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Process Management Support for Emergency Management Procedures

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Abstract: Process management has proven to be instrumental for the engineering and assessment of courses of actions for business operations in many industrial application domains. Processes management means appear therefore as natural vehicle for the definition and analysis of operating procedures also for the emergency management domain. The question arises of what is an appropriate modelling methodology and how tools tailored to the needs of emergency organisations can support this modelling methodology. This paper reports on the experiences gained in the course of modelling specific emergency processes, in our case the cross-organisational treatment of mass casualties. Then, we will introduce the tool platform of project ERMA that has been designed to support such processes.

1. Introduction

Emergency organisations have to prepare for an increasing number of disasters as history shows. Hence, preparation is crucial for the success of the response. Because the size of some incidents might exceed the capabilities of a single organisation, several rescue organizations have to cooperate. Therefore, a corporate planning process is required to prepare for such an event.

Process management appears as natural candidate for such a planning since each planning revolves around activities that have to be conducted and monitored. Starting with early work on process management for software projects [1], process management has been carried to an increasingly growing number of application domains. However, major application domains are confined to manufacturing and production industries that can be characterized by their well-defined processes. Support of knowledge-intensive and complex processes is yet scarce. Although process management has proven its positive impact on organisations' performances in many industrial and commercial applications, customized methodologies are required that are tailored to the terminology and modus operandi of domain experts [2]. In light of this experience, rescue forces also call for a process modelling methodology and tool support that are customized to their objectives for operational planning.

Process management means have not been investigated for fire brigades and rescue forces, besides studies about the use of workflow management for organising information flows [3]. However, our focus is not the automation of processes, but the planning phase for improving the preparation. Communication processes have been studied resulting in multi-agent systems for the support of communication processes [4]. But, the core of their functional reactions, e.g., how to set up a treatment area for injured persons at a larger scale, has not been represented and in particular analysed. Only some standard tactics have been defined for local activities [5]. Yet, fire brigades are embarking upon the development of reference models that can be shared among different organizations.

Therefore, process management methodologies considered as industrial practice appear attractive at first glance. Event-driven process chains (EPC) mimic the nature of rescue processes, since each activity is triggered by an event, which resembles a notification or report in the terminology of fire brigades, and each activity causes by its execution further events. Moreover, fire brigades are used to link each activity with a strategic or tactical goal as essential part of their strategy definition. Hence, EPC appear as natural choice for the capture of know-how on rescue management processes. Even entire rescue plans can be modelled with this kind of modelling method [6]. However, the modelling environment is far too complex to be used by domain experts in the emergency management domain. In particular, assistance amid the guidance of modelling exercises has to be custom-tailored.

In this paper, we first introduce a formal model of an emergency management process that has been formalized in cooperation with a major fire brigade. The topic of this process is the coordination of rescue teams for the treatment of mass casualties, e.g., when 500 to 1200 people are injured. Then we present the electronic risk management architecture of the EC project ERMA, where process modelling support is integrated as a first prototype.

2. Modelling Mass Casualties Procedures in Cologne

Current practice in the emergency management domain is characterized by the use of paper documents for the representation of process knowledge. Processes are mostly described on a textual basis, as Word documents. They are exchanged among rescue organisations for mutual agreement. Once a communication and discussion process has been successfully concluded, i.e., successful reconciliation of the process, they are used as reference documents. As a result, the process is encoded in an unstructured document consisting of a textual description and images. As such, unstructured documents describe the nature of operations, but the processes described can not be processes in a formal stance with regard to analysis and execution. Graphical notations to the other extreme are easy to use, but do not carry semantic information about the matters modelled, although they provide transparency at first glance compared to the current practice of unstructured documents. With this kind of representation, any formal analysis is also impossible, since the processes cannot be reasoned about. Hence, a formal representation will be beneficial due to its processing facilities. Models can be analyzed as well as views can be defined to focus on specific aspects such as the workload of specific departments.

Several methods have been investigated to represent emergency management processes with different scopes of interest and concern [7], [4], [3], [8]. Our concern is the analysis of quality characteristics of emergency processes, i.e., does one have sufficient resources in place for the processes, does one face a potential overload for specific organisational units in certain periods of relief operations, or do some activities not comply with overall tactical and strategic objectives. In order to check for such kind of properties, the planning process has to result in a formalized process model of the relief procedures that can be analyzed according to this kind of integrity constraints, while each integrity constraint can be formulated in terms of logical conditions. Such a formalization calls for a modelling framework that allows the representation of at least activities and their control flow, resources, organisational units, and goals. Events surface as further natural ingredient of the model, since all operations are triggered by messages or observations.

Therefore, a modelling methodology has to carry these accounts, if one wants to analyse the performance of processes planned. Since our research question has been whether relief organisations can benefit from process management approaches as other application domains do, we surveyed methodologies and tool support in first place. Literature and system evaluation unveil a strong account of control flow coverage. Coverage of complex and ad-hoc organisational and resource aspects is not supported by many systems, as illustrated by workflow-oriented approaches such as WS-BPEL (Web Services Business

Process Execution Language) or YAWL [9] that have automation as prior concern on their agenda. Some commercial workflow management systems have an organisational modelling account, but no elaborated support, such as systems along the lines of the Workflow Management Coalition [10], like Bonapart [11].

Our starting point has been an emergency management process that requires several rescue organisations to cooperate. The process revolves around courses of action to be taken for handling emergency events that involve the medical treatment of mass casualties through supraregional support (ÜMANV – Überregionale Unterstützung beim Massenanfall von Verletzten) [12]. In this context, we particular focus on the planning aspects. The automation of processes is outside of our scope due to the nature of these processes that take place out on the scene.

The need for a balanced representation of control flow-oriented as well as organisational aspects has brought us to the decision to employ extended Event-driven Process Chains (eEPC) [13] as initial modelling methodology for the emergency management domain. Consequently, we selected the ARIS Business Architect [14, 15] as our modelling environment for the modelling exercise with the fire brigade of the city of Cologne. Extended EPC have been “rephrased” in order to comply with the terminology of fire brigades. The concepts and the structure of extended EPC were preserved to a considerable degree by assigning different semantics. However, some modifications were necessary to address requirements of resources or capabilities of measure carriers. Activities were named measures, events were translated into notifications and reports, capabilities and duties of organisational entities and units were explicitly distinguished. In addition, plans were dispatched for classifying activities, e.g., classifying injuries of people according to treatment priority. Information resources of the eEPC were translated into a physical stance, e.g., infra-structure (geographical and traffic management), requirements for a treatment location, instead of using them for the modelling of information logistics.

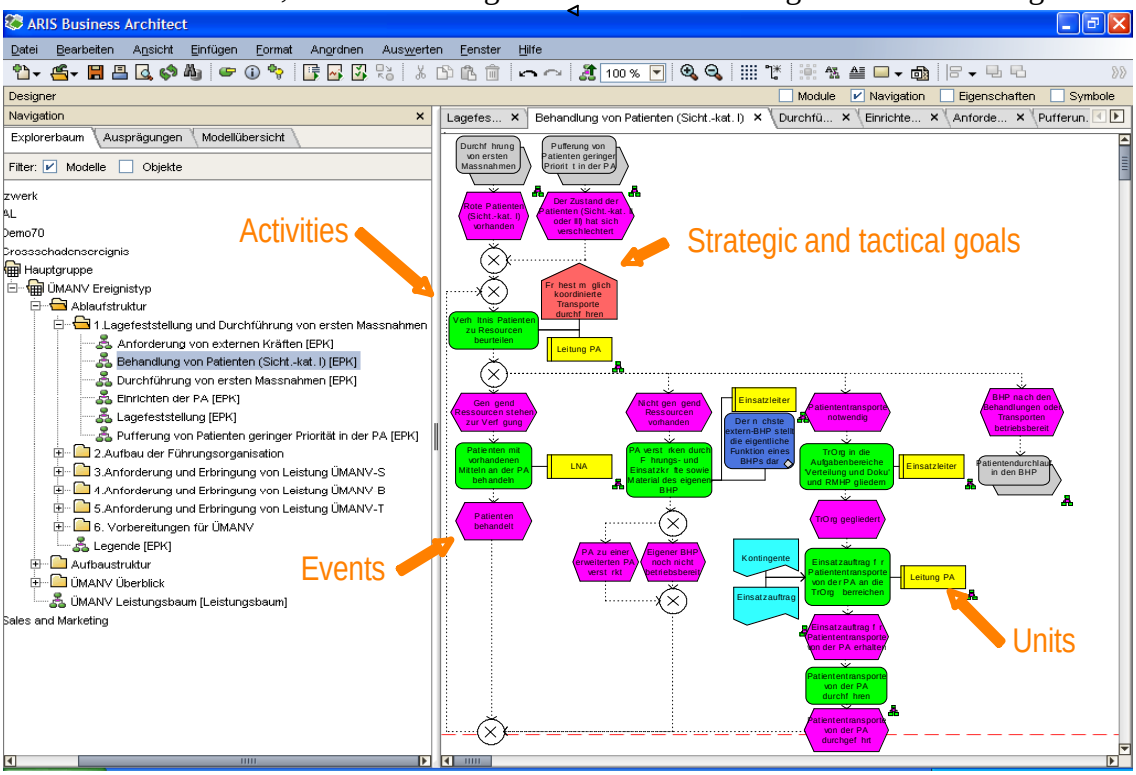

Figure 1: Model of the ÜMANV Presented by the Adopted eEPC

Figure 1 shows a screenshot of the ARIS modelling environment displaying a part of the model for the ÜMANV. It highlights the flow of activities, plans involved for the classification of activities, resources required, and in particular objectives.

The modelling approach based on eEPC has proven beneficial for the fire brigade. First, the domain-specific modelling constructs and views enable emergency organisations to prepare their operational plans as usual. Based on these models, reference models can be established that enable the exchange between regionally different organisations and thus foster consistency of concepts across relief organisations. In addition, best practises can be promoted by encouraging those disaster management organisations to use already assessed operational concepts, to adopt them, and to further adjust them according to the capacities individually. This is especially useful because these organisations are not able to prepare for every possible scenario due to less staff and budget. With regard to modelling economics, single process modules can be extracted from the modelled disaster plan and reused for different scenarios. This possibility for reuse has proven highly useful in particular for coordination phases.

Amid modelling phases, distinctive modelling views are supported. Various process presentations aid in the comprehension of different aspects. For example, the organisational view provides a detailed overview of the organisational structure, the required competencies of each measure carrier as well as their technical resources, while a flow-oriented view focuses on the flow of activities. During reconciliation processes, views further support focusing on those aspects that are only relevant for certain organisational units. Hence, views resemble dynamic summaries.

Once, the model is available, several means for analysis were implemented in terms of reports. As such, reports specify several views on parts of the model, e.g. “show all activities that are carried out by a specific organisational unit”. The use of such views allows the fire brigade to immediately analyse their process model with regard to certain criteria, for example whether there is an overload of specific organisational units like the command centre. Actually, certain performance checks delivered directly a benefit for the fire brigade that has not been possible without the formal model. Typical checks include workload on the set of resources and feasibility of services during specific periods. This way, field trials can be significantly enhanced by enforcing a pre-validation of operational concepts, which acquires the required degree of awareness before redundant exercises take place, and in addition saves time and costs.

To summarise, the benefits of the process management approach has been proven and users could directly capitalise on the models due to the provided means for analysis. However, from a usability point of view, the tool chosen as well as other tools evaluated have proven to be too complex for the process planners of the fire brigade. Hence, custom-tailored tool support is required.

3. ERMA Approach to Risk Management Support

Based on the experiences gained with the fire brigade of Cologne and the tool support evaluated so far, the decision was made to support the modelling of emergency processes with a domain-specific process editor providing its specific structures, terminology, and method. This editor is currently developed in an EU-funded project named ERMA, where it is integrated in a process workbench allowing also manual walkthrough of processes for the demonstration of courses of actions. ERMA (Electronic risk management architecture) [16] strives to support risk management processes in small to medium-sized communities in case of natural or man-made disaster. The supported life cycle of risk episodes ranges from key indicator-based monitoring services, via process-oriented guidance for prevention and relieve, up-to public alerting services that are accompanied by citizen relationship management components to advise the public and gather information from the public. A pivotal element in this life cycle is know-how about processes.

The ERMA emergency management platform comprises:

- Proper risk assessment through a key indicator system: access to monitored sensor data related to various natural and industrial risks existing within their district;
- Process guidance by a process management workbench;
- Information to and from the citizen by enhanced emergency telecommunications systems and a citizen relationship management portal.
- Groupware support by a team collaboration component for integration and connection of different emergency teams enabling information exchange among stakeholders;
- Modular system architecture with SOA interfaces.

The unique features of the ERMA system lies in this combination of modules and their functionalities not available on the current market. In science, individual modules have been tested in the domain of emergency management. Examples include the simulation of events with training purposes [17], the support of information dispatching [18], or collaboration processes [19]. Unfortunately, no commercial system has emerged from these prototypes. This lack of services motivated the birth of ERMA.

The ERMA process workbench serves as core of the system by providing guidance for operation during an event. Main advantage of the ERMA process workbench is the usability of the modelling environment that enables the modelling of processes by crisis management experts themselves.

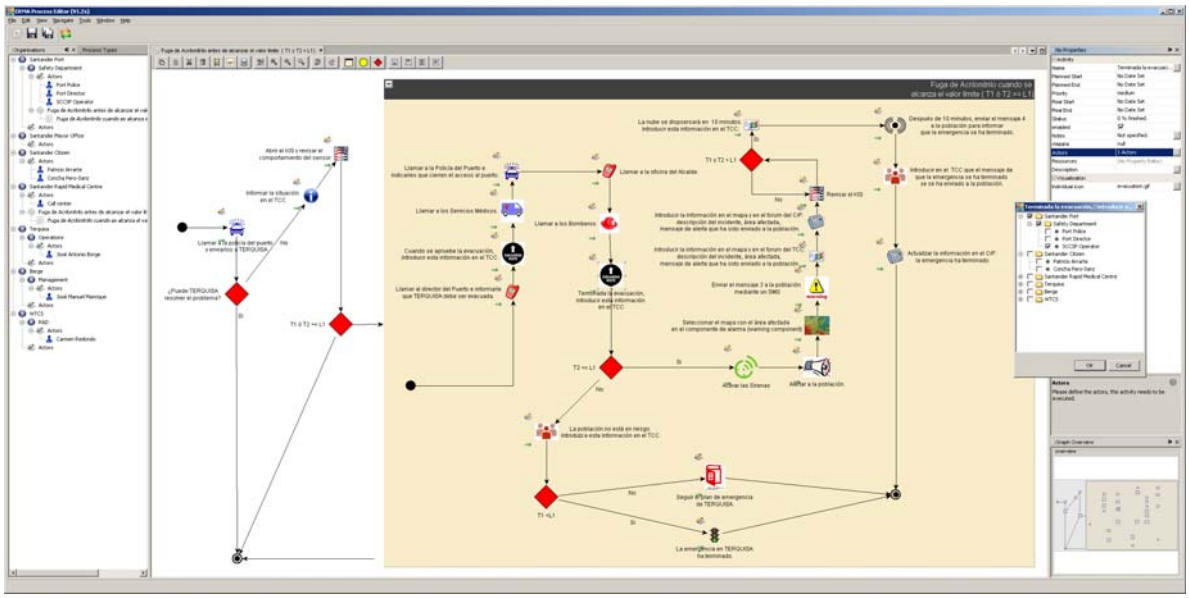

Figure 2: ERMA Process Workbench Editor with a Process from ERMA

The process workbench editor is based on a well-defined data model describing emergency management processes, organisations, and resources. The ERMA user can design processes by using a comfortable lightweight process editor with a typical graphical component for visualising processes as nodes with directed edges as sequences. Main functionalities of the process workbench editor in its current version are:

- Modelling and editing of emergency processes with an intuitive editor;
- Modelling of static and dynamic organisations of the emergency management domain;
- Manual walk-through of process flow (simulation);
- Automatic layout of graphs (hierarchical, incremental hierarchical, organic, orthogonal);
- Easy adaptation to terminology and iconic of the target user group;
- Seamless integration in office environment as well as specific operation centre software by use of SOA.

The user interface of the editor (see Figure 2) deliberately follows common process management tools like ARIS, but is streamlined and simplified. The main window is divided in 3 vertical sections headed by the main menu bar. The left part shows hierarchical trees in (1) the organisational tab: organisations, associated actors and processes, and (2) the process types tab: all processes of the database structured in user-defined classifications. The middle section (3) provides the graph panel showing the process flow of a selected process. Several "open" processes can be displayed in different tabs. The right section presents attributes of nodes or edges selected, and in the right lower corner a graph overview allowing a birds-eye-view of the top process.

Processes consist of activities; processes and activities can be connected by directed edges to show their sequence. In addition, decision nodes can be inserted to allow branching of activity lines. Each activity has several attributes, like name, planned start and end, priority, real start and end, status, actors assigned, and attached files. Activities could be visualised by a standard or user-defined icon. The latter allows an easy and user specific grasp of the purpose of an activity. Figure 2 shows an excerpt of a process modelled for one of the ERMA user, the port authority of Santander in Spain. The modelled scenario describes a chemical toxic cloud due to an accident in a chemical plant in the port area.

4. Lessons Learned in ERMA

The ERMA project has finalised the implementation phase and conducted two field trials, in Romania and Spain, both with success. Both trails have been scenario based, showing how different users can access the platform in different locations, demonstrating the exchange of information and timeliness of notifications.

In the beginning of the project, external experts surmised that rescue staff might not be able to abstract their procedures in such a graph-oriented way in the process workbench. However, the final feedback from the ERMA users and audience in the trials showed, that even the presentation of flows of actions as graph needed some little time to conceive, it stimulated the users to re-arrange and fill their processes with great engagement and convinced the audience immediately. Some visitors expressed spontaneously their interest to use such a tool for learning purposes, and referred to the case of mayors newly elected and inexperienced with emergencies.

In general, the feedback was positive, and some lessons learned can be derived.

From a technical point of view:

- The visualisation of emergency procedures in process management style is intuitive and easy to grasp. Even though, computer-illiterates or beginners need some learning time to understand concepts and interface logic.
- Most communities have very vague emergency plans. Procedures seem to be locked in the head of experienced staff, but are not traceable by electronic or paper means. Determining emergency scenarios and extracting procedures for process models must be accompanied by process modelling and risk experts.
- Authorities often underestimate the spread and usefulness of modern communication channels like mobile phones and Internet during crises situations. But apart from informing people in danger, also citizen feedback and communities' exchange give authorities new means to gather information and also to channel citizen participation [20], [21]. It is also often disregarded, that such communication channels might have their biggest impact before (early warning) and after (recovery) an incident.

From a political point of view:

- Smaller communities tend to delegate responsibilities to superior organisations.
- In many regions several organisations are responsible for different tasks of emergency relief (be it medical support, fire fighting, recovery). These organisations have often

different terminologies, chains of commands, and procedures for emergencies. Not to mention states with a federal structure. Authorities attending the field trials were very pessimistic about common agreements among organisations involved.

- Often, communities concentrate only on direct threats well known and experienced. However, a diversity of risk might surface that is not considered so far. Hence, flexible means are required to adapt to such new kinds of risk once they happen. Knowledge about processes – in particular their strategic objectives – appear as natural ingredient to leverage such changing environments.

5. Conclusions

We have started with the question whether emergency forces can benefit from the employment of process modelling approaches that have proven their potential for various application domains. We experienced that once formal models were in place, fire brigades were immediately in the position to capitalize on our approach due to the means for process analysis. Based on the different views generated from process models, various performance and completeness perspectives were studied. Respective analyses range from the mere evaluation of the sufficient availability of resources, over the adequate distribution of activities across organisational units, up-to a resilient workload for critical operational units. Hence, the question posted at the very beginning has to be answered by *yes*.

Consequently, we started to customize the process modelling tool to their operational and organisational needs. Some of these customisations have already been implemented by the current version of the modelling tool, e.g. adaptation of terminology and constraints on modelling structures. Still, additional adjustments are planned to rectify user acceptance and usability from a domain experts point of view.

Project ERMA has been started to provide an intuitive modelling environment for processes in the emergency management domain. A first prototype has been finalised with positive response from the field trials, first lessons learned are summarised in this paper. ERMA also offers a platform to integrate processes into the overall information flow between emergency management teams and to and from the citizen. Since ERMA uses a SOA approach, it is able to orchestrate services from existing systems. The employment of SOA serves also future business models of ERMA: external information providers can market their services to authorities to be used in case of emergency. Further exploitation steps will include identifying potential end users as customers to summarise requirements and to start with best practice processes. These models can then be shared between communities facing similar risks, and therefore this facilitates the burden of the abstraction task. At the same time, an ERMA user group will be established to support spread of information about the capabilities of such IT-systems in the emergency management domain. This will naturally attract new customers. The planning on this user group is currently in process, news about this and further steps will be published soon.

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References

[1] Curtis, B., Kellner, M.I., and Over, J., *Process modeling.* Communications of the ACM, 1992. **35**(9): p. 75-90.

[2] Sedlmayr, M., Rose, T., Greiser, T., Röhrig, R., Meister, M., and Michel-Backofen, A. *Automating Standard Operating Procedures in Intensive Care*. in *19th Intl. Conference on Advanced Information Systems Engineering (CAiSE'07)*. 2007. Trondheim, Norway.
[3] Mak, H.Y., Mallard, A.P., Bui, T., and Au, G., *Building online crisis management support using workflow systems.* Decision Support Systems, 1999. **25**(3): p. 209-224.
[4] Loper, M. and Presenell, B. *Modelling an emergency operations center with agents*. in *2005 Winter Simulation Conference*. 2005.
[5] Lakenbrink, S., *Kölner Konzepte*, in *BRANDSchutz, German magazine for fire brigades*. 2003. p. 746 - 752
[6] Arsenova, E. *Unterstützung der Prozessmodellierung im Notfallmanagement*. in *Informatiktage 2008*. 2008. B-IT Bonn-Aachen International Center for Information Technology, Bonn: Gesellschaft für Informatik.
[7] Hoogendoorn, M., Jonker, C.M., Popova, V., Sharpanskykh, A., and Xu, L. *Formal Modelling and Comparing of Disaster Plans*. in *Proceedings of the Second International Conference on Information Systems for Crisis Response and Management ISCRAM*. 2005.
[8] Yao, X. and Turoff, M. *Using task structure to improve collaborative scenario creation*. in *4th International ISCRAM Conference*. 2007. Den Haag, Netherlands.
[9] van der Aalst, W.M.P. and ter Hofstede, A.H.M., *YAWL: yet another workflow language.* Information Systems, 2005. **30**(4): p. 245-275.
[10] WfMC. *WFMC.org Homepage*. http://www.wfmc.org/ (5/2008).
[11] Emprise. *BONAPART® EMPRISE Process Management GmbH*. http://emprise.de/emprise.shtml?id=2757 (5/2008).
[12] Schmidt, J., *Einsatzkonzept MANV Überörtlich. Rheinische Projektgruppe „MANV Überörtlich"*. 2007: Cologne.
[13] Scheer, A.-W. and Thomas, O., *Geschäftsprozessmodellierung mit der ereignisgesteuerten Prozesskette.* Das Wirtschaftsstudium 34 (2005), Nr. 8-9, 2005: p. p. 1069-1078.
[14] Scheer, A.W., *ARIS–From the vision to practical process control.* Business Process Excellence, 2002: p. 1-14.
[15] Scheer, A.W. and Nuettgens, M., *ARIS Architecture and Reference Models for Business Process Management*. Business Process Management: Models, Techniques, and Empirical Studies, ed. W.M.P. van der Aalst, J. Desel, and A. Oberweis. LNCS 1806. 2000, Berlin: Springer. 376-389.
[16] ERMA Consortium. *ERMA Project Homepage*. http://www.erma-project.org.
[17] Pollak, E., Falash, M., Ingraham, L., and Gottesman, V., *Operational analysis framework for emergency operations center preparedness training.* Proceedings of the 36th conference on Winter simulation, 2004: p. 839-848.
[18] Van Someren, M., Netten, N., Evers, V., Cramer, H., De Hoog, R., and Bruinsma, G. *A Trainable Information Distribution System to Support Crisis Management*. in *2nd International ISCRAM Conference*. 2005.
[19] Georgakopoulos, D., *Collaboration Process Management for Advanced Applications.* International Process Technology Workshop, 1999.
[20] Palen, L. and Liu, S.B., *Citizen communications in crisis: anticipating a future of ICT-supported public participation.* Proceedings of the SIGCHI conference on Human factors in computing systems, 2007: p. 727-736.
[21] Careem, M., Silva, C.D., Silva, R.D., Raschid, L., and Weerawarana, S., *Sahana: Overview of a disaster management system*, in *IEEE International Conference on Information and Automation*. 2006.