An event driven approach to bridge emergency management, reflective debriefing and experience based learning

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Abstract – An increasing number of information and communication technology solutions provides surveillance and management support. This includes all levels of software systems from sensor data acquisition, information processing to interactive user interfaces allowing maintenance of an operational picture. The paradigm of an Event Driven Architecture represents a design approach for sustainable use of data. Besides primary use to ensure civil security in response to an incident, the recognition and processing of events allows to bridge emergency management with reflective debriefings and experience based learning. This article reflects the results from research on the potential of event logs created by operational data collection complemented by observer logs in case of trainings.

1. Introduction

Emergency management requires preparation for critical, complex situations that are characterised by the need for decisions, the existence of alternative options, high interdependencies between and intransparency of system elements, irreversible actions and challenging time constraints (cp. [1, 2]). Decision makers are part of high reliability organisations, managing assessable but unforeseeable risks [3]. In the case of an abnormal situation like an emergency, it is necessary to recognise everything that happens, to interpret the context, to derive action alternatives and to decide. Due to time constraints it is often impossible to analyse the effects of each possible action [4]. Covering other phases of the emergency management cycle, "learning and understanding what actually happened before, during, and after the crisis is extremely important for the improvement of the response process" [5]. 'Events' have to be detected and interpreted. In this context an 'event' is something that happens in reality (cp. [6, 7]); therefore a situation is characterized by the combination of events. For example, an explosion, an emergency call and the alert to citizens are important examples for generic types of events. To learn from experiences it is necessary to generate an 'organisational memory' [1] in terms of event logs including structural changes of response teams, status changes of resources, changes in the command hierarchy etc. [5].

First responder organisations collect data in various structured and unstructured digital formats already. Due to the amount and structure of data, human actors need to be supported by information and communication technology (ICT) when transforming the collected data into actionable knowledge. Events carry important semantics as they represent activities of high significance within an organisation. The Event Driven Architecture (EDA) represents a paradigm which complements the event driven characteristics of an emergency with technological capabilities for supporting human actors in terms of the recognition, processing and representation of events.

Besides support for emergency management in the response phase, this paradigm carries promising potential to bridge this phase and processes like debriefing and preparative trainings (cp. [1]). Event logs can be used by commanders as a foundation for reflective debriefings showing operational strengths and weaknesses; they can be transferred to trainings scenarios in terms of environmental factors [8] and real experiences [9].

The advantages can be even increased when looking at trainings following an application oriented and constructivist approach (see [9] for details). Trainings can be designed as real-world or table-top exercises where the simulation of a 'story' or 'scenario' (i. e., an artificial pre-defined event log) supporting specific learning goals represents a major challenge for coaches. Besides that, observers need to track actions of trained staff to allow detailed debriefings. Event Driven Systems (EDS, i. e., systems implementing the EDA paradigm) provide functionality for technical supported observations with benefits for archiving observations as a core requirement [10]. Therefore, event logs created by automatic event recognition (based on sensor systems, communication channels, video recordings etc.) can be complemented by manually annotated data.

The research presented in this article builds up, on the one hand, on the potential which is available in today's organisations already and, on the other hand, on the added

value promised by new technological developments in the field of EDS. The article addresses the question: "How can ICT satisfy demands for support in reflective debriefings and experience based learning assuming an increasing level of data collection during emergency management?" This research question subsumes topics calling for different research approaches (see chapter 2) answered by an Even Driven Approach (see chapter 3). Based on results from human centered research in two German and European projects conclusions are drawn and an outlook to research in ongoing security research projects is given (chapter 4).

2. Methodology and related work

At first, our research is based on a market study of information systems for emergency management including data collection in terms of surveillance and monitoring during an incident. The study targeted command and control solutions (C^2 systems) especially used by German organisations. Most of them are based on a message oriented middleware representing the communication channel of the systems. Some of these solutions allow the analysis of operation data and playbacks of the collected data. Special attention was paid to the demonstrator implemented in the European research project OASIS allowing form based documentation of 'lessons learned', PRO DV SASIS[ÜSA] providing exercise control options and a scenario management and statistics tool by Ruatti ST called ISTC. In addition to C^2 systems, Virtual Training Environment (VTE) products are currently introduced to various sites in Europe and are focused by several FP7 research projects (e. g., L4S, INDIGO, CRISIS, PANDORA) or national collaborative projects (e. g., ASPIC, DESCARTES). Only in a few ambitious projects these products are utilised for optimised pre-assessments and corresponding management activities (cp. [11]).

In a second step, we conducted semi-structured interviews and participating observation to understand the needs and possible use cases for documentation tasks, in debriefings and for operation oriented trainings. 46 fire officers of the Fire Department Dortmund participated in a first set of interview sessions; in addition, 24 exercises were observed at the State fire service institute North Rhine Westfalia. Within a second set of interview sessions, eleven fire officers were observed and interviewed when using specific prototypes with respect to usability standards. These human centered activities allow us to complement literature research and statistics by perceptions of potential end users of the technological solutions.

In parallel, we designed and implemented prototypes for emergency management, data analysis, debriefings, observer support and learning management [12]. The prototypes follow a system-of-systems approach : The system (as a whole) is built by subsystems, i. e., logical subsumptions of correlated components. Each of these components represents an independently working solution for specific objectives and providing dedicated functionality. Additionally, existing tools for behavior analysis and Learning Management Systems (LMS) were used for this research step (see following sections). These prototypes allow conclusions on the potential of ICT to bridge the gap for experiences based learning.

3. The event driven approach

Technology has to support human operators and decision makers to recognise events (resulting to 'event object streams' and being handled by 'event processing') and to interpret them in the context of the real situation ('use cases/applications' supporting 'processes'). We propose to bridge all use cases adopting the paradigms of Event Driven Architecture (EDA) and Service Oriented Architecture (SOA) as an 'Event Driven SOA' [13]. This approach allows applications to access specific components and pieces of knowledge within the corresponding architectural framework.

3.1 The technical EDA paradigm

As presented, the Event Driven Architecture (EDA) defines the framework for a technical solution of these challenges. Figure 1 highlights the integration approach by following the data and information flow from sensors (observing the 'real world' and creating 'event object streams' as a result of event recognition) through 'event processing' to 'applications' (dark grey part of the cycle showing main interfaces for C^2 systems and ICT solutions for data analysis, debriefings and trainings).

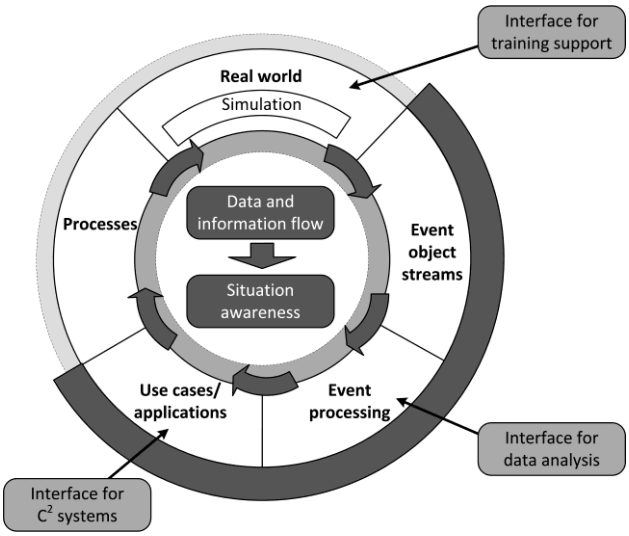

FIG. 1: The event driven approach based on the EDA paradigm (based on [14])

Besides sensing real world artefacts (GPS, vehicle data, communication channels, video cameras, chipsets and software in handheld devices, Web 2.0 tools etc.), pre-defined aspects can be simulated in training exercises in order to create an intended scenario. Based on sensing results and defined event recognition schemes, 'event

objects' are detected and added to the event log of an operation. Depending on the type of event considered specific applications or use cases respectively are triggered. The regarding outcomes are visualised via the graphical user interface or processed within the decision support or command control system respectively.

The backbone of an EDS is built by an 'integration subsystem'. One of its central components is a message-oriented middleware (MOM), implementing the publish-subscribe pattern (asynchronous communication). This approach follows a standard architectural model of Enterprise Application Integration (EAI). It enables the whole system to be extended by additional and alternative components. As an integral part of EDS, ICT components communicate via the MOM. Besides standards from the field of EDS, domain specific standards can be used to unify data exchange and to enhance automatic data processing. Taking into account existing standards like CAP and EDXL, specific requirements in Germany were transferred to DIN specification 91287 [15] implementing basics from process analysis and semantic data modelling.

3.2 ICT use cases

Our research is based on the assumption that emergency managers use ICT solutions in terms of C^2 systems today and in the future. Therefore, the 'operation' implies important use cases for the EDS and its user interface. Figure 2 presents an overview of the prototype used for our research (see, e. g., [12] for more details). Besides location- and resource-oriented views to real-time information, event based information supports decision making in terms of triggers (green pop-up window), overviews and statistics. The interaction of a commander with this user interface (e. g., the officer-in-charge enters information about the size of a fire in the map) can be interpreted in terms of 'events'.

In addition to this real-time use of the EDS, data analysis tools need to be provided to commanders and specialized analysts. We use an existing tool and adapt its user interface to the specific needs of users (for details see [9]). Besides behaviour research, such kinds of tools are well-known in the field of usability labs and the analysis of sport events like soccer matches. Their main focus is to observe human actors while tracking exactly their individual environment and ensuring data collection for comparative research. Noldus The Observer® XT allows to visualise various data streams, to synchronise these streams and to highlight events for detailed data analysis.

FIG. 3: An exemplary learning object based on actual event logs collecting via operations or trainings

After (a) collecting data and recognising events during an operation as well as (b) analysing this data and reflective debriefing after an operation the event driven approach allows to transfer event logs to experience based learning. Figure 3 shows an extract from a learning object generated based on event logs from a training exercise.

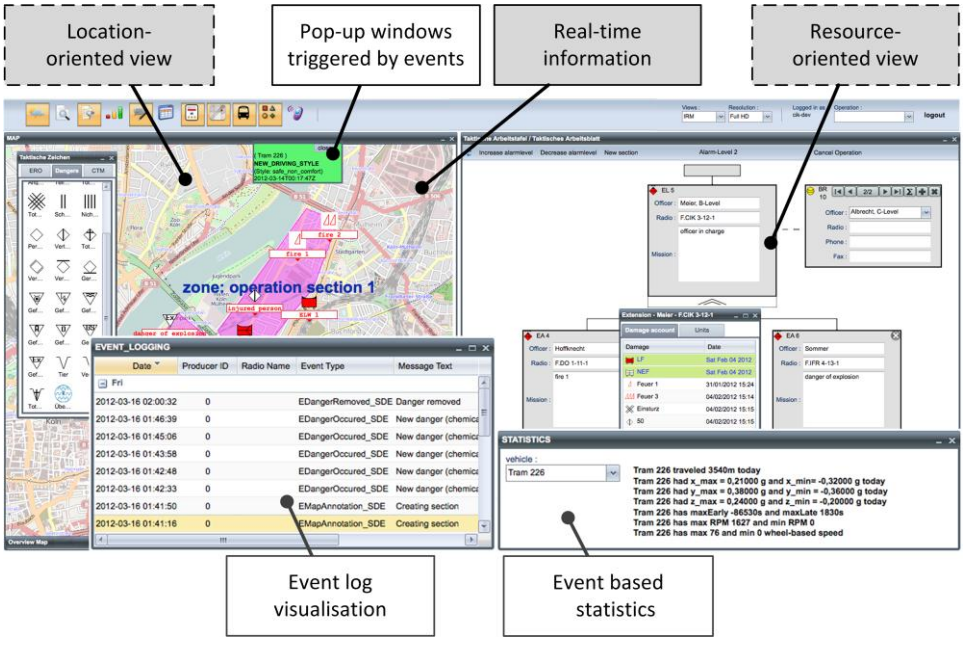

FIG. 2: The graphical user interface for C^2 system usage

4. Results and conclusions

As a summary of all studies described in chapter 2, the event driven approach proved to bridge emergency management, reflective debriefings and experience based learning successfully. Technologically the Event Driven SOA allows to integrate use cases and applications. Besides solving issues of incompatible interfaces, our approach is mainly based on an integrative usage of actionable knowledge based on automatic or manually collected data. Our research showed that modelling the event types to be recognised is a challenging but significant success factor; in addition to technical validation of event models, qualitative interviews confirmed that the provision of relevant events in a log adds value to debriefings and trainings with respect to experience learning. Nearly all interviewees (14 of them were confronted with the learning content using the ILIAS LMS) confirmed that, for high level commanders, scenarios based on a real event logs from their own practice or from other fire brigades would facilitate new learning dimensions ; they even provided extended ideas for the application of this approach.

Besides these positive results we have to state that we had to overcome terminological issues initially. Bringing together security and ICT research, well-established glossaries need to be integrated. Nearly 70% of interviewees reduced the scope of the term 'event' to an emergency (for example, dangers happening in a specific environment) instead of correlating it also with the emergency response (e. g., forces starting firefighting). Additionally, for the definition of event types as a key of our research the cooperation between practitioners (bringing in expert domain knowledge) and researchers (introducing new approaches concerning relevant events and feasibility of event recognition) was essential.

This paper presents findings for bridging operations and other use cases; we need to extend these research efforts towards a sustainable application to trainings and learning environments. This concerns both design approaches to support authoring of learning content, observations and the provision of information to trained staff. Technical solutions should be enhanced by functionality extending information with explanations for end users. Further evaluations need to complement this approach. Within the German security research programme, we will address these challenges in a follow-up project.

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