The Andean Information System for Disaster Prevention and Relief: SIAPAD an initiative for the development of a thematic SDI

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Abstract

The Andean Information System for Disaster Prevention and Relief – SIAPAD (as it is called in Spanish) is an Andean Committee for Disaster Risk Prevention and Relief (CAPRADE) initiative oriented to provide tools for data and information discovery, visualization and to facilitate access to the data available in the different technical organizations of Andean countries participating in the initiative (Bolivia, Colombia, Ecuador, Peru). SIAPAD includes a geoportal aiming at making available relevant information to support decision making during the different phases of the disaster risk management process (prevention, mitigation, preparation, relief). The architecture of SIAPAD promotes and takes advantage of the current initiatives oriented to develop a Spatial Data Infrastructure in the Andean Community. This paper describes the functions and architecture of SIAPAD.

1. Introduction

Effective decision making in the field of disaster risk management requires information on hazards, vulnerability conditions and the risk a specific territory, and the community living in it, is exposed to. This also involves knowledge of the human resources, legal frameworks, material resources and methodological tools available to support implementation of disaster risk management policies. The Andean region presents conditions that make the information management a priority in disaster risk reduction strategies. In particular:

- Significant recurrence of potentially disastrous natural phenomena (earthquakes, volcanoes, floods, etc.).
- Growing vulnerability as urban population expands without appropriate planning.
- Local institutions and organizations capture and process information about disasters (e.g., meteorological institutions, seismic institutions, etc.). However, usually it is difficult to access the information or even know about its existence.

Therefore, it is necessary to promote in this region the development of information systems that increase the visibility and access to the information that usually is associated to geographic references. For this purpose, internet and web based solutions, linked together by standards oriented to sharing geographical information, provide an adequate technical context with acceptable costs.

This paper describes a technical solution, called SIAPAD, an information system that has been developed to answer this need of an information system to share geographical information. The paper describes, first, the context under which SIAPAD is being developed. Next, the paper describes details about the SIAPAD application and its relation with the implementation of Spatial Data Infrastructures in the region. Finally, the paper presents references to related work.
2. The CAPRADE AND PREDECAN Project

In the framework of the Andean Strategy for Disaster Prevention and Relief, which is promoted and led by the Andean Committee for Disaster Prevention and Relief (CAPRADE), activities related to the creation of an Andean Information System for Disaster Prevention and Relief (SIAPAD) had been included in the Thematic Axis 2 “Information, research and development”. This initiative is supported by PREDECAN, a European Union – Andean Community financed project dedicated to build capacities for disaster risk prevention in the Andean Community.

The general objective of PREDECAN is to contribute to the reduction of people and infrastructure vulnerability to natural disasters and to promote sustainable development. More specifically, the project aims at the improvement of disaster risk management capacities through the strengthening of national institutions, policies and the coordination to carry out planned activities. The project has five lines of action: a) governance: organizational, legal and policy frameworks, b) knowledge of risk and information system, c) risk reduction and land use planning, d) communication and education, and, d) local pilot experiences. These lines of action are in direct connection with those established in the Hyogo framework for action 2005-2015.

Activities regarding the definition of SIAPAD’s graphic interface and functional design began late 2005. A preliminary diagnostic was carried out in order to assess the region's state of development concerning risk management data production and publication. The study mainly looked at existing national or transnational information systems, data availability, and the technology used to serve data over the Internet. The results of the diagnostic, validated in regional events, were used to define what the SIAPAD should be: a tool to facilitate the discovery and access to existing data produced by scientific and technical institutions of the region.

In order to achieve SIAPAD’s main objectives, CAPRADE with the support of PREDECAN and technical assistance of private companies (SUNGEMINI and IVER Technology) executes a working plan that includes: capacity building (use and implementation of standards for data cataloguing and interoperable Web services for data sharing); software development (search tools and protocols), and hardware provision. All activities concerning the development of both SIAPAD graphic interface and functional design are carried out through a participatory process involving data providers as well as information users.

The SIAPAD system is expected to be fully operational by the end of August 2008.

3. The SIAPAD application

The major goal of SIAPAD’s project is for the technical institutions of the region, which provide risk related data and information, to define and implement standards for data and information cataloguing and publishing. Most of today’s risk related information availability deficiencies are derived from technical difficulties to share information between different stakeholders. Though the weight of political issues can not be disregarded either. SIAPAD includes a geoportal, an Internet access point, providing tools for data and information discovery, and visualization. The SIAPAD searching (information) sources are different technical organizations of the Andean countries (Bolivia, Colombia, Ecuador, Peru). SIAPAD aims at making risk management relevant information available to a wide range of users, who in turn could use it to support decision making during the different phases of the disaster risk management process (prevention, mitigation, preparation, relief). The portal increases the visibility of the information about disasters and risk management produced by the different institutions, contributing to a
more effective execution of their tasks.

SIAPAD is an initiative that contributes to the solution for a problem with a great social and economic impact by using an advanced technical approach adjusted to the particular conditions of the Andean Community countries. The main goals of SIAPAD are the following:

- **SIAPAD** is oriented to provide support to the different actors who participate in the risk management process. For this purpose, SIAPAD provides automatic tools to find the required information resources in the Web (internet) with automatic specialized search engines and visualization tools.

- SIAPAD also contributes to promote a general normalization and standardization of the processes for producing and disseminating relevant information about disaster risk management processes.

The main principles applied in the design of the system are:

- **Distributed information production.** The information producers are mainly the different institutions in the Andean Community that generate useful information for planning and executing tasks oriented to risk management. Each local institution is responsible for producing and maintaining the information that it administers, i.e. SIAPAD is not a producer of information. The existing information managed by the institutions follows different formats. For example, in the case of geographical information, the information follows different coordinate systems.

- **Sustainable technical solution.** The applied technology must have acceptable costs according to the development conditions of the countries of the Andean Community. In addition to that, the technical solution must be flexible to accept changes in the future to allow the inclusion of new components.

- **Wide range of users.** Since SIAPAD is oriented to increase the information access, the technical solution must be easy to use for both users who are familiar with disaster risk management tasks and, also, general users. This also includes both users from the Andean Community and international users. For instance, SIAPAD can be useful for decision makers (in governmental local or national sectors), territorial planners at the technical level, persons in charge of preparation and operational attention of disasters, academic and scientific sector for research tasks, educators, press, public in general, etc.

### 3.1. The functionality of SIAPAD

The conceptual model guiding the SIAPAD graphic interface and functional design emphasizes the need to establish a closer link between the users and the producers. It aims at defining not only the type of information product that such a system should deliver but also the most appropriate way that information should be presented to the user in order to facilitate its use. For this purpose, it presents different mechanisms for data searching and retrieval designed to help different user types. At the same time the tool intends to provide means to assist in the education process of non-specialized users.

Access to the information is provided with the help of a web portal containing search methods and visualization tools. Figure 1 shows the current graphical design of SIAPAD web portal prototype.
The web portal provides three different searching methods:

- **Keyword-oriented search.** This method uses specific keywords to find the required information. For this purpose, the user writes one or several words to direct the search. The user can also constraint the search by providing spatial and temporal references. SIAPAD looks for information that is organized following standards for data documentation. This search method is effective when the available information is adequately documented with metadata as it is done in Spatial Data Infrastructures. In the Andean Community, this is currently being developed but, at the present, it is still partially available, so additional searching methods are also required.
- **Thematic search.** This method provides to the user a hierarchy of themes related to disaster risk management. The user selects the particular theme by using a hierarchy browser. This search method is effective for users who are specialized in the vocabulary of disasters and risk management processes.

- **Task-oriented search.** This method provides the user a set of prefixed typical questions to help in usual tasks related to disasters. This is especially useful for general users that are not familiarized with the vocabulary about disasters and risk management. The total set of prefixed questions is organized for different types of users (for example, researcher, general-user, territorial-planner, etc.) and, within every type of user, for different tasks.

Thus, besides the keyword-oriented search, SIAPAD helps users in the searching process by
The metadata repository in each facilitator node is populated by two different mechanisms: external applications searching for available data. This discovery service is used both by the SIAPAD application running in the facilitator node and also by available for searches via a standard Catalogue Service for the Web (CSW). This discovery service is used both by the SIAPAD application running in the facilitator node and also by external applications searching for available data.

In order to present such information, SIAPAD uses a specialized geographical viewer (figure 2) that shows to the user the information results found by the search methods.

3.2. The SIAPAD architecture

SIAPAD follows a distributed organization in a network of information according to international recommendations for data interchange (Davies, 04). It is conceived as a component of a thematic Spatial Data Infrastructure following standards for web services for geographical information promoted by international initiatives and international organisms (OGC, ISO, INSPIRE, 05). The system forms a network of five national nodes called facilitators. The goal of each node is not to produce information but making the information access easier to the different web servers in the Andean Community and presenting it in useful form for decision makers. The organization is open in such a way that it gradually allows an easy inclusion of new information and nodes without software changes in programs.

As can be seen in Figure 3, the facilitator nodes keep a local metadata repository, which is available for searches via a standard Catalogue Service for the Web (CSW). This discovery service is used both by the SIAPAD application running in the facilitator node and also by external applications searching for available data.

The metadata repository in each facilitator node is populated by two different mechanisms:
Automated metadata harvesting. The metadata manager can be configured to harvest metadata records from the standard discovery services provided by the server nodes. This is the preferred way to collect metadata, since it keeps the local records at the facilitator in synch with the original metadata.

Manual metadata insertion. The metadata manager also allows the addition of new metadata records to the repository. This option is used only in the case that some metadata of interest for SIAPAD must be searched locally but cannot be automatically harvested.

Although not shown in the figure, each SIAPAD facilitator can also be configured to search in other catalogues. The performance of these external searches is not as good as the local one, but they provide a way to search in catalogues which for convenience or technical limitations are not harvested. For instance, other SIAPAD facilitator nodes are searched in this manner.

The SIAPAD searching and visualization engine has been developed through the integration of existing open source tools, which are strongly compliant with open standards. GeoNetwork Open Source is used as metadata manager and CSW server, while the SIAPAD application uses the PostgreSQL database and components from the Community Mapbuilder library. The design is flexible enough to inter-operate with the diverse software platforms and data management formats used by corresponding institutions in the Andean Community.

3.3. The SIAPAD search model

The search system is the core of SIAPAD as an information system focused on a certain domain (disaster risk management) and a range of user profiles. The local configuration for facilitator nodes includes a common dictionary for keywords and their synonyms, related to disaster risk management. The key idea of the SIAPAD search system is that all user queries are finally transformed into a search expression built from the keyword dictionary, using parenthesis and logical operators (conjunction = AND, and disjunction = OR). This logical expression is then passed onto the CSW search query via the OSG Filter XML (OGC 5b, OGC 07).

The search models must then provide a way to generate appropriate search expressions based on simple user choices. The following two main models support the searching methods: (1) the thematic model includes the set of physical phenomena considered by the node (earthquakes, hurricanes, floods, etc.) together with the set of risk management processes at different levels of detail, (2) the task model includes the set of user roles together with the typical tasks and usual questions for each user profile.

Figure 4 shows the components of each model and how the user choices are transformed, by means of lookup tables, into the final search expression. In the case of the thematic search, the user can select either a physical phenomenon or a specific theme within a risk management process, or both. Each phenomenon has an associated keyword, given by table P, and each theme has an associated keyword expression given by table T (the expressions in table T and Q are formed using keywords from the common dictionary). The base search expression is then built as a conjunction of the keyword from the chosen phenomenon and the expression from the given theme. A similar sequence is followed in the case of the task-oriented search.
A problem arises in the search process because many keywords may have synonyms used in the metadata records (for instance, “earthquake” has up to six synonym expressions in Spanish), and therefore the base search expression may not find many relevant records. To consider those synonyms in the search, SIAPAD use a technique known as synonym expansion, which consists in substituting each occurrence of a keyword in the base expression by a disjunction of all its synonyms (in the figure, “F” is changed into “(F₁ or F₂ or F₃)”, and so on). This expansion is available in some search engines like Lucene, but unfortunately not directly supported by CSW or its implementations on the server side—a GeoNetwork implementation is expected soon-, which means SIAPAD as client application has to take care itself of performing the expansion on the search expression used in the CSW query. See (Buttcher, 04) for a similar approach in the biomedical domain.

4. Related work

Several works (GDIN, 2005; Peng and Tsou, 2003; Crossland et al., 1995) have shown that Internet and Geographical Information Systems are useful mechanisms that can facilitate the information exchange about disasters. At the global level the “Infrastructure for Spatial Information in Europe –INSPIRE” and the “Open Architecture for Risk Assessment – ORCHESTRA” have been used as reference models (Inspire, 2007). As example of information system initiatives known regional at the regional level it is worth to mention:

- DesInventar: DesInventar is a conceptual and methodological approach to collect and register data about characteristics and effects of diverse types of disasters, with special
interest in those disasters that are invisible when looked at from a global or national scale. DesInventar uses a tailor made software tool allowing data collection, processing and analysis. The disaster effects inventory was designed and implemented by the Observatorio Sismológico del Suroccidente Colombiano – OSSO and “La Red” for social studies in disaster prevention in Latin America – (La Red, 2007)

Geosemantica: is a web based collaborative workspace developed under The Andean Multinational Project “Geosciences for Andean communities (PMA:GCA)”. The project, which is funded by the Canadian International Development Agency, began June 28, 2002 and includes Argentina, Bolivia, Canada, Colombia, Chile, Ecuador, Peru, and Venezuela. The main goal is to contribute to improving the quality of life for the people of the Andes by reducing the negative impact of natural hazards (earthquakes, landslides, and volcanoes). Through the project, updated and integrated geoscience and geospatial information on natural hazards will be provided for:

1. Land use planning
2. Management of emergency of natural hazards

Geosemantica repositories contain georeferenced information such as satellite images, information about geology, infrastructure (ports, airports, highways, pipelines etc.), political boundaries, inventories of geological risks, refineries, power stations, hydropower plants etc.

- “Red BiVa –PaD” (Disaster risk and prevention relief digital libraries): the Regional Disaster Information Center Latin America and the Caribbean (CRID) is an initiative backed by six organizations who decided to join efforts in order to assure the compilation and diffusion of available information about disasters in Latin America and the Caribbean Region. Crid’s main objectives are:

  o Improve and extend the recompilation, processing and transmission of information about disasters, offering services of quality information to a wide range of users in the Region.
  o Strengthen the capacity of create and maintain information centers and documents about disasters on the Sub-Regional (Central America, the Caribbean Region, South America), national and local level.
  o Promote communication via Internet and create electronic information systems.
  o Contribute to the Regional System of disaster information.

SIAPAD is an initiative that is based on, and contributes to, the advance of the Andean countries national spatial data infrastructures (national SDIs). The Andean region is not strange to global developments in the field of geo-information management. Though with different levels of progress, all the Andean countries are working on the definition and implementation of data cataloguing profiles (metadata), interoperability standards, policy and legal frameworks to create their national SDIs. The SIAPAD system is built on such developments. Peru has recently approved (October 2007), through a law decree, the creation of the permanent committee for the establishment of the Peruvian Spatial Data Infrastructure (IDEP); in Colombia the Colombian Spatial Data Infrastructure (ICDE), led by the Agustin Codazzi Geographic Institute (IGAC) published in March 2007 its first geo-portal offering an important number maps and data layers together with a metadata catalogue and search tools, all of this as the result of more than five years of constant effort. In Ecuador the National council for Geo-information (CONAGE), created in 2004 through a law decree, has been tasked with the responsibility of developing the Ecuadorian Geo-Spatial Data Infrastructure (IEDG); Bolivia still lacks a national SDI initiative but there are institutional initiatives.
Along with these national SDI initiatives, there are other information system developments specifically dealing with disaster risk related information management, among which are the following:

- The Colombian Geographic Information System for Disaster Prevention and Relief – SIGPAD being developed by the General office for Disaster Prevention and Relief – DPAD.
- The Peruvian National Information System for Disaster Prevention and Relief – SINFAD developed by the Peruvian Civil Defense National Institute- INDECI
- Although still in its preliminary stages of development it’s worth to mention the Ecuadorian risk management and early warning Information System, developed by the National Civil Defense and the National Planning Department (SENPLADES).

5. Conclusions

In summary, the SIAPAD system, one of the results of CAPRADE under the support of PREDECAN project, has been conceived as an answer to improve the accessibility and to increase the visibility of information about disaster risk management to be used in the context of the Andean Community, a region frequently affected by disasters linked to the occurrence of natural phenomena (earthquakes, volcanoes, storms, etc.). The designed solution is expected to provide support to a wide range of users and decision makers related to disaster risk management. According to the project plan, a prototype of SIAPAD is operational at the end of January 2008 (in one single node) and it is fully operational in August 2008 (with one node for every country of the Andean Community). The development of such a system, contributes to the solution for a problem with a great social and economic impact by using an advanced technical approach adjusted to the particular conditions of the Andean Community countries.

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