

Educational Information

B.S. - Computer Science; Programming Emphasis, University of Wisconsin – River Falls

Minor in Biology (Biotechnology Emphasis), University of Wisconsin – River Falls

Professional Memberships

None

WEB-BASED GIS: PUTTING THE PIECES IN PLACE

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Abstract

The World Wide Web (WWW) and associated technologies offer the promise of integrated business operations and efficiency gains that support the daily planning, maintenance, and service responsibilities of virtually every organization. Online mapping and web-based geographic information systems (GIS) offer extended benefits in the form of data visualization and decision support by providing a spatial context for the information and activities that define each organization. However, realizing the promise of online mapping involves navigating an intricate maze of technologies that can discourage even the most well-intentioned efforts.

This paper describes the technology behind web-based GIS. It introduces the concepts of distributed systems and provides an enterprise-oriented implementation approach that links systems, departments, and business processes around dynamic, map-based user interfaces. The paper concludes with a “Lessons Learned” section that highlights some “best practices” gleaned from project engagements across many disciplines and organizations.

Web-based GIS represents an exciting and advantageous opportunity for many organizations, however getting all the pieces to work together can be challenging. This paper serves to provide a background and context for understanding distributed GIS and getting the most out of web-based mapping implementations.

Introduction − New Opportunities on the Web

At its core, the World Wide Web (WWW) connects people and communicates information. Internet mapping applications have sprung up everywhere to provide a spatial perspective for the volumes of data available. From simple map directions to more specialized data distribution and web services, people around the world are integrating geospatial tools and techniques into their existing web sites.

The terms “online mapping” and “web-based GIS” at first seem mainly concerned with publishing maps on the web. But as we will see, the true potential of web-based GIS lies in the integration of people, technology, and business practices to support the mission critical responsibilities of an organization. Toward that end, map publishing is often an ancillary benefit of more internally focused efforts that rely on GIS to provide a spatial context for tying together the activities and systems that make up an organization.

Internet Mapping Showcase

There are a tremendous number of web sites out there that rely on spatial techniques to present and organize wide varieties of information. Here are just a few that seem to be taking advantages of some of the new opportunities.

- TerraServer – One of the world's largest online databases, providing free public access to a vast data store of maps and aerial photography of the United States. Microsoft operates it as a research project for developing advanced database technology – maps and images are supplied through a partnership with the U.S. Geologic Survey. The site contains 3.3 terra-bytes of information that can be located and downloaded through a map-based interface. (http://terraserver.microsoft.com).

- MapSteDi − Mountain and Plains Spatio-Temporal Database Infomatics Initiative – This online mapping application, sponsored by the University of Colorado, allows users to analyze biodiversity data in the Rocky Mountain regions, both spatially and temporally, in a web format. What makes the site unique is that it ties together 16 different databases across four different organizations and combines that information with background images from popular mapping sites such as the USGS's TerraServer project. End users interact with the system through a typical mapping interface that provides navigation, query, selection, and layer manipulation functionality. (http://mapstedi.colorado.edu/mapstedi).

- PixEarth – This site is a commercial endeavor that supplements two-dimensional map displays with thousands of map-based photos that provide a 360-degree visual context for nature trails, real-estate, news print, and a host of other applications. (http://www.pixearth.com)

While online mapping is often used in a public, internet setting, it is increasingly being considered as an application framework that supports internal operations within an organization. So called intranet applications offer a flexible, scaleable implementation that makes efficient use of existing resources. Different systems (i.e., GIS, Work Management, Customer Management, etc.), as well as different professional specializations and skill sets are linked together through a web-based mapping interface to share ideas, contribute opinions, and develop solutions for the mission critical responsibilities of an organization.

- GIS/WMS Integration − GIS and WMS are inherently linked by the fact that most work management activities occur at a location within a specific jurisdiction. The goal of these GIS/WMS online mapping systems is to create a best of breed solution that leverages GIS to provide the spatial context for WMS maintenance, planning, and operations. Web-based technologies provide a common "enterprise-oriented" approach for linking the systems and increasing the accessibility of the information throughout the organization.

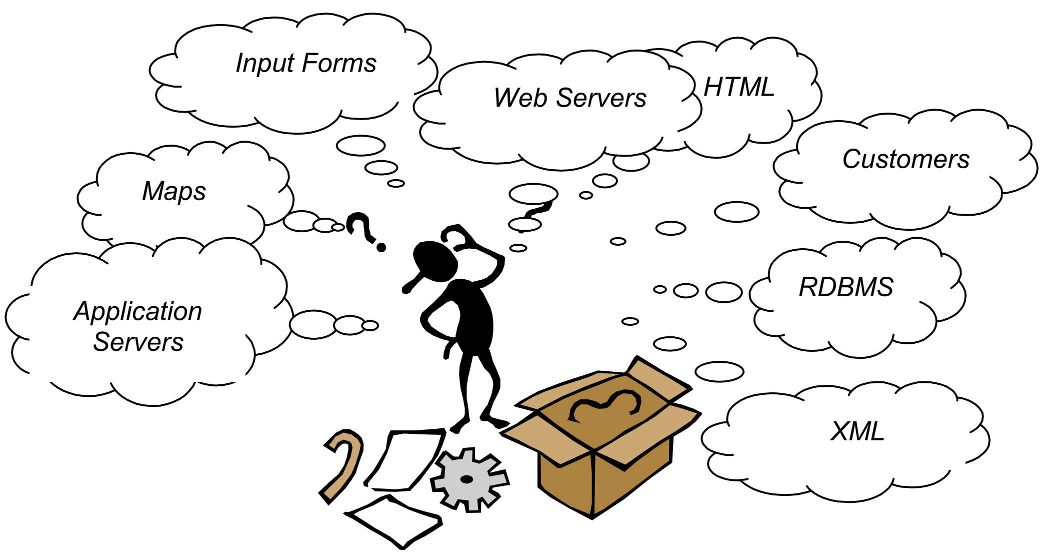
There are tremendous opportunities in the area of online mapping – all offering the promise of data visualization, decision-support, and an efficient use of existing resources. However, online mapping marks a departure from the typical world of information management that most of us have grown accustomed to. Rather than relying on specialized systems to deliver specific content, we need a way to capture the output of those systems, re-organize and format it, and deliver it in a context that people can more readily use to meet their daily responsibilities.

To realize the promise of online mapping, we must approach development in a disciplined manner and for that we need a framework for understanding the technology behind the map. The answer lies in Distributed Systems.

Distributed Systems

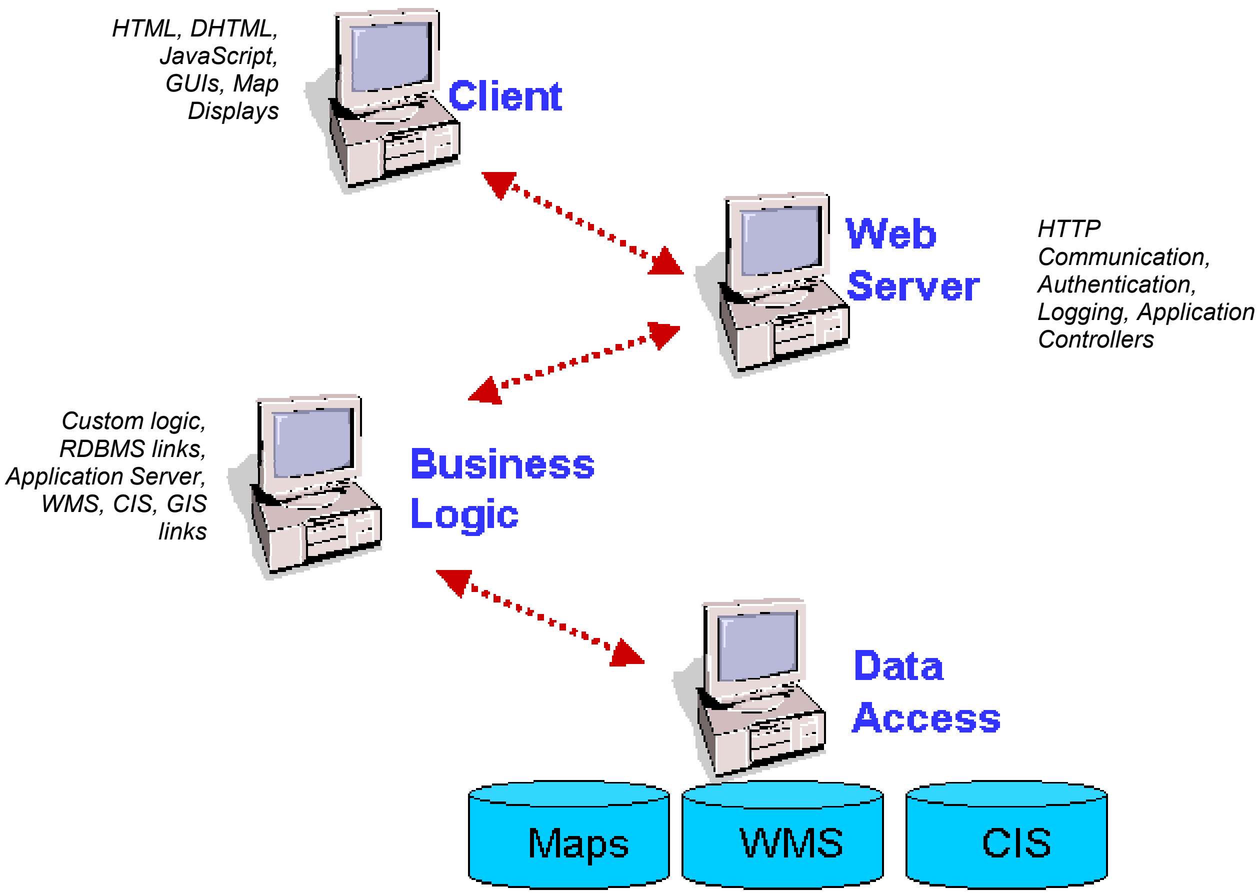
We've been flooded with technology, and the opportunity that it promises, to the point where keeping it straight is very difficult. Figure 1 illustrates a common starting ground.

Figure 1: "Lots of Good Ideas"



In building online mapping applications, we must carefully balance user needs with organizational goals and business objectives. Distributed Systems help by providing a framework where we consider larger systems in smaller, more manageable units and components. Large systems can be broken into logical parts and distributed across different resources in an organization. Figure 2 illustrates a distributed web-based GIS.

Figure 2: Distributed Systems



Conceptually, a distributed system is made up of client applications that communicate across a network and request services from a program listening on a designated part of the network (a "port"). Individual components are strategically placed along the path of the client-server connection to accommodate specialized needs.

The components of a distributed system are organized into tiers; Client-tier, Application/Business Log tier, and Data tier based on their overall role in the organization. The tiers provide a flexible and scaleable road map for laying out the pieces of an Internet mapping system.

Table 1 describes the various tiers and the components typically found in each tier.

Tier	Components
Client	The client tier serves as the "front-end" of the system. Users interact with an organization through tools, menus, and forms displayed in a web browser. Familiar web browsers include Internet Explorer, Netscape Navigator, and Opera, a relatively new, open source, browser that is

	gaining popularity. Client applications typically include: HTML/DHTML – Markup language used to present web content in a browser. Javascript – Scripting language that is embedded in web pages and interpreted as the page is loaded. The strength of Javascript lies in its close association with it's HTML document and it's ability to manipulate HTML elements (i.e., conditional processing, events, opening, closing, resizing windows, etc.). JSP/ASP – Tag libraries that facilitate the integration of dynamic content into an application. The tag libraries hold references to business logic and are easily incorporated into HTML web pages.
Application Tier	The application tier controls all the logic and processing that is necessary to fulfill the various requests initiated by the clients. In this tier, commercial off-the-shelf software is combined with custom programming to support the business processes specific to an organization. The "thread" between the various components in the application tier is the business process itself, not any inherent reliance on technology or vendor specification. Organizations mix and match solutions in this tier to create a best-of-breed solution that supports their unique institutional, financial, and technical environments. The application tier typically includes: Web Server – The web server is an application that listens on a specific port (usually port 80), for HTTP-based requests. HTTP is the protocol that web browsers understand and interact with. Typical web servers include Microsoft IIS, Apache, WebSphere, etc. Map Server – The map server contains support for processing map-based requests. The map server responds to a variety of requests ranging from simple navigation to queries and geospatial analyses. Usually a map server provides an image to fulfill the request, but where needed it may provide physical map features as well. Application Server – The term application server is very broad, but for the purpose of this paper, the application server describes the set of routines and processes that manages client requests and routes them to appropriate server-side processes. Server-Side Programming – In many cases, static HTML-based web documents are not sufficient to handle specific business processes. Essentially a new page needs to be generated for each request. Server-side programming consists of Java-based Servlets and CGI-like applications that act as an in-between component to link client requests

	with other back-end applications, such as ordering systems, password authentication, inventorying, and the like. For example, consider a mapping application. Server-side programming is used to process a zoom request by translating a user-defined extent into a new map image. Other Applications – Systems that provide support for Financials, Human Resources, Work Order Management, etc., are all accessed through the Application Tier. Combined with custom programming, an organization can achieve powerful, tailored, and integrated solutions. Database Connectors − Solutions that request services from data servers typically rely on connectors to gain access to the information stored in the database. The connectors typically are packaged as drivers and provided by the individual database vendors through an API that supports programmatic data manipulation. XML – (Extensible Markup Language), the “meta” markup language is used to describe structure and content for data transferred across a distributed system. It is easy to read, widely adopted, and perhaps most important is that the data can be processed easily by other applications. XML is the markup language of choice for exchanging data between application components.
Data Tier	The data tier contains the corporate data stores that support all aspects of the organization. Relational Database Management System (RDBMS) technologies provide storage, backup, and recovery capabilities. Extended support is provided for map-based layers to enable geospatial operations on location-based data stores.

Thinking about the various components in tiers help to organize and understand how the system ultimately functions. In addition, it enables an organization to align resources in a structured manner. The distributed approach minimizes the necessity for a single person to be an expert across every component and more effectively, places responsibility within the organization itself.

Hierarchical Model-View-Controller Framework

Conceptually, the hierarchical model-view-controller (HMVC) framework takes the ideas of distributed systems and embeds them as a framework that can be used in building online mapping applications. The model-view-controller paradigm has three key components:

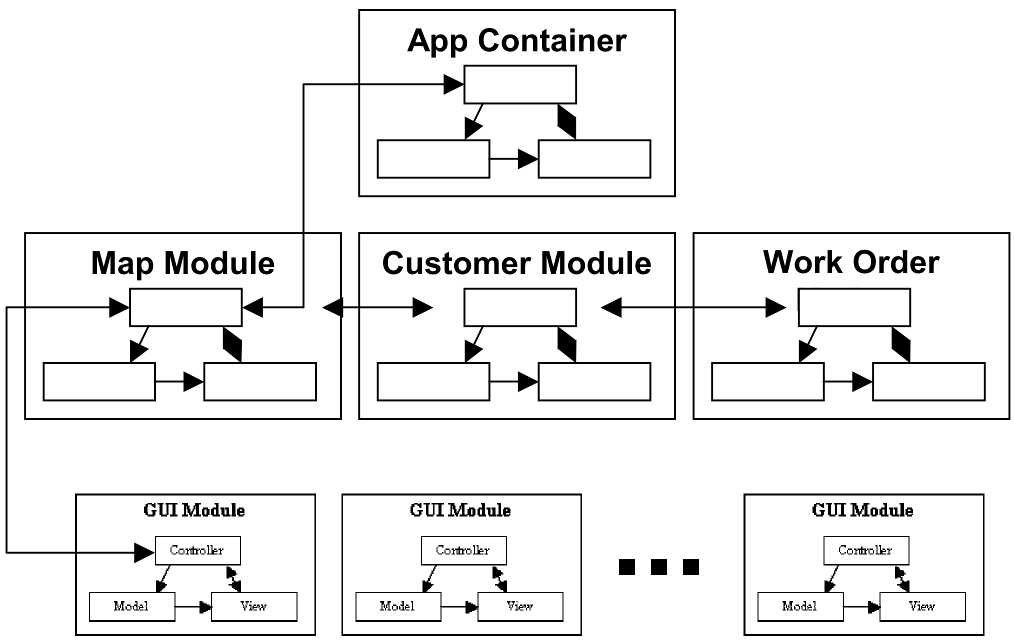
- Model – The model refers to the rules and logic that defines the business processes of the organization.

- View – The view is the end-user perspective of the system consisting of menus, tool bars, and graphics that gather information and display results to the end-user.

- Controller – The controller is responsible for controlling the flow and state of the application.

Figure 3 illustrates one approach to building an online mapping application with the model-view-controller framework. It relies on a triad of components that together solve specific, well-defined software problems, like map navigation, displaying work orders, and storing customer contact information. Using a layered, hierarchical approach, the individual subsystems communicate and work together to deliver a concise, map-based view of information to the end-user.

Figure 3: Hierarchical Model-View-Controller Framework



The HMVC Framework allows users to view subsystems of the overall application and to define requirements and resources along specialized skill sets. For example, the mapping subsystem includes navigation, query, and analysis capabilities that may be isolated from the larger system. Links to the larger system are provided to enable cross-module operations such as selecting a customer and zooming to that address.

HMVC provides a powerful, easy-to-understand, layered design approach for developing a mapping application that links together many systems. It is responsibility-based and provides the following key benefits:

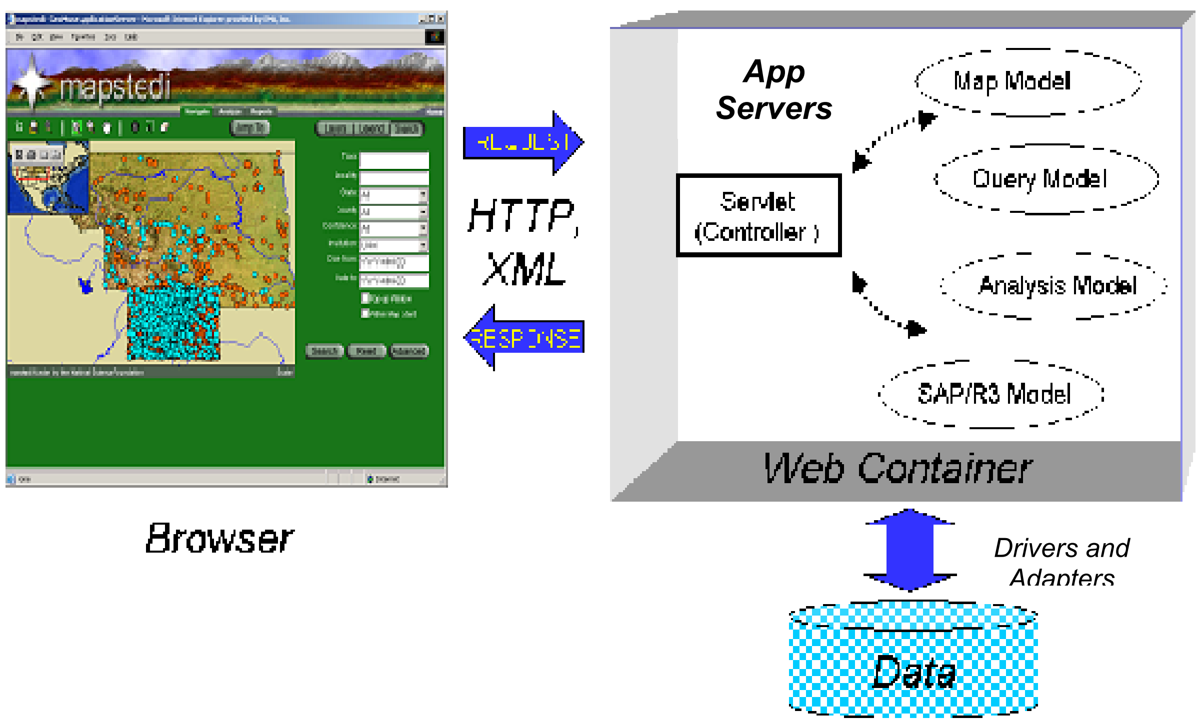
- Focused components – Components are isolated, encapsulating specific behavior and exposing that behavior through well-defined accessor methods.

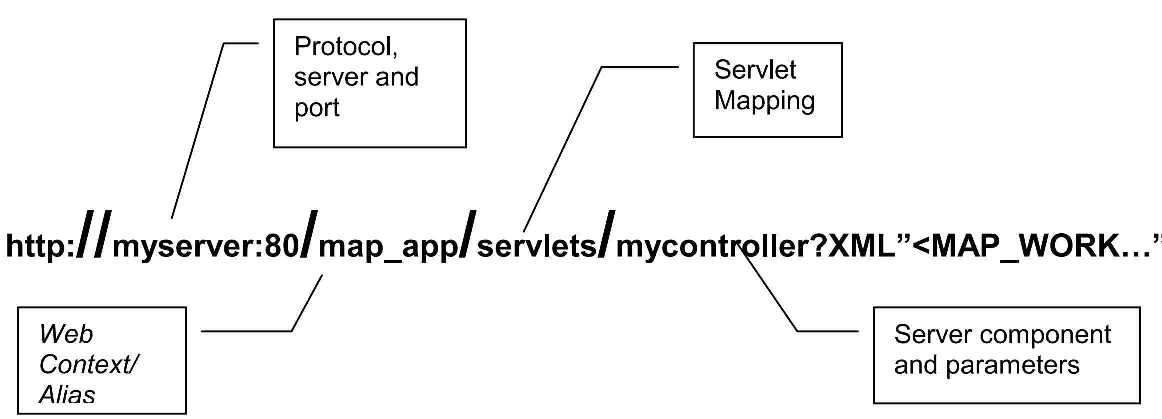
- Minimal coupling – The layered nature of the framework limits references across the components. Components are linked through parent-child relationships in the hierarchy.
- Localized exposure to third-party code. Each link to third-party code is handled in a specific MVC triad to limit the systems' dependence on the third-party code.

Putting the Pieces in Place

Many online mapping applications have been built around the concepts of distributed programming. Its inherent strength in linking seemingly disparate systems continues to drive its popularity. Some of the workflows and scenarios that have been developed include: locating service complaints, map-based management of work orders, geographic allocation of resources, what-if scenario modeling, and many others. Figure 4 illustrates an example application.

Figure 4: Online Mapping Site





Lessons Learned

To minimize risks and shift the odds toward a successful implementation of web-based GIS technologies, the following considerations are offered:

1. Consider organizational aspects of the implementation. Often times, the distributed nature of the online mapping application cuts across existing boundaries in terms of responsibilities, skill, and resources. Implementation activities must anticipate how the technology “fits” within the broader organization and continually address knowledge transfer, education, and other efforts that foster organization-wide adoption and support of the distributed solution.

2. Build strong project teams. Distributed implementations require input and collaboration from a number of “experts.” Include as many specialists as are necessary to accommodate the different technologies, business goals, and end-user perspectives.

3. Less is more. Focus on the simplest things that can work and use those components to validate design decisions and gain an appreciation for the distributed nature of the solution.

4. Keep it real. Only attack new features when they are absolutely needed. Many times features are conceptualized and built into systems only to be re-worked when they are packaged within the context of the broader application.

5. Iterative deployments. Allow end-users to gain familiarity and understanding for the distributed system by implementing development versions of working applications. Too often solutions are “delivered” and the initial exposure is vastly overwhelming to the majority of users. Iterative deployments can be used to introduce end users to not only the technical capabilities, but to help align resources and skill sets.

6. Timely development cycles. Break long development cycles into chunks that are as short as practically possible – three-four weeks – each reaching a modest goal that developers can commit to and deliver on.

7. Keep strong ties between developers and customers – let customer prioritize work and answer questions – shorter development cycles accommodate changing requirements.

8. Work at a realistic pace – overtime can be effective, but can’t be sustained.

9. *Test all the time*. Stay disciplined with regards to testing and data development. Most functionality requires modifications to data stores. Try to avoid developing capabilities until the data stores are available for testing and validation.

Conclusion

For centuries, people have recognized the inherent capability of maps to organize and communicate vast amounts of information clearly and concisely. The visual nature of maps helps people understand relationships that are just not "seen" in documents, reports, and spreadsheets. As organizations seek to leverage the power of map-based information to support their mission critical responsibilities, they are increasingly relying on distributed systems to drive their implementations.

Distributed systems align organizational resources and business practices into separate tiers based on inherent strengths – data tiers that store information, client tiers that present information, and logic/application tiers that link the two.

The distributed framework potentially exposes a new paradigm for thinking about software and information technologies. Rather than relying on specialized systems to deliver specific content (i.e., mail messages through Outlook, work orders in a WMS, maps in a GIS, etc.), we can envision a tiered system that packages and presents integrated views of that information in a format that is easy to use and understand. Application servers, potentially, mine various data sources, discern myriads of relationships and package that information for delivery to our desktop, cell phone, television or any other interface that is available. In the same manner that a map can organize work order data against a background of geographic features, a distributed framework can help organize the information and activities that make up our daily routines.

The paper presents online mapping in the context of distributed architectures and enterprise systems integration to provide a framework for considering web-based GIS implementation. But really, we've just scratched the surface of the conference themes – "Everyone's Online, Boundless Opportunities, Performance for a New Age." There are indeed boundless opportunities!