SahanaGIS A Rapid Deployment GIS Framework for Humanitarian Relief Operations

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Abstract

Sahana is a Free and Open Source Disaster Management system that began as a response to the 2005 Tsunami in Sri Lanka and has since been deployed in many disasters around the world. A major requirement arising from these deployments has been the need for Geographical Information Systems (GIS) capability, tightly integrated with the disaster management capability of Sahana. The GIS capability should be easy enough to be configured by a normal volunteer, but at the same time should be able to provide advanced capabilities normally associated with GIS.

As SahanaGIS is tightly integrated with the Sahana Disaster Management System, there are some implications that apply to SahanaGIS that don't usually apply to conventional GIS – most of them associated with the lack of time, personnel and resources during humanitarian relief operations. SahanaGIS is designed and structured to mitigate these problems as much as possible: it makes use of Open Standards, existing Free/Open Source GIS tools, access to a wide variety of services and data-sources, distributed and reuse centric architectures, service oriented components etc. as solutions to handle the issues associated with ad hoc disaster relief operations.

SahanaGIS provides the ideal platform to rapidly deploy a workable GIS solution to aid in humanitarian operations: it also allows more advanced GIS capability to be integrated via interoperability. This paper looks at the approach followed to build the framework and the important design decisions in the framework architecture to cater to this specific domain. It looks at some requirement scenarios that have directly influenced changes in the architecture, as well as the solutions that were used to cater to it. It also looks at the importance of having reusable components and the advantages of using F/OSS solutions. It provides a case for interoperability by explaining the importance and advantages of using open standards and sharing data. It also looks at the implications of being tightly integrated with a disaster management system.

1. GIS for Humanitarian Relief

Sahana (Sahana 2005) is a web based collaboration tool that addresses the common coordination problems during a disaster from finding missing people, managing aid, managing volunteers, tracking camps effectively between Government groups, the civil society (NGOs) and the victims themselves. Since its first deployment in 2005 for the Asian Tsunami, the Sahana Disaster

Management System has been deployed and used in major natural disasters around the world, ranging from China to the United States. The Sahana project gains valuable feedback and requirements from these deployments, and nearly all these requirements consist of the need to have some sort of GIS capability built into the system.

The usage of GIS in humanitarian relief operations is not a new concept, and the importance of it, as well as the practical issues associated with it is well known and well documented (Currion et al, 2006).However, with a visible increase in the number of natural disasters in recent times, usage of Sahana to mange these has increased as well, making the need for good GIS capabilities in Sahana that much more important.

SahanaGIS is a project within Sahana to build a GIS framework that can be used to rapidly deploy GIS for humanitarian relief operations. Due to the time constraints associated with ad hoc response operations, there usually is difficulty in obtaining quality spatial data of the region concerned as well as difficulty in finding specialized GIS personnel. SahanaGIS attempts to solve these problems, by building a flexible F/OSS GIS framework built on Open Standards.

2.   Sahana Deployment Requirements for SahanaGIS

The Sahana Disaster Management System has been deployed in the aftermath of many disasters, to help coordinate and manage disaster relief operations. These deployments have nearly always been major case-studies for Sahana, where much insight is gained on how the system operates in actual usage scenarios, how intuitive and usable it is, how flexible and scalable it is. Specific requirements and feedback from users of the system have immensely helped Sahana to become more practical and relevant to its domain.

The deployment map in Figure 1 shows the various Sahana deployment globally. The colored regions of the map show thevarious locations that Sahana has been officially deployed and used at. An official deployment here means a deployment that is done in collaboration with the Sahana community, with preferably a notification on a Sahana mailing list, or with the approval of the Sahana project management committee. Of these deployments, the regions in red are where GIS capabilities of Sahana were used or where there were further GIS requirements as well. The regions colored yellow were where Sahana was used without GIS capabilities.
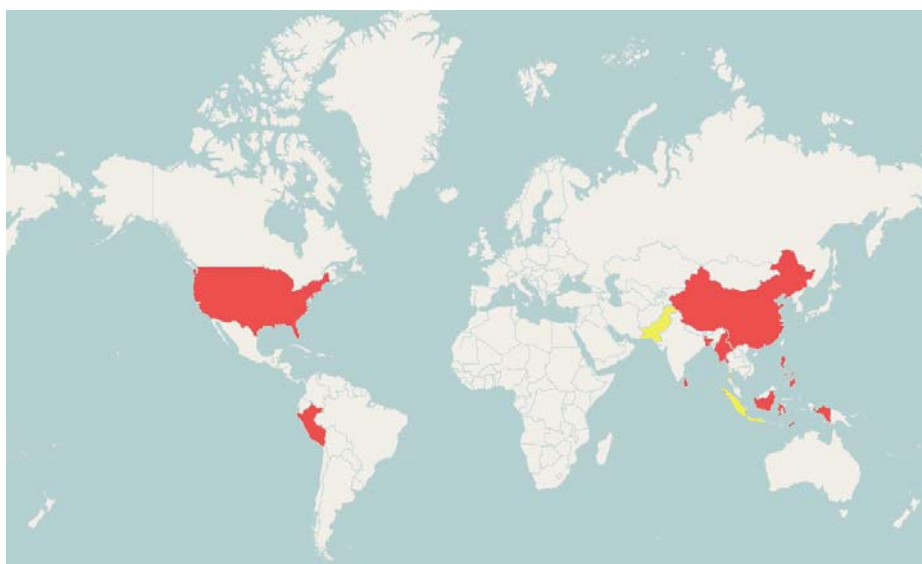

Figure 1. Sahana deployment and GIS usage map

The usage of GIS capabilities at various levels in Sahana during a deployment, and the feedback or additional requirements resulting from it, have influenced the design decisions of SahanaGIS. As newer deployments take place, it is expected that SahanaGIS will continue to evolve based on feedback obtained from them. Along with changes to the overall GIS architecture, some deployments have required quick solutions to specific problems, which have had to be provided as quick hacks in very short periods of time.

Following are described some of the requirements arising from historic deployments, solutionsreached, and differences made to the overall architecture:

2.1. Sahana Shelter Management for New York City

Sahana was implemented in the city of New York in 2007, as a pre-deployment as part of its Coastal Storm Plan. The system was customized for Mass Evacuation and Shelter Management System, and was used to store information regarding 500+ shelters, 20000+ staff etc. The system already consisted of many tabular reports. Addresses for all shelter locations were available in separate spreadsheets already. A requirement was to also provide simple map-based reports of shelter locations, to aid in decision making, and to provide users with the ability to enable/open shelters from a map-based interface. The customizations were required to be completed in 2 months.

Due to the time constraints, it was decided to use Google Maps to provide map-based reports and simple interfaces. The team made use of Google's geocoder to bulk geocode the shelter locations via web services. A problem faced however was the long response time it took to geocode 500 entries: the Sahana web interface for geocoding usually took around 5-10 minutes to respond, which disrupted flow. The team managed to reduce the response time by categorizing the 500+ shelter addresses into the 5 New York boroughs, and allowing bulk geocoding by boroughs, thus reducing the response time to nearly 1 minute.

2.2 Myanmar/Burma Sahana Deployment and OSM

Sahana was deployed for the Myanmar cyclone relief efforts in June 2008. There was a requirement here to have up-to-date maps of the region, showing affected areas, and to use those maps as data-sources withing Sahana. The existing data sources used in Sahana contained relatively older maps, and thus some sort of collaboratively edited mapping sources were required.

The deployment efforts were handled by members from the Sahana community, the OpenStreetMaps(OSM) community and the Myanmar IT professionals community. It was decided to use a locally hosted version of OpenStreetMaps, edited by the local community to contain updated data for the region. The idea was to selectively commit changes to the upstream OpenStreetMaps servers periodically as well, thus ensuring that valuable new data from this deployment was reflected in OpenStreetMaps as well. Usually, the latest stable version of Sahana is used for deployments, since they have undergone rigorous testing and are thus more suitable for usage than its unstable development counterpart. However, the GIS catalog functionality was only available in the unstable Sahana trunk: this GIS component was merged with the stable version of Sahana for use in the Myanmar deployment. The community obtained and setup a local OSM

server, which was then accessed by Sahana as Tile Mapping Service (TMS). The Sahana GIS catalog at the time didn't handle TMS, so this feature was built in and committed to the Sahana code base before being used for the deployment. The Myanmar IT Professionals community added new data via GPS units to the local OSM server, which in turn was accessed via Sahana.

3.   Design of GIS Functionality for Sahana

As a F/OSS project, SahanaGIS has the advantage of being designed, developed and reviewed by a large community, consisting of humanitarian experts, GIS specialists, GIS developers, GIS users and Sahana end users. Even though it might take slightly longer to reach community consensus for design decisions, it pays off in the end since the solution turns out to be one that is approved by a large group of people. The following are some of the SahanaGIS design goals for the current architecture.

3.1 Design Goals of SahanaGIS

The following are some important design goals of Sahana.
- The GIS functionality of Sahana should be tightly integrated with Sahana
- SahanaGIS should be able to integrate and work with existing GIS infrastructures, data-sources
- SahanaGIS shouldn't be limited to a few data-sources, but must allow users to select their sources from a wide variety of options
- The GIS functionality of Sahana should be intuitive and easy to configure by normal users, since this might be used a lot in humanitarian situation where specialist GIS users might not be available.
- The GIS architecture of Sahana should promote distributed development
- The system should be built in such a way that changes in architecture due to newer requirements or feedback resulting from deployments should be possible without too much disruption in the flow of development

With these design goals in mind, the following decisions were taken as the GIS architecture approach for Sahana
- SahanaGIS should be built as a distributed architecture of small reusable components that serve each other – this would make the system more flexible and customizable, and would help in the design of the section mentioned below.
- Each component would be standard-compliant based on Open Standards. Thus they can collaborate with existing data-sources that adhere to standards as well. For instance, the Sahana GIS catalog module uses the OGC standards (OGC, 1994) WMS, WFS to retrieve spatial data sources: thus any data served as WMS, WFS can be accessed and viewed by SahanaGIS.
- Each component should re-use from existing F/OSS solutions where possible: thus making use of the global knowledge base of the F/OSS GIS community. SahanaGIS currently uses F/OSS tools such as OpenLayers, UMN MapServer, Proj.4 etc. which provide the required base functionality for SahanaGIS. This means that critical functionality required for

SahanaGIS is already available via many stable projects.

 – Even though advanced GIS analysis capability would prove to be advantageous, it cannot always be assumed that the required GIS infrastructure would be available during disaster response - thus the system should be built for the lowest common denominator environment. Sahana can be used with a wide variety of databases, ranging from SQLite to Oracle. SahanaGIS is designed to maintain this database independence by storing spatial data as simple floating point values instead of the OGC (OGC, 1994) formats: Well-Known-Binary (WKB) or Well-Known-Text (WKT), thus ensuring that Sahana data can be used across databases, regardless of whether they support GIS data storage formats or not.

 – Sahana should contain an index of freely available spatial data-sources, and the administrators of the system should have the ability to add new sources as required.

 – SahanaGIS should provide mechanisms to efficiently publish or share its spatial data to be used by external systems, as decided by the administrator of the system.

4. SahanaGIS Architecture

SahanaGIS is the generic term used to describe the GIS functionality of the Sahana DMS. Sahana is a web-based application built using the LAMP (Linux-Apache-MySQL-PHP) stack. It has a modular architecture, where components that perform specific functional tasks such as capturing information regarding shelters etc., are built as modules which can be added or removed as required. Sahana is built on top of the Sahana Application Framework (SAF), which is a PHP framework built to host the Sahana Disaster Management System modules.

The Sahana Application Framework consists of APIs and libraries that provide technical functionality to the Sahana modules. SahanaGIS consists ofcomponents of the Sahana Application Framework, which consists of libraries and APIs that provide GIS functionality to the Sahana modules (Careem et al, 2007), as well as modules that provide GIS functionality directly to end-users.

The current SahanaGIS architecture (Sahana GIS, 2007), as depicted in Figure 2, consists of the following components, based on the above goals and decisions.
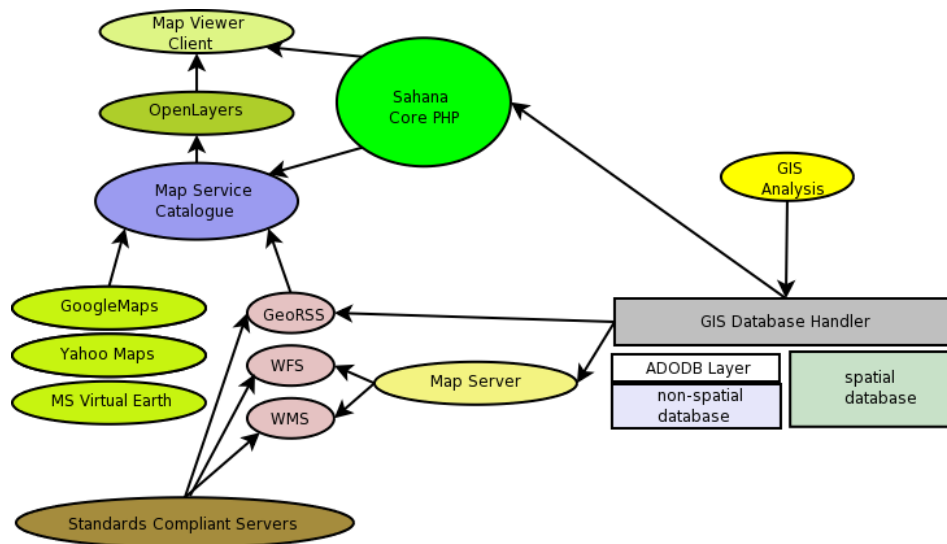
Figure 2. Sahana GIS Architecture Diagram

Libraries and framework components:

- Map Viewer Client: This module provides a map viewer client which allows to view maps from different sources. This is currently built using the OpenLayers Javascript library.
- Map Service Catalog: This is a generic GIS catalog module that provides administrators of Sahana with an interface with an index of available spatial data-sources. Administrators have the ability to add/edit data-sources, manage visibility of data-sources to end users etc. As shown in the image below, the Map Service catalog currently handles WMS, GeoRSS data sources, commercial APIs such as Google Maps, Microsoft Virtual Earth, Yahoo Maps, Multimap, file layers such as KML, OSM. The objective of the Sahana GIS Catalog module (Figure 3) is to make the management of spatial data-layers that much more easier and provide users with as much choice as possible – this is part of SahanaGIS' design goal of making the GIS functionality of Sahana more accessible and user-friendly to normal users - which means that a fairly substantial GIS can be configured by someone with little or no experience of GIS.
- GeoRSS Import/Export: This module provides Sahana with the ability to import GeoRSS feeds from external sources, as well as export Sahana data as GeoRSS feeds. At deployment, Sahana could contain a rich set of data regarding the disaster it is setup to manage: the ability to share this data integrated with spatial data of the region would mean a rich set of geographical data being served out to the GIS community in times of a disaster.
- Cascading Map Server: provides the ability to host spatial data from within Sahana by making use of a mapping server such as UMN/Mapserver.
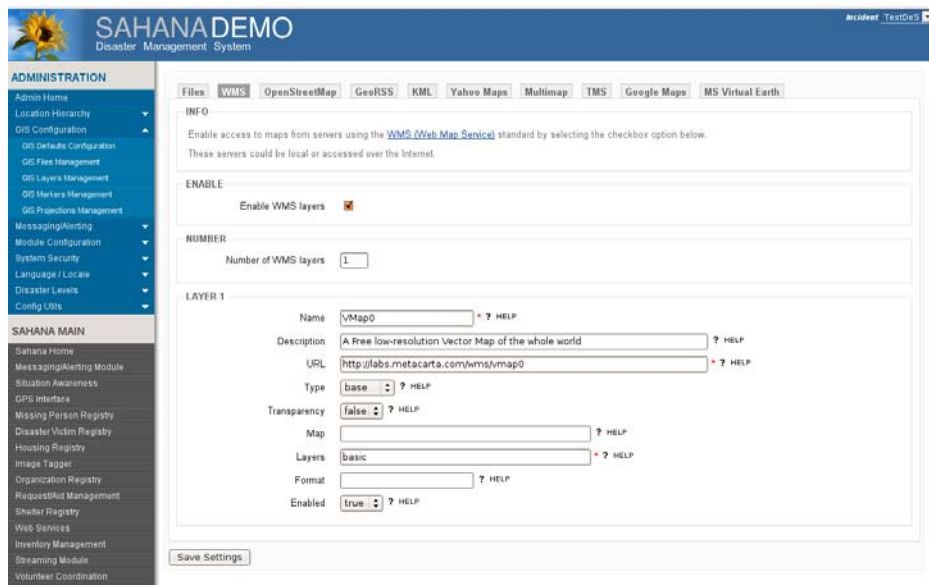- Spatial Database: Spatial database such as PostGIS, which could be used for GIS Analysis

Figure 3. Sahana GIS Catalog Module

Applications:

- Situation Mapping: This is a Sahana module that allows users to collaboratively manage situations by entering information and related media for specific points on visual maps.
- GPS Interface: This module allows GPS tracks and waypoints to be uploaded to and downloaded from Sahana and GPS devices. The module uses F/OSS tools such as GPSd and GPSBabel.

5. Conclusion

SahanaGIS is a rapidly developing GIS framework for disaster management that is adding to the capabilities that have made Sahana an internationally recognized success. SahanaGIS builds upon a foundation of experiences learned through deployments around the world. SahanaGIS builds upon open standards allowing it to be integrated along side existing and complementary efforts. SahanaGIS leverages existing work done throughout the F/OSS GIS world.

References

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