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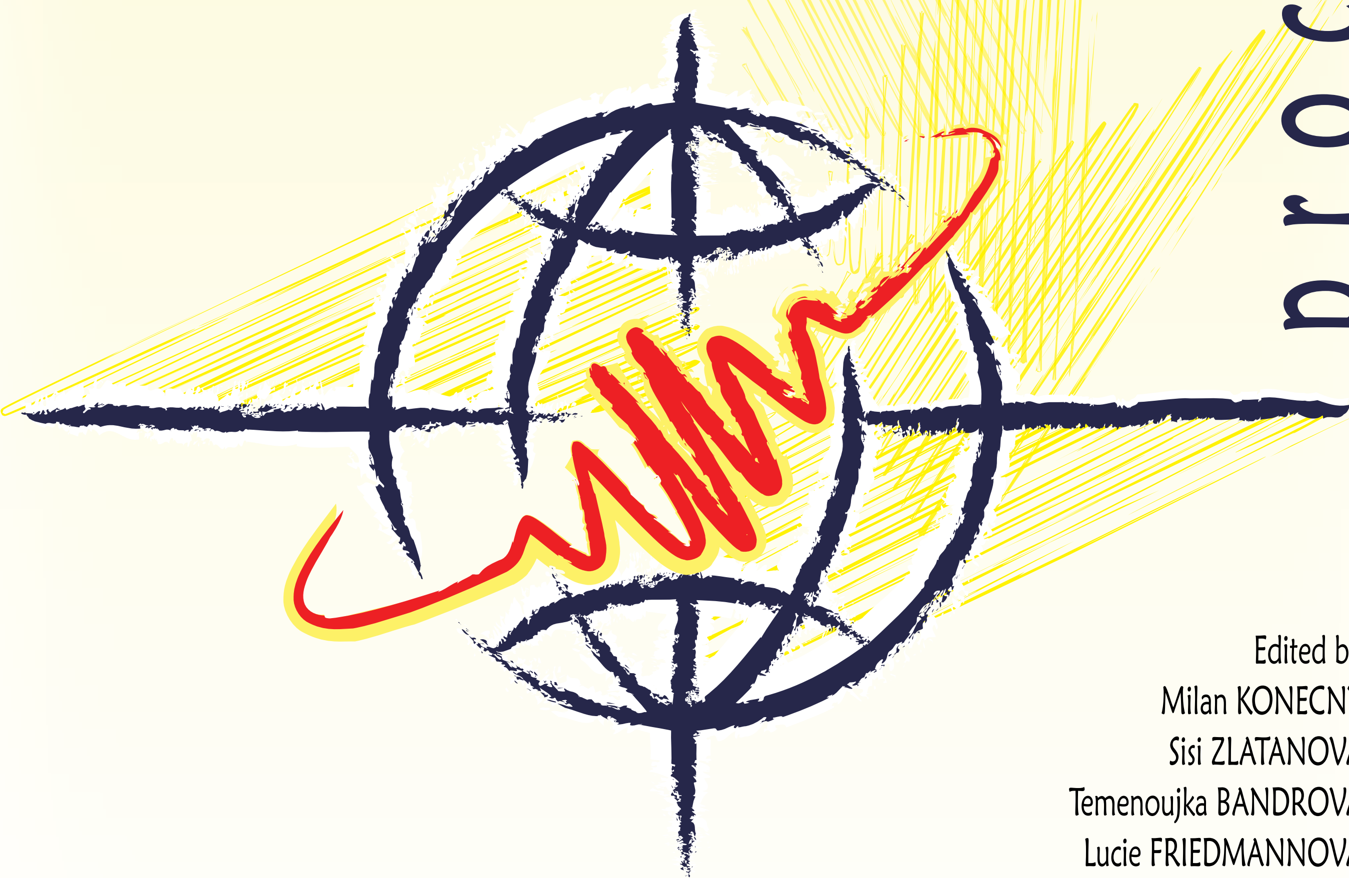

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Towards Better Solutions

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COLLABORATIVE POST-DISASTER DAMAGE MAPPING VIA GEO WEB SERVICES

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Abstract
To mitigate the consequences of increasingly frequent disasters across the globe, better real-time collaborative post-disaster management tools are needed to allow the integration of different types of data from diverse sources. The "International Charter for Space and Major Disasters", in conjunction with intermediary agencies, provides for space resources to be available to support disaster response. It is widely seen as a successful example of international humanitarian assistance following disasters. However, the Charter is also facing challenges, with respect to accurate and timely data deliver and lack of validation, with information flow being largely mono-directional. It is therefore, fundamental to move away from static map data provision to a more dynamic, distributed and collaborative environment. Geo–Webservices can bring together vast stores of data from heterogeneous sources, along with geospatial services that can interact in a loosely coupled environment and be used to create better information. The aim of this paper is to evaluate the relevance and importance of Geo–Webservices in the disaster management domain and present a suitable Geo–Webservice architecture for a collaborative post-disaster damage mapping system. We will present our ideas for a prototype based on this architecture, which will showcase some scenarios of collaborative disaster mapping with possibilities for User Generated Content.

THE CURRENT STATE OF POST-DISASTER MAPPING

The increase of disasters across the globe in recent years with static map provision attests to the fact that there is need for dynamic and distributed real-time collaborative disaster management techniques. The growing frequency of disasters poses great challenges due to increasing disaster response needs and recovery costs. The development of Disaster Response and Management (DRM) aided by more coordinated approaches, coupled with good use of technical means, have already brought about a range of collaborative measures. There have been developments in collaborative information coordination with news feeds and news alert, for example by AlertNet, Virtual OSSOC and ReliefWeb, with alternative practical collaboration within various humanitarian organisations. By making it possible to integrate different types of data and information from diverse sources, collaborative disaster damage mapping can strengthen analytical capabilities and decision making for disaster response. The development of near-real time Earth Observation (EO) systems and geo-information techniques has contributed significantly to support the management of major technical and natural disasters, as well as humanitarian emergency response. To minimize the impacts of these natural and technological disasters, concerned organizations require accurate information regarding the geographic extent of the affected areas, both during the outbreak and shortly after the suppression of the event within the shortest time possible (Gitas, 2007).

In spite of many developments in the domain of satellite imagery provision towards disaster management (e.g. Zhang and Kerle, 2008), it is important to note that raw satellite images remain of little use to emergency response personnel. It takes a careful processing, analysis, mapping, and interpretation to generate the required situation maps which can be read and understood by non-satellite expert users. This is important in simplifying the map output and incorporating non-experts in decision making and relief coordination. Involvement of users from all walks of life with varying professional backgrounds in participatory disaster damage mapping, input, reporting and field validation is important in enhancing the spirit of collaboration and outreach.

The International Charter for Space and Major Disasters

The "International Charter for Space and Major Disasters", further named the Charter for short, has been a champion in space data acquisition and delivery of image based information to organisations involved in disaster response with the ultimate aim of helping to mitigate the effects on human and property loss (Ito, 2005). It aims at providing a unified system of space data acquisition and delivery to those affected by natural or man- made disasters through Authorised Value Adding Resellers (Mahmood, 2008). There has been an increasing number of activations, aided by a recent growth in Charter membership, now including DMCii, CONAE, ISRO, JAXA, USGC and NOAA, adding their space resources to those of CSA, CNES and ESA, a success in meeting the modern challenges of varying disaster types across the globe. The Charter's activities have managed to establish a working response mechanism to disasters by providing transformed information and know-how for disaster management (Ito, 2005). Major improvements in space-based disaster response were realised after the formation of the Charter and the many players in the provision of image derived information. Increasing sophistication of situation and inventory maps within a short time in recent years has improved the speed of disaster response. For instance, in the wake of Cyclone Nargis that struck Myanmar in May 2008, satellite images were produced within hours indicating the path an impact of the cyclone, and within days a range of quality images indicating the extent of standing flood waters and destruction of villages were available.

Efforts by industry and other organisations

Several private companies and new NGOs have recently become involved in post-disaster damage mapping, management, response and recovery. For example, ImageCat Inc., RapidEye, TerraSAR and MapAction focus on post disaster response. There also are Public Private Partnerships (PPP) between the public and private sector, UN, the Charter and NGOs in disaster response and management. These PPP's are important in bringing in a pool of resources, technology, expertise and combined efforts towards rapid disaster response.

ImageCat Inc. has been developing tools for better post-disaster damage and situation mapping based on ground data mashed with image-derived information. Currently the Virtual Disaster Viewer (VDV) is being developed which offers an alternative method of rapid and robust damage assessment, based on expert interpretation of satellite imagery, validated later against field observations. Working within a specially designed online tool developed in MS Virtual Earth, disaster experts are assigned specific areas, or tiles, of the affected areas to review and provide their assessment by comparing before and after high-resolution satellite images acquired by DigitalGlobe and GeoEye imagery companies. Initial information gathered includes the number and size of damaged structures and the location and scale of humanitarian relief operations. With limited access to the disaster zone, disaster experts and reconnaissance teams around the world can help in the response, by providing a detailed assessment of the unfolding scene. VDV, once implemented, will help in disaster reconnaissance, providing the global earthquake and humanitarian communities with an assessment of damage and human loss for an event that otherwise may never be well understood. VDV is a prototype project still undergoing testing and implementation phases. This project is of commercial interest and therefore might have limited usefulness in humanitarian efforts.

The Joint Research Centre (JRC) and EU ORCHESTRA projects are also developing appropriate disaster management tools and techniques. The collaborative geo-information capturing for disaster response by EU-JRC in collaboration with Red Cross, World Bank, African Union and other organisations is part of the breakthrough process in disaster response initiatives. ORCHESTRA aims at consolidating information from disparate information systems to support disaster and emergency management operations (ORCHESTRA, 2008). It has designed and implemented specifications for a service oriented spatial data infrastructure for improved interoperability among risk management authorities.

Competing and conflicting interests

Depending on the stakeholder's perspective, disasters can represent a challenge or an opportunity, leading to a variety of possible competing or conflicting interests. On both the affected and the supporting side of the event there are entities that either have a humanitarian or a commercial motivation. For both fractions responding to an event may be the main mandate, or just one of several challenges requiring resources. Thus while originations such as MapAction may be able to focus their resources on aiding disaster response, for others, such as UNDP, disasters need to be dealt with as an additional challenge to meet development objectives. Also for UNOSAT, primarily associated with post-disaster damage mapping, disaster mapping competes for time needed for many other mapping activities. Disasters, however, can also constitute a source of prestige, be it for different disasters response websites vying to be the main platform, or different UN organizations. For example, within the UN body different entities, such as OOSA, OCHA or UNOSAT, have had disagreement on who should have the right to trigger the Charter.

Of greater concern from a practical disaster response perspective, however, are commercial interests. Disaster response has become an interesting business area where the lines of humanitarian support, research, and commercial interests blur. ImageCat, for example, has effectively partnered with humanitarian and research organizations (e.g. the Multidisciplinary Center for Earthquake Engineering Research, MCEER), and has developed tools that can greatly assist post-disaster damage mapping. However, it fundamentally remains a commercial company, and as such there are limitations in the use of their data or tools, and no permanence can be assumed for any currently available support.

We also see potentially competing interests on the side affected by the disaster. Such events can represent an opportunity to attract relief and reconstruction resources to the area, which are typically somewhat proportional to the scale of the damage. Hence a temptation exists to exaggerate the magnitude of the damage sustained during the event. Since we are proposing a system that integrates feedback and validation from the affected areas, a resulting unreliability must be considered in the setup.

CHALLENGES FOR POST-DISASTER MAPPING

Despite successes, such as an increasing number of activations, better visibility, and more reliance of decision makers and disaster response professionals on such space data, the Charter is facing challenges in many areas of its operation, especially in accurate and timely data delivery. These observations are not unique to the Charter, they can be said to be true for all post-disaster mapping.

With the increasing amount of end-users and other stakeholders, collaboration becomes more important. With the technology currently used, data flow is largely mono-directional, hence no participatory collaboration is possible, resulting in a situation where resources and knowledge are insufficiently well coupled. There is a need to move away from project based static data provision to a dynamic, distributed and collaborative environment that enables *multi-directional information flow and feedback mechanisms*.

The need for collaboration

The type and number of stakeholders involved in the response to disasters and emergencies has evolved and grown over years, with smaller niche players gaining in importance. The growing use of geodata, including satellite imagery and its derivatives, and better spatial data integration have led to more timely disaster response, rehabilitation and reconstruction. The Charter itself is conceptually embedded in a wider risk reduction and disaster response framework. The Global Earth Observation System of Systems (GEOSS) works with and builds upon existing national, regional, and international systems to provide comprehensive, coordinated EO and vital information for society. The Global Monitoring for Environment and Security programme (GMES, intermittently also called Kopernikus), as the GEOSS European contribution, has been operating and running related services after its inception. The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth under its nine societal benefit areas (GEOSS, 2005). The data are coordinated, analysed and prepared for end-users by RESPOND, a tranche of ESA's GMES Service Element projects with an alliance of European and International organisations working with the humanitarian community to improve access to maps, satellite imagery and geographic information. RESPOND is funded to produce thematic and damage maps on behalf of its consortium to the humanitarian community.

The need for multi-directional information flow and feedback mechanisms

The websites operated by the organisations processing Charter data have been designed mainly to disseminate map products to users, and to provide access to map resources and data to thousands of experts in the disaster domain. In the technological architectures used currently, depicted in figure 1, the disaster map provider has set up a website from which end-users can view and download maps in print-optimised Portable Document Format (PDF).

However, the satellite images are analysed in western countries, and without a direct input, feedback and communication link to the disaster area (Kerle, 2006). This approach is ill-suited to meet the varying needs of different stakeholders, and does not provide for them to add local knowledge and additional information to the mapping process, nor aid in product validation. Studies of previous post-disaster map products (e.g. in Kerle, 2008) have shown that exclusive image-processing and map production by European entities, without field knowledge contribution and map validation by stakeholders in the affected area, can lead to map inaccuracies. Furthermore, the post-disaster maps are needed by different users and at different times, and are ideally produced with a specific user group in mind. However, such customisation and flexibility is lacking and remains a challenge.

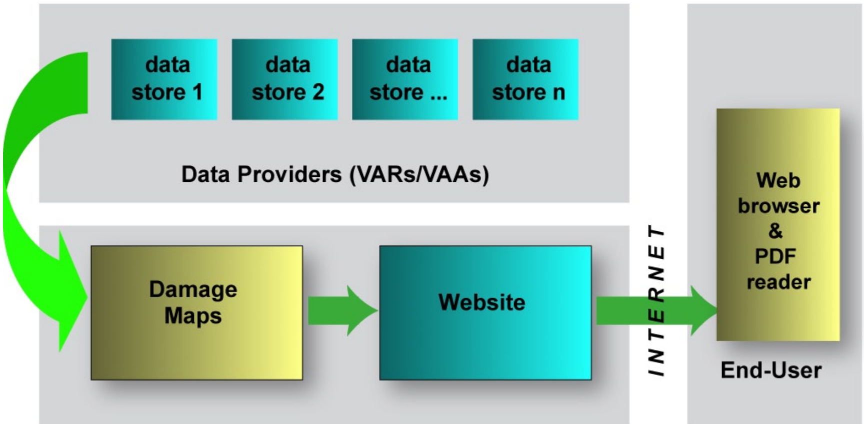

Figure 1. Example of an architecture presently in use: delivery of PDF maps to end-users from UNOSAT website.

Some efforts towards this have already occurred. The Joint Research Centre Support to External Security (JRC-SES), focuses on collaborative Geo-information capturing to support emergency response (Lemoine, 2007). It has built a Global Disaster Alert and Coordination System (GDACS) that provides near real-time alerts about natural disasters and tools to facilitate response coordination, map catalogues and with a Virtual On-Site Operations Coordination Centre (Virtual OSOCC). The major technological breakthrough here is the distributed access to geospatial data by analysts with an extensible architecture to interface image processing, visualization using Google Earth. However, the wider humanitarian organizations on the ground are not involved in map production.

An appropriate application framework has to be developed to enable several stakeholders in various locations to add value and work on the same disaster. This *geospatial e-collaboration* in emergency response is technically feasible with extensible elaborate spatial analysis and geo-processing. The process should be adaptable to local thematic specificity of typical disaster emergency response. When considering these new ways of post-disaster mapping, we have to take into account that Charter data use remains complicated, as original imagery is not free as such and also cannot be used freely after the use by the officially designated processing entity. The original data are not available to potential end-only the resulting post-disaster maps. The Charter's free provision of disaster information via open platforms is limited by its mandate and legal framework. Therefore any distributed system architecture needs to deal with these access restrictions in a secure way.

TOWARDS COLLABORATIVE POST-DISASTER DAMAGE USING GEO-WEBSERVICES

Current geospatial technology, especially web-based, does enable a flexible, multi-directional dataflow, allowing for feedback and annotation mechanisms. Non-standardized frameworks for Web-based Collaborative Decision Support Services (WCDSS) amongst stakeholders do exist, an example is the web-based wells flow prediction in Oak Ridge Canada to support information exchange and knowledge, software and model sharing from different organizations on the web (Cheng, 2006). But because such a system does use proprietary interfaces, it is not useful for a larger, not pre-defined user community. To allow such solutions to function in the increasingly collaborative environment described above, there is a need to work according to Open Standards. Such standards have been developed and are increasingly used nowadays in so-called Spatial Data Infrastructures, and our goal is to develop a generic architecture for such a collaborative post-disaster damage mapping system. This architecture is based on Geo-Webservices.

Geo-Webservices

The development from monolithic to distributed GIS architectures has revolutionalised seamless data access and transfer across networks. It is now possible to integrate spatial information from different geo-processing systems and also integrate spatial information into non-spatial information systems. Such Service Oriented Architectures (SOA) have well defined interfaces that interact with other loosely-coupled network software applications. They fully encapsulate their own functionalities and make it accessible only via well specified and standardized interfaces (Köbben, 2008). This is achieved by encoded data in a standardized, platform and application independent manner by use of encoding schemes and generic web service standards such as the eXtensible Markup Language (XML), Web Service Description Language (WSDL) and Simple Object Access Protocol (SOAP) utilized to deploy geographic web services.

There exists a range of proprietary Geo-Webservices in the market. They include Google Earth/Maps, Yahoo Maps and Microsoft Virtual Earth/MultiMap. Free geo-browsers to view data through these services are available, both 3D and 2D, where 3D globes are a three dimensional interactive virtual globe that displays the Earth through a combination of different layers of information. Next to that, non-proprietary Open Standards have been developed in an open and participatory process, and owned in common. An example of Open Standards for Geo-Webservices is the Open Web Services (OWS) specifications of the Open Geospatial Consortium (OGC). The OGC was founded in 1994 as a not-for-profit, international voluntary consensus standards organization that develops Open Standards for geospatial and location based services. Their core mission is to deliver interface specifications that are openly available for global use. The Open Web Services specifications are the basis of many high-profile projects (e.g., the European Community INSPIRE initiative). There are OWS specifications for most parts of the spatial data storage, analysis and delivery process: For geographic data encoding there's the Geographic Markup Language (GML); for spatial data delivery the Web Coverage Service (WCS) and Web Feature Service (WFS), for querying and retrieving raster and vector data respectively; for processing of spatial data the Web Processing Service (WPS) has been defined. Note that this specification does not standardize the analysis or processing methods themselves, but rather defines a standardized interface that lets you publish geospatial processes, and lets client software find those processes and employ them. The most used standard is the Web Map Service (WMS), for data visualisation in the form of maps. A new emerging specification is GeoDRM, for Digital Rights Managment of geodata.

Importance of Geo-Webservices as a tool for collaboration

Collaborative damage mapping requires situation assessment from existing and new dataset, impact assessment with post-disaster imagery and organisation of post-disaster work. Web services will enhance multi-stakeholder data access, editing, validation and mash-up with their dataset to create their own products. The dissemination of disaster information should be robust and dependable, and meet user needs without compromising quality and timely provision. This collaboration initiative can only be achieved where distributed services act as a geospatial one-stop for seamless data management. A unified system allows fast collation and analysis of distributed dataset with expert knowledge. Satellite imagery alone cannot meet disaster response initiatives, hence, it is important to link infrastructure with ground networks as envisaged in the GEOSS architecture. Geo Web Services can thus lead to a wide range of services for a long term, comprehensive and high quality EO system in support of critical disaster response. The development of global, regional and national nodes is not an exception for these disaster management organisations. The main focus is to design a suitable framework of services and client solutions for a collaborative disaster mapping system.

A Geo-Webservices approach can connect the various disaster management agencies, allowing more customised delivery of data and information, and allow users to add value by providing their own information, thus creating new synergies in a loosely coupled environment. Despite past achievements in providing image derived information, the Charter currently lacks a framework for collaboration, synergy and feedback from major stakeholders in disaster response.

User Generated Content (UGC) and Neogeography tools

Apart from image analysis, emerging web services for the generation of comprehensive and easy-to-use map products can be used to display damaged infrastructures in the field by disaster experts and Geo-Information Volunteers. Reference data sets such as place names, road network, rivers, critical infrastructure, and other damaged information can be captured by use of new interoperable web 2.0 User Generated Content (UGC) tools such as geotags, Flickr, GeoRSS and GeoWIKI.

Geo-tagging is the process of tagging images to various open layers in the form of geospatial metadata, thus help users find a wide variety of location-specific information. Geotagging-enabled information services can also be potentially used to find location-based disaster damaged infrastructure. Unlike Geo-tags, **Flickr** organize images as tag clouds, with place names. It offers a fairly comprehensive web-service Application Programming Interface (API) that allows creation of applications that can perform almost any mapping function, and indeed disaster damage maps. Humanitarian experts can take photographs of damaged infrastructure and tags it to the disaster mapping system. GeoRSS is an emerging standard for encoding location as part of an RSS feed (http://en.wikipedia.org/wiki/RSS). By building these encodings on a common information model, the **GeoRSS** collaboration will promote interoperable and compatible web services across the disaster domain. GeoWIKI is essentially a means of many people contributing to the development of a large database (crowd-sourcing). A number of databases are being developed using a Google Earth based **GeoWIKI**, designed to enable anyone who accesses it to contribute or modify its content. Wikis are often used to create collaborative websites and to power community websites to which the proposed collaborative disaster mapping system will incorporate.

The use of geotags has become an important part of the geospatial networking community where images are embedded on a map with synchronisation of photos to a location in form of coordinates. Geotagging as a neo-concept is also being incorporated into more applications using open standards and platforms that already exist. It has already been incorporated into more commercial applications and merged into geo-information as a discipline. With improvement in data sources integrity, it is now possible to log activities according to time and location on mapping applications with GPS coded cameras via satcom and location-aware web links like Flickr. The changing information paradigm with a new world of information access via open access and Neogeography tools listed above applies to Volunteer Geographic Information (VGI), usage of geographical techniques and tools used by expert and non-expert group of users. These web services provide general base map information and allow users to create their own content by marking locations where various events occurred or certain features exist. Disaster experts in the affected region can increase the quality and real time input in the damage maps.

Architectural Structure

For disaster geo-collaboration, the architecture has to cope with web service specification, OGC specifications and their dynamic integration. It serves as a collaborative Web-based Spatial Decision Support System (WebSDSS) architecture (Cheng, 2006). The main goal is to design and demonstrate an open, service-oriented software architecture, which improves the interoperability among actors involved in post-disaster damage mapping. An interoperability arrangement includes technical specifications for collecting, processing, storing, and disseminating shared data, metadata and related products.

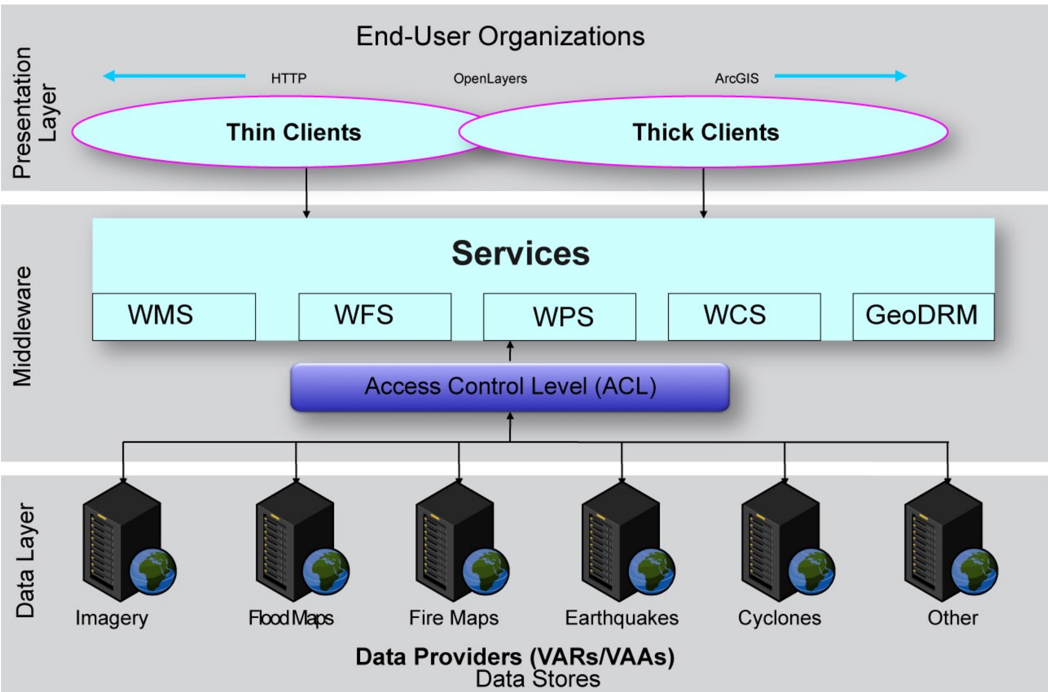

Figure 2. Generic setup of an extended Geo-Webservice architecture

The wide diversity and essential independence of component systems calls for a particular style of systems architecture that emphasizes interoperability. Interoperability allows systems to interoperate even though they are developed and operated independently (Christian, 2008). As shown in Figure 2, we propose a dynamic and adaptable extended web service architecture with manifold software infrastructure for disaster management agencies, stakeholders, humanitarian community and distributed end-users. Such a framework allows a flexible and problem-oriented integration of different services and applications supporting interoperability among them (Radetzki 2002). Different user profiles can have appropriate access rights and privileges on the datasets. End users might employ for their purposes a range of applications, from simple so-called *thin clients*, with a limited functionality (e.g. a standard web browser for viewing maps from a WMS) through to *thick clients*, e.g. a full blown GIS or image processing system that uses the architecture to access and process the base data.

Prototype

The proliferation of location-aware end-user applications is increasing the demand for Web service-based delivery of geospatial content (Lehto, 2007). We develop use case scenarios as part of the test-beds for a technically feasible collaborative disaster management system. The main goal of this prototype is to demonstrate the technical concepts of a system that:

- Can provide online access to various map data and integrate heterogeneous disaster information sources,
- Contains customized map presentation forms and access options,
- Acts as a collaborative platform for post-disaster damage mapping,
- Uses open interfaces and standards that conform to OGC/ISO specifications.

Use Case Scenario's

A couple of use case scenarios was developed to demonstrate the feasibility of the proposed extended architecture, these use case scenarios outline possible applications order to achieve real time disaster map dissemination and feedback to and from heterogeneous end-users.

In the first scenario, end-users of post-disaster maps have the possibility to *spatially annote* these maps. Using a simple thin client (running a standard web browser), they can add notes or remarks that are geo-tagged, i.e. linked to a fixed point in the map. These spatial annotations are made available in the web portal (see the red arrows in figure 3), and therefore can be viewed by others users. They could also be used by the mapping agency to further approve their maps (see the blue arrows). Likewise, the agency can use these annotations to actively seek help, for instance by posing questions such as „*does anybody know if this building is still standing?*" or „*is this road passable?*". The content of the spatial annotations is not limited to tex, as we can employ links to existing photo-sharing services (such as Flickr or Panoramio) or even to other geo-webservices (such as Google Maps).

For the second scenario we envisage a more limited user group, such as stakeholders and collaborators that are asked to actively collaborate on the production of post-disaster maps. These users would have a thick client, such as ESRI's ARcGIS system, and would use that to help with data processing, in our use case delineation of damaged areas. These inputs are used to process the data for the final damage maps, hence a secure access and validation mechanism needs to be in place.

Prototype architecture

As a proof of concept for the use of open standards for end-user access to disaster maps, we are setting up a prototype project based on appropriate service specifications. The aim is to connect to different servers hosted by valued adding resellers and combine output of these servers in the distributed client machines via a browser or geo-processing software. For this reason, our proposal is to develop bi-directional web enabled services. As seen in figure 3. An interface will be created to display the user profiles in order to be aware of the requirements of a remotely located end-user. The service has to be configured for any newly registered end-user. The architecture supports editing, customization and integration with thick client, a system embedded with geo-processing applications for data processing.

A first step in designing a functional distributed infrastructure is to decouple the traditional architecture into three components: data layer, middleware and presentation layer. A presentation layer is responsible for the end-user interaction and the visualization within the thin-thick client (machine is embedded with geo-processing applications) environment (Beliën, 2005). A prototype is developed and focuses on the concepts of distributed services. A mechanism is needed that makes it possible to discover the available web services since the proposed architecture distributes components over heterogeneous locations. The architecture is extended with a catalogue provider that registers all available data services using Universal Description, Discovery and Integration (UDDI). The catalogue provider tells service consumers that there is a map service available at a certain URL and that this service can process certain requests.

This prototype is currently being built, using already available Open Source components that we have experience with in ITC education and research projects. The Geo-Webservices layer will largely be based on UMN Mapserver (http://mapserver.org), while the thin client will be developed using the OpenLayers API (http://openlayers.org). The use of this setup is demonstrated (albeit not for the post-disaster mapping domain) in sites such as the Melka Kunture virtual archaeological site (http://geoserver.itc.nl/melkakunture/expert/) and the Cartesius Flood Mapping test (http://geoserver.itc.nl/cartesius/).

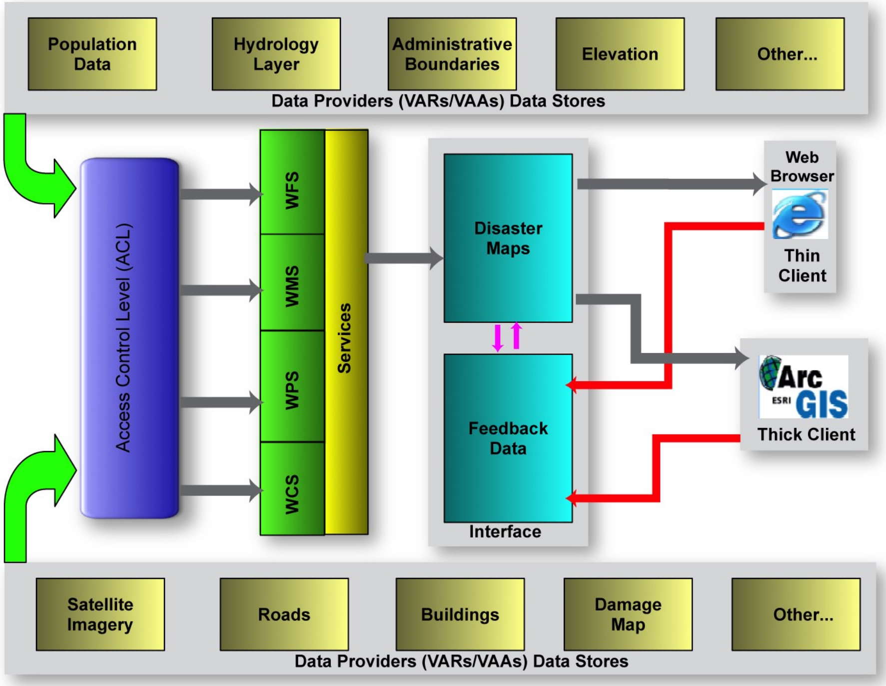

Figure 3. The proposed prototype architecture.

DISCUSSION AND RECOMMENDATIONS

Collaborative Disaster Management System

Information systems used in the field of disaster management are often not as open and extensive as needed to consolidate the complex data sets and the different systems for solving tasks and questions based on complex workflows and scenarios. There is currently no singly accepted architectural model for web services as a whole, although a number of groups (W3C Architecture Working Group) have already begun work on defining how web services will be used with their products. Interoperability as well as application-oriented integration of methods, data and systems must be improved. This could be realized by designing distributed software architectures, which enable and support flexible and interoperable keeping, integration and networking (Kohler, 2006). Our proposal is more of a working dynamic system as compared to VDV, which is more rigid and not adaptable to real time post event damage assessment. VDV is a closed system and requires expert to perform complicated interpretations of damage features for different disaster types. VDV relies on costly civilian satellite products from Digital Globe and GeoEye, which requires enough resources to do commercial tasking and divert its coverage to disasters within the shortest time possible.

The success in disaster response will depend on data and information providers accepting and implementing a set of interoperability arrangements, including technical specifications for collecting, processing, storing, and disseminating shared data, metadata, and products. Today, disaster management agencies need hours to acquire and analyse satellite imagery, and to deliver post-disaster damage maps to the stakeholders. Geo Web services will greatly expand the value of spatial data and processing resources, leading to effective decision making process. The Geo Web has become an important element of workflow which is fundamental for web-mediated disaster activities.

Quality Control and Assurance

The process of data provision, integration and sharing should conform to ISO and OGC standards and specifications. The utility of GML and OGC Web Services such as WMS and WFS have already been demonstrated (Kohler, 2006). Data quality and control especially in open platforms is a must, a prerogative of intermediary agencies and in particular the charter node to regulate the access, editing and integration of the dataset via a common protocol. Access logs for local and thematic experts are important in product monitoring and surveillance. Much has been said regarding the creation of global institutes of global geographical data quality control, and indeed Value Adding Resellers (VAR's) should play a leading role in data quality and accuracy assessments. Experts and non-expert stakeholders should have regulated access and editing so as to keep track and source of information, an important step in disaster damage mapping through enforcing restricted access to data or to declare views on the relevant data for certain users (Herrmann, 2008). An interoperable language is needed to declare policies for operations on Web Services used, containing rules that define which data can be accessed by a person through a given condition.

Geospatial Digital Rights Management (GeoDRM) should be part of the collaborative quality control mechanism in post disaster damage mapping. GeoDRM is a conceptual framework, an array of standards, and software tools for guarding the rights of both producers and consumers of geospatial data and services (Lieberman 2006). It addresses a variety of ad hoc approaches which currently exist for defining the exchange of value occurring between any users and providers of geospatial content and services, whether open or proprietary. OGC GeoDRM initiatives have been working at an open standard framework and testing open source tools for GeoDRM-enabling OWS. These initiatives should focus on protecting the rights of users and providers of disaster information.

Access Control Levels (ACL) created in authentication services to manage permissions, subject to the level of access rights and privileges of heterogeneous disaster damage mapping organizations and their relationship with the Charter and in particular the host organisation. Whether these permissions are directly bound to administrator or indirectly via additional associations like administrator-role and role-permission depends on the implementation of the Authorisation Service. Access control regulates conditions under which specific individual carry out the read, write and edit of the data (Zlatanova, 2008). Independent from the way permissions and principles are related, an Authorisation Service is able to retrieve the permissions for a given end-user. Thin clients access using web-browser while thick clients access via Simple Object Access Protocol (SOAP) over HTTP or a proprietary binary protocol over standard TCP/IP. A trustworthy authentification mechanism should be put in place to curb data misuse. In the above architecture, security can be ensured between the services and the clients by establishing HTTPS and/or Secured Socket Layers (SSL).

CONCLUSION

The Web 2.0 phenomenon has revolutionised Geo Web platform, spanning all connected heterogeneous systems. Web 2.0 applications deliver information, consuming and mashing-up data from multiple sources, including individual users, while providing their own data and services in a form that allows integration by others, creating network effects through an architecture of participation, to deliver rich user experiences. The web 2.0 environment has led to increasing interactions on the web, where technologies that run behind the web are becoming more convergent.

The best solution to meet current post-disaster damage mapping challenges is to employ off-the-shelf geo web tools and services. It enhances geo-collaboration where data providers improve their data quality by receiving ground truth information from end-users. The process of real time data sharing and transfer with distance reduces the cost of travel and shipping and encourages a two way communication channel enhancing participatory approaches to common disaster challenges. The web service architecture provides the ability for heterogeneous stakeholder's access their partner‘s disaster information in the same geographic context. Real-time damage mapping enables distributed disaster management experts to put damage evaluation into local context, aiding in response and recovery. Geo-Webservices provides a means for analysis, augmenting both speed and precision of disaster situation evaluation.

Geo-Webservices provide more possibility for organisations to enhance the power of GIS as a tool for solving disaster related problems. Dozens of data sources, many of them hosted by disaster management organizations, are now searchable and accessible through a portal. This enables users to drill through spatial data in all formats and track down the information needed about a specific area. The data resources and data access provided by Geospatial One-Stop repository will be critically important in all of these areas. This project demonstrate that geo Webservices can fluidly supply up-to-the-minute the rapidly changing disaster thematic information. Disaster management agencies can now have additional capabilities in the areas of web-based online geo-processing and GeoFusion Services, an infrastructure for spatial information.

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