Cultural Analysis and Formal Standardised Language — a Mass Casualty Incident Perspective

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ABSTRACT

Handling highly dynamic scenarios as they arise in *mass casualty incident* (MCI) situations requires lots of information about the situation and an extremely flexible IT infrastructure that can assist in managing the incident. Normally, rescue workers from different organisational cultures do not communicate across their organisational boundaries, but in an MCI they have to efficiently collaborate in order to successfully manage the incident.

In this paper we argue that qualitative *cultural analysis* can provide important insights into the design of technological systems that are to be deployed in inter-organisational settings like an MCI. We will show how the engineering of complex knowledge based systems for such scenarios can profit from the results of such an analysis.

Keywords

Cultural analysis, linguistic awareness of cultures, knowledge engineering, standardised language, ontologies.

INTRODUCTION

For police, medical services, and fire and rescue services, the most important *security authorities and organisations* (SAO, in Germany called BOS — "Behörden und Organisationen mit Sicherheitsaufgaben"), the successful handling of routine rescue missions is based on exercise and experience. Routine scenarios are usually of a small scale nature and can easily be handled by rescue forces. However, in large scale scenarios up to *mass casualty incidents* (MCI), the rescue forces at the scene are overwhelmed by the number and severity of casualties. In order to successfully handle MCIs, various SAO have to manage and work closely together to cope with the scenario. Our research aims at developing a framework that provides IT-support for the strategic (goal directed) cooperation and communication of emergency management organisations.

When developing new technologies, a liaison with the intended users is very important for the acceptance and successful application of these technologies. This liaison is at the heart of the usability of any technology where human and machines interact. This is especially true in highly dynamics scenarios like MCIs where humans from different organisational cultures and computer systems together have to solve a difficult problem. Approaches that account for *the human factor* in technology design comprise classical usability studies applying quantitative methods (see Bangor, Kortum, & Miller, 2008) as well as culture studies based on qualitative data. Usability studies are already widely used; culture studies however are seldom applied to the design of complex technological systems. The aim of this paper is to point out how qualitative cultural analysis can contribute to the overall usability of human centered technological solutions and why this methodological approach should receive much more attention.

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CULTURAL ANALYSIS

Cultural analysis is based on a definition of culture that refers to culture as a life world and primary world. Cultural analysis is a special technique for the description and analysis of the communication and behavioural processes within national cultures. On the basis of these contributions we lifted the methodology and concepts of the national culture analysis to the organisational level — by focusing on SAO in MCI and the definition of culture described above. Inter-organisational communication that is based on the above mentioned definition of culture can be understood as intercultural communication. In contrast to other approaches, in our case we describe the linguistic differences not as exemplary but comprehensively from an anthropological point of view — in our opinion a necessary precondition for successfully developing a user centred technological assistant system. Understanding culture as a discursive construct that emerges in interaction in life world also led us to a deeper analysis of *one aspect* (besides the nonverbal, paraverbal, and extra verbal elements) of communication: the verbal element. Verbal interactions between members of different SAO are characterised by different bases of knowledge and different verbal behaviour and symbolic actions. This can lead to inter-organisational (intercultural) *misunderstandings* or to a simply *not-understanding* of each other (Liedtke, 2002). Actions that are based on these misunderstandings can have fatal consequences for the MCI management. Especially in the case of a not-understanding, a significant amount of additional communication is needed to resolve the situation, so that friction loss arises which impairs the overall solution of the mass casualty situation.

This paper focuses on one specific example of technology design, that of a software system for MCI support involving mobile devices (e.g., tablet computers and PDAs) which is expected to support communication and information gathering as well as the transport of information within and between SAO in mass casualty incidents. Existing systems consider primarily intra-organisational communication and barely address the dependencies between different SAOs which also are very relevant for effective inter-organisational communication and decision-making. Accordingly, for our MCI scenario, much qualitative data about inter-organisational communication was collected in interviews and during observations of real incidents. How this data is and in our case was used for a cultural analysis will be described in the next paragraph.

Cultural analysis as a fieldwork is based on free observations (in our case exercises and assignments), guideline based and narrative interviews, as well as document analysis[1]. The data collected by these methods provides a basis for the understanding of the specific semantic concepts of the (sub) cultures which are in the center of the analysis. To describe the communication styles of a SAO on a verbal level, the focus lays on understanding the language used for intra-organisational communication. Organisational cultures typically cannot be viewed as being homogenous. This is especially true for the organisations involved in MCIs. The federalistic structures in Germany cause regional differences within the SAO. Police, medical services, fire and rescue services are regulated by the respective federal state and not by the federal government (due to Art. 30, 70 of the German constitution). Our cultural analysis therefore addressed the actual SAO specific communication between the rescue workers handling the MCI. The analysis of this communication allowed us to identify the key language concepts used in the different organisations. The resulting collection of concepts was then used to analyse to what extend the vocabularies of the different organisations semantically overlap and what complications and behavioural consequences these overlaps can cause for the MCI management.

SECURITY AUTHORITIES AND ORGANISATIONS AS ORGANISATIONAL CULTURES

Institutions and organisations as cultures should be analysed with regard to identity delivering specifics. These specifics include "(…) typical behaviour, symbols, ceremonies, rituals, styles etc., which depend obviously on the organisational structure (hard factors) and practiced values, norms, organisational patterns, codes etc. (the soft factors)" (Ahlf, 2000). Cultures are differentiated by the habits that their members developed (so called standardisations) in the following categories: "the communication, the thinking, the feeling, the behaviours and actions" (Hansen, 2003). This standardisation builds a base for what members of the respective culture understand as being "normal". Culture in that sense is a product and means for social interactions which can be observed in organisational forms (e.g., organisation, company, and institution) and strategies (decision making process and behavioural tendencies) (Strähle, 2010). The habits mentioned by Hansen typically are not present in isolation but in different combinations. The preferences that certain cultures realise are called communicative styles. These styles should also be reflected in the way technical communication systems are designed and used for MCI support. In this case the technology understanding is socio-cultural. Organisational cultures integrate many different communicational styles and therefore are multilayered communication products where the interpretation of intra-organisational verbal interactions is based on interpretational schemata (concepts) that allow

[1] This method was developed by anthropologists who undertook research on indigenous people for cultural comparisons (see especially Geertz, 1973).

routine behaviour and the transfer normality and plausibility. Based on this understanding of culture any kind of technology has to be integrated into these habits and routine operations to be accepted and to assure an effectively use by the end-user (Banse, 2010). From this point of view, classical methodologies of "internationalization" and "localization" of software like it is used by professional software developers seem to be not profound enough.

In this paper, we focus on the semantic dimension of verbal[2] communication and interpret "meanings" as "interpretational schemata". These are learned during the socialisation processes of the apprenticeship and refreshed through experiences. We therefore believe that later, when different SAO interact with each other verbally in a MCI, the interpretation of the SAO specific (standardised) language takes place with recourse to the intersubjective world of everyday life and that the intended meaning of the words can only be construed wrt to the background of the individuals using them. A full mutual understanding of language used by the rescue workers form the different SAO therefore is very unlikely. This can cause inter-organisational misunderstandings, biased interpretation and unintended behaviour and thereby complicate the cooperation at the scene. Any attempt to use technology for the improvement of inter-organisational communication must therefore take into account, that this support will only be effective if the technology is accepted as part of the culture and if it allows for normal, plausible and routine behaviour (in the sense of communication). This must be ensured in advance by a qualified cultural analysis.

LINGUISTIC AWARENESS OF CULTURES

Verbal communication according to the perspective of communication science cannot be reduced to the exchange or transfer of information or symbol based behaviour. Language rather is a form of behaviour that humans as social beings developed in the course of their existence to satisfy re-occurring needs such as knowledge transfer, behavioural guidelines, or orders with known meanings. When speakers and listeners of different languages speak with each other, immediate linguistic differences become obvious and problems throughout the interaction can be expected. Linguistic awareness of cultures means the following: All cultural differences are "hidden" in linguistic manifestations. These expressions of cultural differences are found in all languages and can be classified in different categories. They are presented in culture specific explicit or implicit forms by both speakers and listeners — a further source of mutual misunderstanding, if these linguistic indicators or manifestations are not perceived by the interactors (Müller-Jacquier, 2010).

Terminologies and sets of phrases (as standardised language) are an expression of a specific development of an organisational culture. Through a shared socialisation of members of an organisational culture or sub culture, it can be assured that the connotation of the phrases and the symbols are the same and that misunderstandings are avoided (Bolten, 2007). However, symbols do depend on the context of the one who is using them (e.g., a crisis or everyday life situation) and same phrases can be based on very different underlying concepts; called homonymy. Only when symbols, conventionalised as codes, are shared partially between communication partners, understanding is possible (Bolten, 2007). Shared codes are the basis for shared mental models in a situation which requires to develop common goals, decisions and to initiate necessary coherent measures. Examples for codes that members of different SAO do not share are the following phrases that appear similar but have different meanings, because they are based on different knowledge: The "Alarm- und Ausrückeordnung" (alarm and response regulations) of the fire and rescue service is abbreviated as "AAO", while, within the police this abbreviation is used for the "Allgemeine Aufbauorganisation" (general organisational structure). And, vice versa, different phrases are used by different SAO for the same concept. Examples for that are the phrases "Massenanfall von Verletzten" (MANV: Rescue Service name for MCI) vs. "Größere Gefahren- und Schadenslagen und Katastrophen" (GGSK: Police name for MCI), or the phrases "Bereitstellungsraum"[3] (Rescue Service, Fire Department) and "Kräftesammelstelle" (Police). When members of different organisational culture interact, so-called accommodation processes take place. Phenomena that describe this process are thought-understanding, complexity reduction, ignoring of misunderstandings and hiding of non-understanding.

To deliver meaning is the basic goal of communication. However, the personal cognitive connection between the words one uses and the interpretations that are associated with them are not easily reproduced in other communication partners. When communication partners of different SAO meet, a very significant percentage of the communication is used to verify the vocabulary and the meanings that are connected with words. In order to successfully design an on-site emergency management information system that can be used by different SAO

[2] The dimensions of verbal communication are the semantics, the speech act, the skilled action sequences, and the discourse conventions (Knapp, K.; Knapp-Pothoff, A., 1990).

[3] A kind of "assembly-area" or "marshalling-areas".

and that offers a liaison with all SAO, a thorough description of the code of every organisational culture involved is necessary. Especially when designing user interfaces, these symbolic and linguistic specifications must be included, because they characterise the communicational style of the organisation and are part of what the future user expects to be normal. The standardised languages of the SAO can be extracted by cultural analysis, as well as tactical symbols and other verbal conventions. It cannot be the goal to achieve assimilation of the thought and behavioural forms but to reduce the verbal distance between the organisational cultures. Therefore, user centered methods must be developed to diminish these inter-organisational communication problems and paradoxies. A MCI support system therefore should support the communication between different SAO by reflecting the communication styles of all organisational cultures and by using standardised languages — not with regard to its wording but meaning.

IT-SUPPORT FOR MCI MANAGEMENT

In order to realise IT-based management and communication support for MCIs, it is necessary to use the SAO specific terms in a semantically correct manner. The following example illustrates how the core issues "not-understanding" and "misunderstanding", identified by the cultural analysis manifest themselves on the technical side of the MCI management.

Let us assume first that two rescue workers that are not working side by side and communicate via a technical system have a communication problem — e.g., because one of the two is no longer in the range of the communication zone, or is too busy to actively listen, or because the communication channel between the two is suspended. In such a situation of communication interrupt the addressee must accept and work with unreliable and incomplete information. Or he might try to resolve the problem by contacting the sender again if he becomes aware that a communication attempt was made but failed. Secondly, assume that a rescue worker receives a message but cannot capture its intended meaning (a case of not-understanding). The rescue worker can solve this situation by asking the sender for detailed information or further explanations. Both cases lead to a communication overhead which may be necessary (e.g., if the message is important for avoiding a hazardous situation) but nevertheless is unwanted and sometimes dangerous in an MCI scenario. One of the goals of IT support therefore must be to make the technical side of the communication as robust as possible. This is a real challenge in highly dynamical situations like MCIs.

A case of a "misunderstanding" communication problem is present if two rescue workers X and Y — say a police man and a member of the fire brigade — from different SAOs communicate with each other via a technical system and X interprets a message of Y with respect to his own SAO specific vocabulary. Then, if the vocabularies of the two different SAO disagree in the meaning of key concepts used in the communication, misinterpretations may result, which are disastrous for the situation at hand.

Experience shows that it is unlikely to reach a common use of only one unified language for all SAO (which would avoid the technical variant of the "misunderstanding" problem in the first place). Such a lingua franca is not accepted in the domain of MCI applications. Hence, a natural way to avoid misunderstandings of this type would be to design a technical system that knows how the different SAOs use the key concepts of an MCI. This system could then automatically transcripe key parts of the messages between different SAOs from the vocabulary of the sending SAO to that of the receiving SAO. Because in the MCI context messages typically are short, unambiguous (at least to the sender) and of only a few different types (e.g., orders, information, requests, or warnings) this translation should be possible in practice as soon as it is clear how the SAO specific vocabularies relate to each other.

The following sections explains how we went about to formally model how the different SAO involved in a MCI use language and how a combination of cultural analysis and ontology engineering can guarantee that the resulting models are also machine-processable.

KNOWLEDGE ENGINEERING FOR MCI MANAGEMENT

In order to achieve a formal representation of the vocabularies used by the SAOs, we applied the artificial intelligence (AI) approach of knowledge representation (KR). It has been stated that, the "Research in the field of knowledge representation and reasoning is usually focused on methods for providing high-level descriptions of the world" (Nardi and Brachman, 2003). The descriptions can be effectively used to build intelligent applications which have the ability to find implicitly consequences of their explicit represented knowledge (Nardi et al., 2003). In AI description logics (DLs) ontologies are the state-of-the-art KR technique used to formulate, exchange and reason with knowledge about a domain of interest (Bader et al., 2007). Description logics usually have a precise formal semantics which controls how to correctly reason with knowledge that is coded in this

logic. Moreover, there is also a strong support for DLs in the form of publicly available reasoners, development tools, and APIs.

An ontology resembling the language use of a SAO expresses a unified formal representation of concepts used by this SAO in rescue tasks. In order to model ontologies effectively, each step in the design and development process of such ontology should be well considered. This topic is addressed by the research area of ontology engineering which provides various suggestions and methodologies for ontology modelling. A comprehensive overview of ontology modelling is given in (Gómez-Pérez et al., 2004) and a brief survey about various development methods can be found in (Fernández-López et al., 1999).

In our project, we decided to follow the knowledge-engineering methodology designed by Noy and McGuiness (2001) which divides the development process into seven steps (see Fig. 1): Determine the domain and scope (1), consider reusing existing ontologies (2), enumerate terms (3), define the concepts (4), define the roles (5), define the facets/restrictions (6), and create instances (7). Once step (7) is finished the ontology can be used by computer programs as a knowledge base (KB) which contains the assertions describing the MCI at hand (see Fig. 1). During the evaluation and the adjustment phases, the seven steps will be executed iteratively to gradually improve the quality of the ontology. During this process the following guidelines should be taken into account: "There is not just one correct way to model a domain — there always are viable alternatives. The best solution (...) depends on the application that you have in mind (...). Ontology development is necessarily an iterative process" (Noy and McGuiness, 2001).

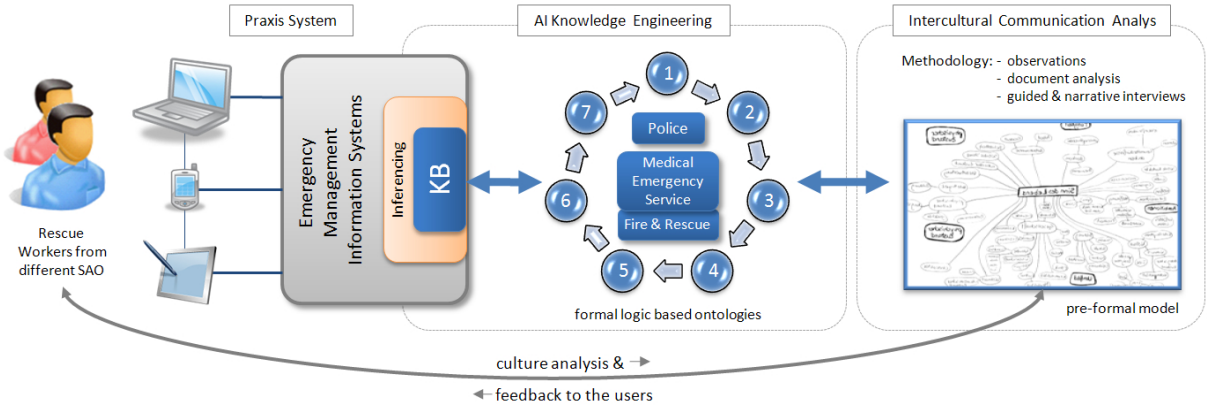

Figure 1. The Ying and Yang of Cultural analysis and Knowledge Engineering.

This approach to Knowledge Engineering is a user and application oriented view of the modelling process and should not be understood as a philosophical or cognitive science approach. The quality of the modelling result depends mainly on the successful application in the emergency management system itself; "*the proof is in the pudding*" (Gruninger and Fox, 1995). The challenge of the user centered ontology development lies in the proper definition of the vocabulary and the semantic relations between the concepts involved. On one hand, the definitions must be clearly delimited to allow effective reasoning. On the other hand, the vocabulary must cover all the concepts which are relevant for the management support system. In order to delineate the domain of applicability of the ontology and in order to guide the identification of user requirements for the MCI support system our modelling process was guided by *Competency Questions* (CQ) in the sense of (Gruninger et al., 1995; Uschold and Gruninger 1996).This also ensure that the final ontology will meet all requirements which are addressed explicitly or implicitly by these questions. In our case, the results of the cultural analysis played a major role in the formulation of the MCI specific CQs that drove the ontology development.

The MCI-Ontology

At the start of our project, we aimed at developing one ontology for each individual SAO. But the first results of the culture analysis signalled that it would be more appropriate to model two separate ontologies: the police domain (in Germany called "Polizeiliche Gefahrenabwehr") and a combined one for the medical/fire and rescue services (in German called "Nicht-Polizeiliche Gefahrenabwehr"). We decided to unify the ontologies for the medical emergency service and the fire and rescue service because they use very similar terminologies. We intend to merge the resulting ontologies into one homogenous ontology which provides the schema for the cen-

tral data repository for the our emergency management information system. This so called MCI-Ontology[4], from a communication science perspective, is the result of formalising the SAO terminologies in a *machine-processable* way. It is formalised by using the *web ontology language* (OWL, especially OWL-DL).

The MCI-Ontology has not yet undergone its final iteration and will be adjusted to fulfil not yet addressed MCI requirements. At the present time, the ontology defines around 300 concepts, among them rescue workers, vehicles, special leading structures, organisational concepts and properties about injured people. The definitions in this ontology are based on a cultural analysis which took into account MCI observations, the German regulatory standards (e.g., DIN 13050, PDV 100, and FwDV 100) and the standard textbooks on rescue and disaster management. Accordingly some of the concepts are only partially defined (via sufficient but not necessary conditions) while others have full definitions. In order to ease the understandability and maintainability of the ontology we augmented each concept definition by a comprehensive human readable annotation. The MCI ontology currently is extended to cover the German police culture domain.

PUTTING THE KNOWLEDGE TO USE

With the MCI-ontology assistance can also be given to the culture analysis itself, because the formal representation as a structural and logical framework provides a rigid model of the vocabularies of the different SAOs. Suitably presented, this model can be used by domain experts, researchers, and engineers who are interacting with the MCI domain. Their studies with the MCI-ontology can give a feedback to the cultural analysis phase of the MCI modelling process and thus initiate another iteration of the model building and refinement cycle. As a result we expect both, a qualitatively better overall domain model, and a significantly better user centred implementation process of the emergency management system. All communication specifics from the involved SAOs must be taken into account at the design process of an emergency management system. The system should therefore guarantee that the relevant concepts all are used semantically correct by the rescue workers. If the user interface correctly "talks the language" of the users, we expect a significant positive impact on its acceptance.

Because it has a clear cut formal semantics, the ontology language we used to code the MCI ontology allows for automated reasoning about the modelled MCI domain. Formal reasoning (inference) uses knowledge that is explicitly contained in a knowledge base to infer implicitly represented knowledge. For logic based ontologies like the MCI-ontology standard inference services like *subsumption*, *concept consistency*, *equivalence*, *instance checking* or *relation checking* (Baader et al., 2007) can be realised for the knowledge base management system of the MCI support system.

With the help of the "equivalences" service, e.g., different names for the same concept can be disguised as being semantically equivalent. Also, if different concepts have the same name (e.g., "AAO" as used by the police vs. "AAO" as used by the fire and rescue service) but a different meaning, then they can be automatically decided to be not-equivalent. Furthermore, non-standard inference services, e.g., the computation of the *most specific concept* (msc) or the *least common subsumer* (lcs) concept, can be used to support building and maintaining the ontology and the knowledge base resting on it.

Especially for our MCI scenario we regard the following services as relevant for an IT system which supports rescue workers:

1. *Model validation.* Reasoning services can be used to check the consistency of a model, to automatically build concept hierarchies or to classify individuals of a KB. This sort of reasoning can support the development and maintenance of ontologies. Automatic model validation can uncover inconsistencies in the conceptualisation of the MCI domain, and thus ensure the integrity of the ontology. By automated reasoning it is also possible to identify unintended concept subsumptions, equivalences or instance assignments in early phases of the modelling process.
2. *Computation of justifications and explanations*. Whenever an IT-system by itself makes decisions or helps in preparing complex decisions the question arises how these decisions or how decision relevant data are justified. Imagine, e.g., an operation manager receiving an automatically generated information about some important situational fact, e.g., the information "Hazardous substance is involved on the scene". Then each leader should be informed immediately about this fact — if it is true. The operation manager therefore might like to know how this information is justified and why it was issued to him in the first place. A first step towards the automatic generation of such explanations for DL based KBs is the work on justifications by Horridge et al. (2008).

[4] The current version of the MCI-ontology is available via: http://users.minet.uni-jena.de/~ukrueger/mci-ontology.

3. *Plausibility checking.* One functionality which was suggested by our cultural analysis concerned the necessity of plausibility checks on data entries — last but not least because in an MCI event, one and the same IT device typically can and will be used by workers from different SAOs. In order to perform plausibility checks the MCI support system can use the reasoning services of the MCI ontology and the conceptual knowledge contained in the ontology itself. In contrast to conventional IT-systems this checking is not restricted to simple (input) data type checking but can involve complex logical plausibility tests. In case a user input fails to pass the plausibility checks the system can use the above mentioned explanation capabilities to inform the user why this happened. This sort of supercharged plausibility checking therefore could help to maintain a high degree of coherence of the overall IT-system during the entire MCI management process.

Each of these services can be implemented with the help of an automated reasoner over the MCI ontology. Model plausibility checking is a core functionality provided by any DL based ontology and the other two can be realised by more or less complex programs that use the reasoning services which are built into the DL. In our project we currently are working hard on these realisations.

RELATED WORK

According to the science of intercultural communication, a lot of work focuses on the impact of language in intercultural communication and the description of national cultures (Spitzer, 2000; Liedtke, 2002; Rebhein, 1985; Kriegel, 2009) by using different types and variations of culture analysis and definitions of the terminology of "culture" itself. These works and analyses are all based on an understanding of culture which is different from that of cultural analysis: they focus on culture as national and thus intercultural communication is understood as an international communication. But in contrast to these approaches we described the linguistic differences comprehensively from an anthropological point of view to lay the basis for a user centered IT support of the MCI process. The methodology of *culture analysis* and its problems on the linguistic level are discussed in the works of Bude (1991). Müller-Jacquier (2000) created the *Linguistic Awareness of Culture* (LAC) model with a focus on developing an intercultural training module based on the problems related to the linguistic aspects of intercultural communication. Holliday (1999) identifies different paradigms of "culture" in applied linguistics, especially in organisation cultures at the mezzo level of the institution. The relation and interaction of culture and technology is also detailed described by Banse and Grunwald (2010).

Several other ongoing and completed projects aim to use knowledge based techniques in the field of disaster management. Like in our project they model some parts of the rescue domain in a formal way. One example is the SIADEX project (Asuncin et al., 2004) where DL knowledge bases have been used to describe the scenario, the resources and the goals in a forest fire fighting scenario in Spain. As it is typical for an assistance system the KB is used mainly for an automated mission planning purpose. There are no details of what kind of automated reasoning services which are related to ontologies are used and for what purpose. Another project is SHARE (Konstantopoulos et al., 2009) which provides information technology for German fire fighting brigades — tailored for the Dortmund fire brigade. However, as far as we know, no project aims to use extended reasoning support to realise inter-organisational communication.

CONCLUSION

In this paper we have argued that and sketched how cultural analysis can be used to identify the basic requirements for the development of technological solutions that are to be deployed in inter-cultural settings. For this purpose we concentrated on inter-organisational communication and culture because this is the key to a better collaboration in MCIs. We described how the results of culture analysis can be used to focus the design of emergency communication management systems on the user requirements. Our methodological approach to technological developments represents an interesting generalisation of traditional approaches, like, e.g., classical usability studies, since it integrates the user into the modelling process before the actual construction process of the IT-system starts. Cultural analysis not only allows evaluating the acceptance of a specific solution, but also allows identifying interesting statements of the general acceptance of technical innovations in organisational cultures.

Of course, to develop a framework and IT support for inter-culture communication between different SAOs is an ambitious goal and much more difficult as doing the same "only" for intra-SAO communication. We have not yet completely finished the overall MCI ontology; an important fragment concerning the police SAO is still under development. As a consequence we do not yet have evaluation results across the whole range of the MCI management process. Cultural analysis as methodology and using it in the way we did that under the MCI perspective nevertheless was a challenge — especially because it wasn´t applied yet in a comparably complex and technologically loaded setting. Accordingly the analytical methods and the assumptions underlying them still

must be evaluated and adjusted because some of them may prove to be unjustified once the MCI process in its entirety is analysed.

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