ERMA - ELECTRONIC RISK MANAGEMENT ARCHITECTURE FOR SMALL AND MEDIUM-SIZED COMMUNITIES

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Abstract

Project ERMA (Electronic Risk Management Architecture) 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. Process know-how enables effective support of rescue forces on the one hand, but also furnishes an invaluable resource for knowledge transfer and reuse. This paper presents ERMA's approach on the structuring of risk management processes along a process management stance. It reports on ERMA's components with a particular emphasis on its process management services.

Introduction

Any risk episode can be characterised by its unfolding flow of information. Starting with single indicators of an emerging or existing hazard, an avalanche of data overwhelms risk managers once the risk episode has proven to be a serious disaster. The question arises of how to deploy key indicators to assess risks and how to evaluate sensor data according to key indicator knowledge. Based on this assessment, certain decisions have to be drawn. Following these decisions, specific actions have to be taken–i.e. start of processes–and rescue forces as well as the citizen have to be advised–i.e. instantiation of workflows and information delivery in the spirit of citizen relationship management (CiRM). Here it is where process management is essential (Mak et al., 1999). Moreover, CiRM is not only instrumental for the advise of citizens, but also for the capture of information from the citizen–i.e. the citizen acts as an additional sensor network–which for instance can be used for the gathering of information about blocked roads in the case of a snow-related break of woods.

The operational backbone for each risk management episode is located in command centres of local or regional authorities. The level and scope of information technology (IT) support varies significantly, since not standard software solution has been established until now. The vast majority of IT services in command centres is custom made for each organisation. No reference processes or other means of standardisation have gained ground so far as in many other domains.

Yet, some activities typical for command centres are already supported by IT tools, e.g. resource management applications or mapping tools for the display of and interaction with graphical maps comprising tactical symbols and information layers. However, process management is not really supported although its vantages are proven (Mak et al., 1999). Similarly, key indicator systems are also rarely found although they allow for an efficient and effective monitoring of evolving and potentially hazardous situations. This lack is further compounded by the fact that sensor networks are increasing at tremendous speed but they are not used for disaster identification and surveillance. This lack might be due to their high complexity, an inappropriate economics of scale for small to medium-sized communities, or merely people are conservative when introducing new techniques and processes.

The ERMA platform intends to support the entire life cycle of a risk management episode that starts with the identification of a hazardous episode and its assessment. Following a decision on actions to be taken, suitable instructions are given that are accompanied and supported by certain processes. Then, a set of communication and collaboration services are employed to support the communication among rescue and communication with the citizen to give them advise. ERMA provides a set of tools to underpin this life cycle:

- a key indicator-based decision support system combined with a process management component,
- an early warning system to alarm emergency staff and concerned citizens,
- citizen relationship management as well as team collaboration software to support the communication to the citizen and among rescue organisations and other authorities.

The decision support system will derive specific counter actions by assessing the measurement data of sensors and monitoring tools, while corresponding tasks are managed by the process management component. Hence, ERMA will combine the advantages of these tools to a customisable bouquet of a risk management system that is in particular scalable to smaller communities.

ERMA's implementation is based upon SOA (Service Oriented Architecture) in order to link all its components and to allow connections to other external risk management architectures and platforms like ORCHESTRA and OASIS. In this manner ERMA is flexible and extensible and such easy to customise to special requirements of end-users.

The ERMA project started in September 2006 with a two year runtime, and will provide a first prototype to be tested in two user sites in 2007. Final results are expected end of 2008. This paper will present background, state-of-the-art and requirements of ERMA with a first outlook on the derived ERMA system architecture.

Risk preparation and response

The ERMA project focuses on the specific needs of small and medium-sized communities. Hence, an analysis of their risk patterns is required. Information revolving around the preservation of the environment's quality and safety is geographically and administratively dispersed: they include municipalities, fire departments, police, disaster relief organisations, various company types, and many other public and private bodies. Thus, any information gathering process needs a coordination of these different stakeholders. However, initiatives for coordination at the local level are sparse. Hence, instead of a homogenised, co-ordinated, and interoperable process, different information collection processes during major or minor natural, industrial accidents or environmental pollutions are in place.

Hazards threatening small end medium-sized communities can be classified in three categories:

a) Natural risks (earthquakes, landslides, floods, hurricanes and tornadoes, snow falls, tsunamis, volcanoes).

b) Technological risks, associated to the sudden release of large amounts of energy or dangerous substances (fires, explosions, toxic clouds, toxic spills to water, radioactive releases). Usually associated to the existence of industrial sites, sea-ports, and transportation of hazardous materials (by road or rail).

c) Man-made risks related to the activity and the existence of people (forest fires, abnormal conditions in the basic supplies to the population).

Although they have some common features, they are essentially different from the point of view of surface covered (usually a larger scale in natural risks), probability in a given zone, occurrence dynamics, etc., and emergencies should be treated in different ways. However, a common aspect is the convenience of warning the population in time.

From the point of view of emergency management and population warning, these hazards can have completely different features. Thus, a flood, a snow fall, or a volcanic eruption can be often foreseen within a certain time, which gives a safety margin to inform and alert the population. Instead, a toxic release from an industry implies a very short time (alert to population should be performed massively over a given zone and very quickly), and an explosion will probably occur without warning at all.

An essential aspect of emergency plans is, under certain circumstances, alerting the population about the existence of a hazard and giving people sufficient lead time, along with adequate instructions on what they must do (these instructions should also have been supplied in advance). This information must be given only to the population affected by the emergency; otherwise it would create unnecessary fear among other people. This means that a methodology has to be applied -often "a priori"- to define the zone covered by the given hazard. As possibly the dangerous event (as usually happens with technological risks) will take place in or near dense populated zones, or the area covered will be significant (as happens with natural risks), the amount of people to be contacted can be relatively large.

Furthermore, in certain emergency situations the time elapsed between the start of the emergency and the moment in which the effects reach the people can be rather short. Suppose, as an example, a release of toxic gas from a process plant. If the atmosphere is stable, a toxic cloud can be localised; this cloud will move at the velocity of the wind and in a short time can reach an urban zone. If a previous risk analysis has established what to do (zone affected according to the meteorological conditions, instructions to be given to the population for that specific event), quick and massive information to the population affected will reduce drastically the consequences.

Although most large towns have analyzed this problem and have emergency plans ready and alerting systems available (for example, a sirens net), many small or medium-sized communities do not. In these cases, an alerting system such as that proposed in ERMA can be a good solution: a rapid and complete sending of an alerting/instructing message, which could eventually be completed with more specific actions in strategic places (hospitals, schools, isolated buildings, etc.).

Process support

Know-how about processes furnishes an invaluable source of knowledge about tasks to be conducted in order to respond to specific events. The question arises of how to capture this know-how. Recently, major coordination projects have been started to standardise rescue operation. For instance, the treatment of mass casualties, i.e. more than 100 injured people, requires resources from several organisations since only very few cities have the capacities to treat this large amount of injured people with their own forces. Hence, treatment, service and logistic procedures have to be agreed upon as reference processes. These reference procedures have to consider different types of equipment used by various organisations. Even not every fire-fighting vehicle of the same class comes with identical equipment. Also resource limitations apply for the provision of identical services, e.g. space required for the equipment.

The question arises of (1) how to design this processes in light of the various requirements, and (2) how to formally represent them in terms of a process modelling framework.

Know-how about processes is only available in terms of manuals for the most part, i.e. major fire brigades have specified their response patterns by so-called standard tactics. Each tactic describes certain patterns of actions to be taken depending on the event at hand. As such, predefined processes collect experience, organisational and administrative knowledge about how specific actions are to be undertaken, like e.g. evacuations, securing of installations, mounting of flooding dams. Ad-hoc processes allow one to plan end execute not yet modelled series of actions in specific occasions in order to customize pre-defined patterns to event-specific requirements. Once defined and completed, they can be adapted, stored, and reused later for similar situations. Until today, action plans of emergency situations like flooding are collected in large manuals with small or no IT support at all. Such manuals do not support tracing of actions, graphical overviews, showing of interdependencies, logging, or ad-hoc changes by nature.

A formal representation of such processes is required in order to embark for process guidance and analysis. Moreover, the use of workflow engines will ease the definition of complex scenarios, so that each step and respective information exchange can be modelled. In the case of an emergency, involved staff can concentrate on extreme and unusual events while routine jobs are guided by quality-assured workflow procedures.

In a formal stance, a process is a set of temporally or logically ordered activities intended to reach a goal involving resources (Curtis at al., 1992, Rupprecht et al., 2000). A process can be regarded as a system where the elements are activities and resources and the relations are the sequential or logical dependencies between those elements. The set of relations describes the process structure. An original process does not necessarily have to be a "real" process that has occurred in the past or is observed in the present, but it can also be a potential solution of how things could be done in the future. Thus, we define a process model as a mental or explicit representation of original processes such as risk management processes for the medical care of mass casualties.

Process models can be decomposed into different sub-processes, which again can be made up of other sub-processes. Sub-processes on the lowest level of decomposition are called activities. The decomposition of processes results in an aggregation hierarchy. Depending on the intended goal of the representation form, other elements of interest besides activities and logical dependencies can be represented in a process model. Those most frequently mentioned are (Curtis et al., 1992):

- *Agent* – an actor (human or machine) who performs an activity, e.g. a paramedic;
- *Role* – a coherent set of activities assigned to an agent as a unit of functional responsibility, e.g. dispatcher;
- *Artefact* – inputs and outputs of an activity. Artefacts provide important means for process synchronisation in major development projects, while in risk management application they merely address documentation purposes.
- *Resource* – resources represent the capabilities and tools required for the execution of an activity, e.g. motor-driven ladder.

Process modelling serves various intentions. Its major objectives can be classified into five basic categories (Rupprecht et al., 2000) applied to the crises management domain:

- *Enable mutual understanding and communication* – process transparency is enabled du e to a formal representation of the processes and it helps emergency teams to exchange their views on the work to be done and to understand what part they play in the operation.
- *Support process improvement* – the analysis of process models allows the identification of potential bottlenecks, missing synchronisations among activities or missing activities at

all. The analysis can be done by the use of formal reasoners (e.g. static or dynamic analyses) or visual animation.

- *Support process management* – a process model builds the basis for detailed scheduling, planning, easier monitoring, and co-ordination of an actual rescue activity.
- *Automate process guidance* – the documentation of processes support the reuse of process know-how. Thus, process models offer guidance and reference material to facilitate human decision process performance for specific situations.
- *Design process execution support* – once process models are formally capture, specific IT environments can be designed that are tailored to these specific processes, i.e. supporting the enactment of processes.

In first place, ERMA is providing an environment for the engineering of reference processes. This environment is build upon the metaphor of a drawing board for the graphical design of process structures (Rose 1998). Process structures will be designed by rescue workers in an intuitive fashion and formally checked for certain structural properties, such as appropriate synchronisation points or compliance of resource limitations. The graphical support goes beyond prevailing tools, such as he ones for Event-driven Process Chains (Scheer et al., 2002). Specific emphasis will be put on the specific requirements of rescue forces. These requirements include the consideration of resource limitations, compliance with command lines, heterogeneity of equipment, etc. The result of this endeavour will be a process engineering workbench for the design of reference processes. The workbench will build upon experience in the automotive (Fünffinger et al., 2002) as well as medical domain (Sedmayr, 2007). Both sectors can also be characterised by their complexity and flexibility of processes.

In second place, ERMA is going to employ a process engine, which supports emergency staff with predefined and ad-hoc process description. As such, predefined process models collect experience, organisational and administrative knowledge about how specific actions are to be undertaken, like e.g. evacuations, securing of installations, mounting of flooding dams. Ad-hoc workflows allow one to plan end execute not yet modelled series of actions in specific occasions in order to customise pre-defined patterns to event-specific requirements. Once defined and completed, they can be adapted, stored, and reused later for similar situations.

This unique feature of the ERMA system is not available on the market. In science, individual modules have been tested in the domain of emergency management. Examples include the simulation of events with training purposes (Pollak et al., 2004), the support of information dispatching (Van Someren et al., 2005), or collaboration processes (Georgakopoulos, 1999). Rescue organisations are reluctant to employ new IT technology in their daily operations, be it because their application is too time consuming or because the systems require a change of long trained and proven procedures. Systems supporting these procedures, easing their execution, and supporting exchange of experience are still missing.

Implementation

The ERMA project will develop a comprehensive risk management platform which is based on a SOA orchestration of relevant systems. Interfaces to other systems will augment the ERMA service portfolio where needed.

The following figure shows the planned architecture of ERMA with different modules to be integrated and the respective information flow. Optional components (presented in light grey) will be linked by SOA (Service Oriented Architecture) to establish loosely coupled and interoperable services, which can be integrated or deselected for individual requirements. The decision support system (DSS) serves as core component integrating the application logic and scheduling other functions when demanded.

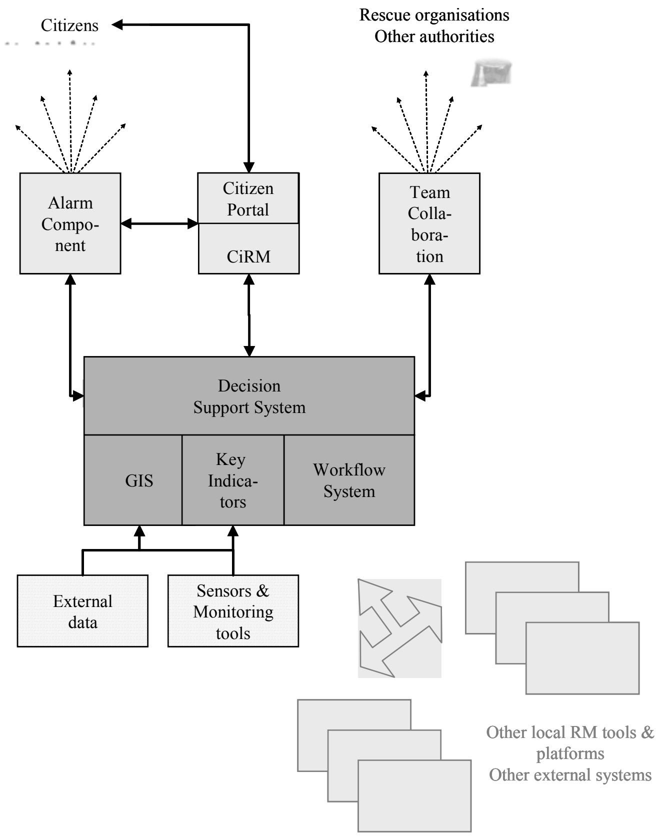

Figure 1. ERMA SOA Architecture

The DSS of ERMA will perform the following tasks:

- collection of sensor data,
- assessment by key indicators,
- derivation of states and actions,
- visualisation of measurement data in specific region, deduced state and actions, and finally,
- display of workflows for corresponding tasks, and
- editing and processing of workflows.

The workflow system will detail the proposed key indicator actions and guide users in executing the necessary steps. These steps in turn have been documented before and the target community has the possibility to adapt existing process models to its own needs in advance or directly in the crisis situation (ad-hoc processes). The exchange and adaptation of workflow models and instances will be possible, which allows the re-use of process models across different organisations.

Each reference process describes certain patterns of actions to be taken depending on the event at hand. As such, predefined workflows collect experience, organisational and administrative knowledge about how specific actions are to be undertaken, like e.g. evacuations, securing of installations, mounting of flooding dams. Ad-hoc workflows allow one to plan and execute not yet modelled processes in specific occasions in order to customize pre-defined patterns to event-specific requirements. Once defined and completed, they can be adapted, stored, and reused later for similar situations. Moreover, the use of the process workbench will ease the definition of complex scenarios, so that each step and respective information exchange can be modelled. In the case of an emergency, involved staff can concentrate on extreme and unusual events while routine jobs are guided by quality-assured workflow procedures.

The ERMA user interface will be designed as a cockpit. The DSS will give indication on what happened and what do to in which order, while additional modules will support communication to and from the citizen and between rescue organisations and involved authorities:

- The alarm component allows one to warn and inform the public by transmitting vocal or textual messages to stationary or mobile phones in a specific region. Feedback tracing collects the response of the public and gives an indication on reachability and such on further measures and scope.
- Additionally, a citizen information portal will be established. It is connected to a citizen relationship management module (CiRM), which furthers communication with the public and also channels citizen feedback and calls to the responsible position.
- Team collaboration software allows sharing of short textual information, forms, movies and images, documents and the like between rescue organisations and/or authorities. Additional features like chat functions, notifications on changes and upload, calendars, address and contact lists supports information exchange between all concerned parties.
- Via SOA external systems can be linked and their information displayed or processed. For example, weather information from a commercial or state provider will be integrated in the key indicator system to support the decision process.

Application

The ERMA system could be used in small and medium-sized municipalities, and would be operated in command centres of disaster management authorities or organisations like fire brigades. A possible scenario is that ERMA supports a city with a river nearby which from time to time bursts its banks.

Its water level is permanently monitored by a sensor system sending data at regular intervals to the decision support system of ERMA. The key indicator system module assesses the current situation on the basis of threshold values and possible threats for the municipality. It also informs via the internet-based citizen portal the public about the current water level, with background information about potential risks, impacts, and guidelines what to do when.

When the sensors report the exceedance of alarm threshold due to a rising water level, the key indicator system checks the incoming values, integrates weather prediction values, and proposes counter actions, which are predefined crises management processes. The flow of activities will be presented by a workflow system. The responsible staff can change and adapt these workflows to the current situation. The workflows show activities, roles and actors, related input- and output documents (like forms), as well as rules and conditions related to activities. Risk managers can coordinate their command chain according this task flow. Setting the state of each activity according the real life state of activities allows one to monitor and "walk" through processes. Real life changes of the process can be transferred to the model as well as to the instance and saved for later reuse.

Additionally, the system stores the current information (instances of the process: time, decisions, involved persons/organisations in activities, etc.) for tracing, logging and after-action debriefing and analysis.

One the key indicator systems signals the passing of a threshold, it activates the corresponding reaction procedure, e.g., the evacuation of jeopardised areas near the river. The risk manager invokes now the attached alarm module to send a multi-channel warning to citizens in danger, for instance, by calling mobile phones or by sending SMS directly to the region at risk. Transfer of information to the citizen portal (i.e. maps) allows one to inform the public about the upcoming evacuation, about blocked streets, and about next steps to do. In addition, citizens can feed the portal with their own observations about the situation, which in turn helps the rescue organisations. The CiRM catches and collects this incoming information, but also provides address and contact data about citizens, logs information exchanges like incoming phone calls, and offers additional information about specific citizens or organisations or facilities like kindergartens (special equipment, special handicaps, etc.).

With the team collaboration software the rescue organisations exchange legal forms, written evacuation plans, and moreover maps of the regions, images and photos taken, or information about past events and crises situations in this location (i.e., what happened last year).

Last but not least, the connection to other risk management systems facilitates the access and pushing of information from and to other systems and institutions. Referring to the scenario written above, a municipality located downstream can be informed about the current water level, the activities of other rescue organisations, or can request or offer shelter for evacuated citizens.

Outlook

ERMA is going to provide a process-oriented workbench for the support of rescue operation in small and medium-sized communities. A specific focus will be placed on risk identification and assessment on the basis of key indicator system, a process workbench for the support of coordinated rescue operations, and a citizen communication component for alerting as well as for gathering feedback. From a process-oriented point of view, ERMA focuses on the design of processes as well as the execution of processes. In the course of process definition, ERMA will build upon the city network of SETRIC (Security and Trust in Cities), which so far produced a significant number of best practice reports, will be used for elaborating the requirements, transfer best practices in workflow models, and disseminating the results.

Due to the employment of service-oriented architectures, ERMA is going to adapt and build upon existing components for alarming, geographical visualisation, collaboration, and citizen relationship management. It will promote a process-oriented stance for supporting emergency management operations. Specific components will be developed for indicator-based risk assessment as well as dedicated process support for risk management. ERMA will combine best-of-class components and best practices on risk management. Its innovative power is due to the combination of services and their customisation features.

The ERMA project started in September 2006 with a two-year perspective. It will provide a first prototype to be tested at two user sites in 2007. Final findings about the performance of the platform and its customisation prospects are expected by the end of 2008.

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