Simulation Over Geographic Information System (SOGIS) Web Service

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ABSTRACT: *Building on over two years of success in adapting geographic information system (GIS), simulation, and Web service technologies to support the planning needs of government agency coalitions, the Multi Agency Planning (MAP) MITRE Sponsored Research (MSR) team is working to integrate these technologies into a seamless Web service portal. Our approach is to use a GIS Web service as a display interface for both simulation results and operator status report information. We integrate a GIS Web service display into an exercise control pane, and feed custom GIS display layers with data from a metadata repository, which in turn is frequently updated by either simulation results or field status reports. The field status reports come from participants logged into a Web reporting service, and we anticipate the use of real-time sensor, global positioning system (GPS), and/or transponder based status data streams as automated sources of updates. The simulation updates come through a Web service developed in another MITRE research effort, called SimServer. We use existing simulations to produce an event and movement log that SimServer plays over the Internet to the MAP Workbench Metadata Server. We leverage the ESRI Tracking Server utility to provide GIS update data streams from the metadata repository as a Web service to thin SOGIS clients. We provide SOGIS client as a pane of the MAP Workbench but it can also be accessed directly. We hope to further evolve this capability in future research to support simulation interaction and composition via the GIS interface, and eventually to provide a simple simulation engine as a web service.*

1. Introduction

Building on over two years of success in adapting geographic information system (GIS), simulation, and Web service technologies to support the planning needs of government agency coalitions, the Multi Agency Planning (MAP) MITRE Sponsored Research (MSR) team is working to integrate these technologies into a seamless Web service portal. A major goal of this effort is to tie our simulation tools described in previous SIW papers [1] in with the other tools we have built or proposed for the Multi Agency Planners' MAP Workbench.

1.1 MAP MSR

The MAP MSR is investigating ways to improve multi agency planning and specifically multi agency information technology planning. Our team has focused on one guiding mission scenario for each of the three years of this project as a means to think through the multi agency planning problem, propose and test processes and technologies to improve multi agency planning, and identify technologies and constructs to support these proposed approaches to multi agency planning.

The first year (FY03) scenario looked at the interplay of commerce, customs enforcement, port security and counter terrorism in the shipping industry [2]. The second year (FY04) focused on the multi agency complexities of a mass migration reaction scenario, based on an actual Operation Plan called Vigilant Sentry. It included immigration, maritime security, foreign policy, domestic policy, law enforcement, counter terrorism, and humanitarian relief issues, in the context of an overarching multi agency operational mission [1]. The FY05 effort focuses on two different scenarios. One is a metropolitan homeland security scenario involving mass transportation, traffic management, and coordination between federal, state, and local agencies in a multi state region. The other is security and enforcement enhancements along the southern United States border, where federal, state and local multi agency planning and coordination must now address the benefits and impacts of significant new technologies that are under consideration for the region.

Results to date include a new multi agency planning readiness model, based on the LISI approach, an appreciation for the value of multi agency planning exercises as a means to work through issues and identify needs, and a realization that existing information architecture frameworks need to be significantly extended to meet the needs of complicated multi agency consortiums.

We have evolved a Web based environment that we call the MAP Workbench to support the proposed planning exercises and subsequent coordination and architecture development activities. We have also developed several small but comprehensive situation federations to support exercises and provide an executable architecture environment. What we are striving to do now is to link the simulation environment with the rest of the Workbench, to provide a convenient and accessible Web based multi agency planning environment to the large and distributed member communities associated with most multi agency planning problems.

1.2 The SOGIS Concept

Simulations of real world operations involve detailed depiction of, and interaction with, map and terrain data. Our experience with a typical military simulation, US Army Joint Military Art of Command Environment (JMACE), involved a considerable amount of scenario set up time devoted to finding suitable maps, bringing them into the JMACE environment, and overlaying specific entity tracks, all to lay the groundwork for the interplay between entities and the organizations that controlled the entities. We are also aware that GIS has grown into a significant community of interest, providing very capable Web based products, that largely do the same thing and more that we needed to do with a map backdrop for our scenario runs. The idea struck us that Web based simulation would be more convenient and powerful if we could leverage the mapping, spatial, and other environmental information provided by GIS to provide the setting for simulated operations. We could then focus our simulation efforts on realistic simulation of the movement and other status changes of the simulated entities in our scenarios. Conceptually this should be rather simple and straightforward, since GIS systems provide for easy extension through additional transparent overlay layers. So, we concluded, all we need to do is to find a way to tell a GIS that entities, as specified icons, should be displayed at specific locations at specific times, and then update those locations to achieve an animated effect.

Research shows that we are not the first to have this idea. For example, a 1991 Winter Simulation Conference paper describes a pre-Web standalone approach linking simulation servers with GIS servers [3]. However, we could not find any later reference to what became of this work. A recent survey of simulation used with GIS also reports that discrete event simulation leveraging GIS as a user interface is an area for development. It does however report that GIS is now widely used as an interface, or even as a simulation environment, for continuous and agent based simulations. These are most commonly environmental, demographic, or hydrographical simulations [4].

2. Technical Approach

Our approach is to use a GIS Web service as a display interface for both simulation results and operator status report information. We use a metadata server with a Web service interface to provide an exercise control panel. We integrate a GIS Web service display into this control panel, and feed custom GIS display layers with data from the metadata repository, which in turn is frequently updated by either simulation results or, potentially, field status reports

The field status reports would come from participants logged into a Web reporting service, and we anticipate the use of real-time sensor, global positioning system (GPS), and/or transponder based status data streams as automated sources of updates.

We use existing simulations to produce an event and movement log that we deliver over the Internet as a data stream. The MAP Workbench Metadata Server receives this stream and uses the metadata knowledge in the MAP server to transform the data stream to conform to a common taxonomy for the multi agency consortium. We then make this modified data stream available through the Web to the thin SOGIS-enabled clients. The end result is a dynamic GIS display layer that overlays the simulated entities with some status, state, or activity information over a map at the correct geographic location. This provides a readily accessible one-to-many display or viewing capability requiring only standard broadband Web access at the client sites. Figure 1, below shows our logical architecture we are using to guide SOGIS prototype development.

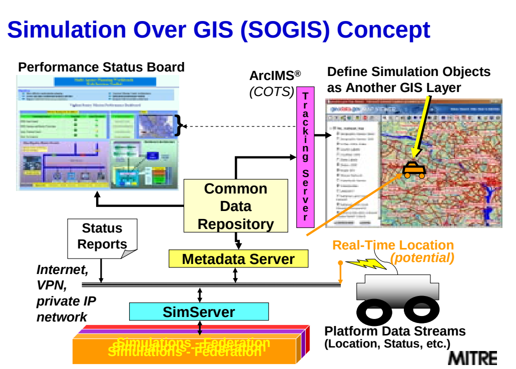

Figure 1. SOGIS Logical Architecture

2.1 Simulation Site Operations

For convenience we currently use the same simulations and federations we developed for the Executable Architecture Methodology for Analysis (EAMA) Case Study (EAMA-CS) [1]. An extension to the JMACE we made for the EAMA-Lite federation (JMACE plus ReThink) provides a data log file output option. This file is in effect a log of entity movement and events, shadowing the events sent out over HLA in the EAMA or EAMA-Lite federations. We were able to replay a JMACE run over SOGIS by using the old log files as input files for SimServer, and then using our SOGIS architecture to route from SimServer, through the MAP Metadata Server, and then to Tracking Server, which serves as the source URL for the SOGIS clients with the GIS map displays. Figure 2, below, shows a typical JMACE scenario that produces a data log for use with SimServer.

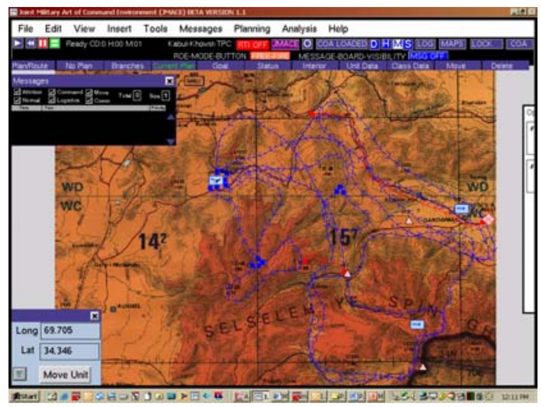

Figure 2: JMACE User Interface

2.2 SimServer

MITRE's simulation data stream service, SimServer, provides the simulation data stream to the MAP [previously defined as Multi Agency Planning] Metadata Server. SimServer borrows techniques and technologies from the Web Services world to offer 24/7 online access to simulated data streams for MITRE Corporation projects, such as the SOGIS component of the MAP Workbench. Data "consumers" go to a SimServer Web Site to plan, configure, execute, and monitor their data streams. Users can also visit SimServer to browse available simulation services and reuse or modify them, potentially foregoing the need to develop, configure, or run simulation resources from scratch. This online approach to generating data streams allows projects access to the data streams they need at a fraction of the cost and time of traditional methods. This is also very attractive for supporting the sorts of multi agency planning exercises envisioned by MAP, in that one or a few simulation sites can address the needs of a large distributed user population, while the users can access and replay simulation results at their convenience. We envision that this will nicely fit the typical usage pattern of running a specific scenario or use case simulation, letting the multi agency planning teams observe and analyze the run and the results, and then letting the teams determine adjustments to investigate for the next run. SimServer on the sending side and SOGIS on the receiving side provide an attractive architecture for this pattern of use.

SimServer operations are based on the premise that data streams can be produced by "configurations" of composable software components. The user builds his configuration by selecting from a variety of available data sources, transformers, and emitters. First, he chooses a data source that offers a scenario that fits the contextual needs of his experiment. Then he selects and edits the parameters of the transformers (i.e. interpolators, geographic filters, and formatters) he needs to manipulate the data. Finally, the user adds one or more emitters that direct the transformed data over the network to his receiving applications.

Once a configuration is defined, it can be launched and the status of the resulting data stream can be monitored from the SimServer site. SimServer allows a user to pause, resume and delete (terminate) any of his active data streams. [see also: 5]

2.3 The MAP Metadata Server

A critical issue for multi agency collaboration is a common ontology for operations, information needs, and products. We meet this need in the MAP Workbench with a semantic management service, that we call the MAP Metadata Server.

We base our semantic management on the W3C Resource Description Framework (RDF), described as "a language for representing information about resources in the World Wide Web" [6] [7]. We extend this concept to describe resources both on the Web and in the real world, specifically in the subset of resources available to or of interest to a multi agency consortium.

We use the MAP Metadata Server as both a repository of semantic knowledge normalized to a specific multi agency collaboration and as a tool suite to translate what we could call "native" information references to the correct corresponding multi agency normalized term or data type. In practice, this simply means that a "police vehicle", "patrol car", or "cruiser" in an agencies status report or entity initialization (say for a simulation or a transponder data stream) will consistently be recorded in the MAP Workbench name space as perhaps a "Vehicle, ground, sedan, police, …)" or some other common and unambiguous reference. Then we can associate other status data, such as time correlated location or readiness or activity, with that specific entity as the planning exercise unfolds.

In the specific case of the SimServer simulation data feeds, we use the MAP Metadata Server to translate what ever a specific simulation syntax and ontology provides as entity identity, locations and status information into the multi agency consortium's common agreed syntax and ontology. This way we adapt the simulation output to the needs of specific multi agency consortium, rather than require a number of existing simulations to rename, and in some cases reformat or even recalculate, the normal output of each simulation. This same approach will also support incorporating real time position and status data streams from actual vehicle or other systems transponders, as well as accept manual stays update streams, all without the need to change the normal output content or format of the transponders or report formats.

We use the translated location and status stream from the MAP Metadata Server as the sole input to the server or servers updating the SOGIS clients.

2.4 ArcIMS® Tracking Server

We are currently experimenting with an ESRI® utility and service called ArcIMS Tracking Server as our GIS update data server. We believe that using this fee for use service will be more efficient for most multi agency planning consortiums than attempting to build, and then host, a similar service on our own. ArcIMS Tracking Server will accept multiple input data streams, from the various multi agency data providers, and then host a position and status data stream. This approach can be wextended using ArcIMS Tracking Server applet plug-ins to dynamically update the arcGIS display client commonly available for use in Web based client applications [8]. One of our research issues is how well this approach works in representative multi agency planning situations, and whether typical member agencies accept the use, and cost, of a commercial fee based data server. Note though, that if display of simulation data updates is the only goal of a SOGIS implementation, it seems attractive to link SimServer with ArcIMS Tracking Server to provide end users with dynamic simulated entity location updates over a map. For MAP applications, however, we think that some Metadata Server capability is needed to transform data from several simulations or agency data feeds into some agreed common taxonomy. The MAP Metadata Server may also need to adjudicate multiple references to an individual entity to provide one "ground truth" for the GIS clients. If these services are required, the added value of ArcIMS Tracking Server needs to be relooked. Conversely, if ArcIMS Tracking Server is used for data collection and fusion, then the ArcIMS Tracking Server Tracking Viewer may be a preferred client-side solution. For now we are using ArcIMS Tracking Server to provide the update data stream, and our own client implementation.

2.5 The SOGIS Thin Client

We use Dynamic HTML (DHTML) and JavaServer™ Pages (JSP) [9] to build an overlay layer to display dynamic entity icons over a GIS map display. We use the ESRI® ArcWeb℠ Services for the client GIS display [10]. An alternative under discussion is to use the Tracking Viewer component of ArcIMS Tracking Server.

[Note to reviewers: we intend to revise and update this section and possibly the previous section prior to the final dead line for Spring 2005 SIW papers to reflect the outcomes of design discussions and experiments currently underway within our team.]

2.6 SOGIS as Part of the MAP Workbench

In addition to stand alone sites for viewing simulations over GIS displays, we also intend to integrate the SOGIS display as a window in our Multi Agency Planning Workbench. This will achieve our vision for linking simulation based executable architectures with other tools in an integrated multi agency planning environment. Figure 3 shows our current MAP Workbench prototype user site. SOGIS will replace the static simulation snapshot that is currently in the upper right pane.

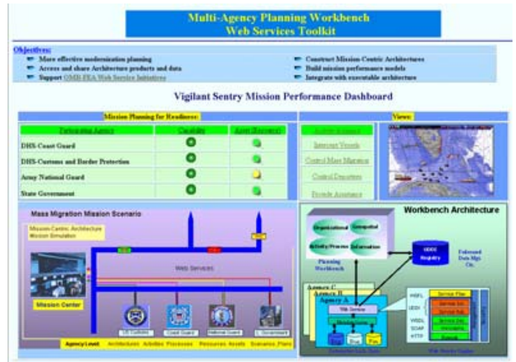

Figure 3: MAP Workbench Site

2.7 Potential Applications for SOGIS

We see our MAP workbench supporting multi agency planning exercises, which would serve as vehicles for moving multi agency consortiums up the Readiness Model ladder to greater interoperability on critical joint operations. This workbench and the exercises themselves would contribute to development of multi agency architectures that would guide each agency's own enterprise architecture to include provisions for multi agency participation.

Other uses for SOGIS include distribution of a simulation or federation display to multi observer sites over the Web. This could in turn support collaboration among the groups, increase mutual understanding, or support discussion of the simulated operations. Using some variant of SOGIS to link simulations into Web based command and control (C2) systems may prove useful.

3. Conclusion

We are culminating our three year Multi Agency Planning Workbench research with the integration of executable architecture and other simulations directly into the MAP Workbench Web site. We are using an approach we call SOGIS—Simulation Over GIS, to accomplish this by leveraging the power of GIS Web services to provide the client display at any number of distributed user sites. We are using our executable architecture federations and metadata server developed in previous years research to feed dynamic entity location and status updates to the clients, potentially leveraging COTS services for data transport and map data access. The result is a prototype full service workbench to support multi agency planning exercises aimed at moving multi agency consortiums to a higher level of interoperability, based on our Multi Agency Planning Readiness Model.

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