Design Process for Decision Support Services to Support Multiple Agencies

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***Abstract*— In this paper, we describe a design process for developing deployable information services in service oriented emergency management systems that support multiple agencies. These services aim to support decision-making based on situational awareness information. The service design process has been defined to support information needs in all phases of the lifecycle of emergency management. For this reason, we believe that the defined design process is general and thus it should be a useful base practice for similar tasks in many other operational environments. There are no type limits for the defined services; they could be independent services or compositions of other services. First, we give a short description of the stakeholders of the domain and our approach for useful emergency information. After that we describe the overall service defining process and give a supportive checklist for service designers and managers of different agencies.**

Keywords-emergency management;decision support; service design.

I. THE STAKEHOLDERS OF THE ECOSYSTEM OF EMERGENCY MANAGEMENT KNOWLEDGE

Many kinds of skills and a lot of knowledge are required by several kinds of participants in the management of major emergencies like natural and manmade disasters and catastrophes. These participants are thus vital organic parts of the ecosystem of emergency management knowledge and they are connected to the information and data networks either as consumers or producers – and in many cases as both. Some of the participants represent well-trained permanent solutions to frequent accidents but some of the parties are connected to a particular situation more occasionally. However, during the lifecycle of disaster management, the goals, overall picture and situational awareness must be maintained as well as possible [3]. So, who are the bodies interested in the knowledge of disaster management? Which groups are the stakeholders of the ecosystem? According to the Emergency Information Interoperability Framework workgroup [4], these stakeholders typically represent state-based authorities like rescue, firefighting, policing, health and emergency, safety, etc. Non-governmental organizations, international coordination agents, ICT solution providers, EM and NGO professional and academic communities may be in crucial positions during the emergency management lifecycle, as are often also the public and several types of volunteer organizations [4]. However, their list is not fully satisfactory. It may be completed by adding new groups like the general public, the victims of a disaster (people and industries), relatives of victims, the insurance and financial sector, and national airlines and other carriers. After some regrouping, refinement, and adding of these new parties, the list may be now defined as follows (examples are mainly US-based):

1) State-based emergency management agencies, for example:
   - operative authorities: Police, Fire and Rescue, Ambulance service, FEMA,
   - expert authorities: Weather service, EPA,
   - co-operative agencies: DHS, Army.
2) Domestic civil organizations, for example:
   - Red Cross, National Guard, Salvation Army,
   - Air National Guard.
3) Large international organizations and agencies, for example:
   - UN organizations: OCHA, WHO, WFP,
   - ICRC,
   - NATO EADRCC.
4) International non-governmental organizations, for example:
   - MSF, OXFAM,
   - MapAction.
5) International support services and projects, for example:
   - UNDAC,
   - EU MIC,
   - ReliefWeb, Sahana project.
6) Research and education organizations of emergency management, for example:
   - Universities and colleges,
   - ISCRAM, IAEM, and NetHope.
7) Information and communication solution providers, for example: EADS Ltd, Nokia Ltd.
8) Public: Non-affected citizens, Media.
9) Victims of the disaster, for example:
   - Peoples and their relatives,
   - Affected communities, companies, and industries.
10) Finance and insurance companies.
11) Airlines, carriers, energy companies, etc. needed for help during the incident.

The needs, available resources, and readiness to contribute to management and communication tasks vary between different groups. Fig. 1 describes an abstract view of the growing interoperability approach.

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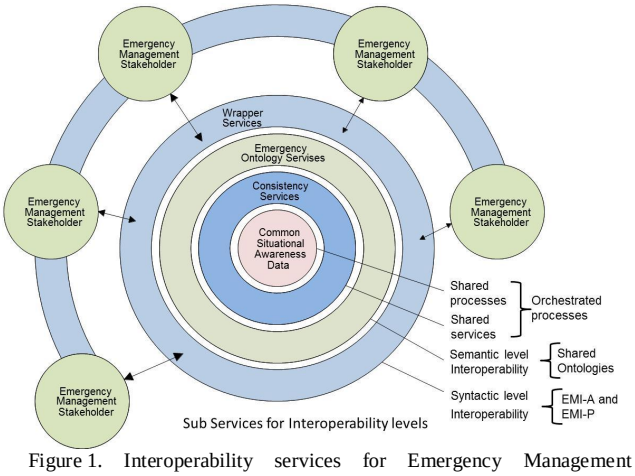

Figure 1. Interoperability services for Emergency Management Stakeholders.

The ability to interoperate via information and communication services could be classified using a five-level scale, starting from no interoperability and going up to business process level interoperability. The intermediate levels are syntactic level, semantic level, and service level interoperability. Different types of stakeholders are in the outmost circle in Fig. 1. Their ability to create a common situational awareness is enhanced via special interoperability services that are used to connect different parties at the appropriate level. Thus, business process level interoperability could be reached using all of these different types of sub-services. The essences of these sub-services are:

- Wrapper services for syntactic level interoperability,
- Ontology services for semantic level interoperability and
- Consistency services for service level interoperability.

Process level interoperability is the deepest level of information exchange and availability to communicate with other operating agencies. Cataldo and Rinaldi gave an example of knowledge sharing using the P2P approach and semantic web services [2] and another example of a service-based system meant to support medical information exchange in real time was given by Hauenstein et al. in [5].

In the next figure (Fig. 2), the different stakeholder groups are positioned based on their need for interoperability.

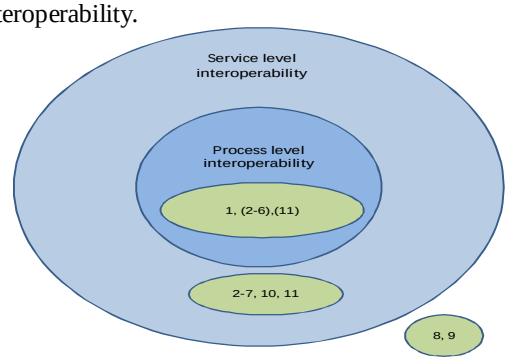

Figure 2. Interoperability needs of the stakeholder groups of emergency management ecosystem.

The key agencies like national authorities (group 1) are the focal point from the interoperability point of view. Their success is based on the practical suitability of the process level interoperability. This could be achieved by orchestrating the common/shared business processes. Domestic civil organizations (2), large international organizations (3), international NGOs (4), international support services (5), international projects (5), and research and education communities (6) could in some incidents also be positioned at the central point of interoperability, or in other words, in process level interoperability. However, normally their interoperability needs are fulfilled by a service level interoperability. This is based on usage of single services independently as a part of their normal operations. Probably most parts of the process level operations might be modeled and orchestrated beforehand and supervised based on the current needs of the incident.

The providers of information and communication technology (7) and finance and insurance companies (10) are positioned to be ordinary service consumers and providers in this model in a traditional way. The public (8), victims and their relatives, affected companies and communities (9) are positioned outside the interoperability service architecture. Their information needs are mainly covered by the dedicated services offered by groups (1) and (2) and also in some cases by groups (3) and (5). There are also auxiliary role stakeholders such as airline and carrier companies (11), whose fluent integration to support emergency management activities in different phases of the emergency lifecycle vary from critical to very important.

II. SYSTEM ARCHITECTURE FOR EMERGENCY MANAGEMENT KNOWLEDGE ECOSYSTEM

Some of the stakeholders are interested in emergency information only at certain times or when certain conditions and limits are met and then only temporarily and/or in an extreme hurry. For this reason, it should be possible to offer open interfaces to stakeholders and organizations that do not take part / operate daily in emergency management. The same applies to the wider public and third parties who might want to implement “ad-hoc” type mash-ups for information sharing and independent communication. Fig. 3 presents an overview of the system architecture for a service-based emergency management knowledge ecosystem [6]. To cite [6] “The main access to the services, i.e., the interfaces of the system are EMI-A and EMI-P. The former is an authorized interface for emergency management services and the latter is a public interface for the general public and non-authorized users of the system(s). Because the concept and function of a service bus is crucial for this ecosystem, there should not be a single point of failure in its functionality. Instead, it should be fault-tolerant and distributable.

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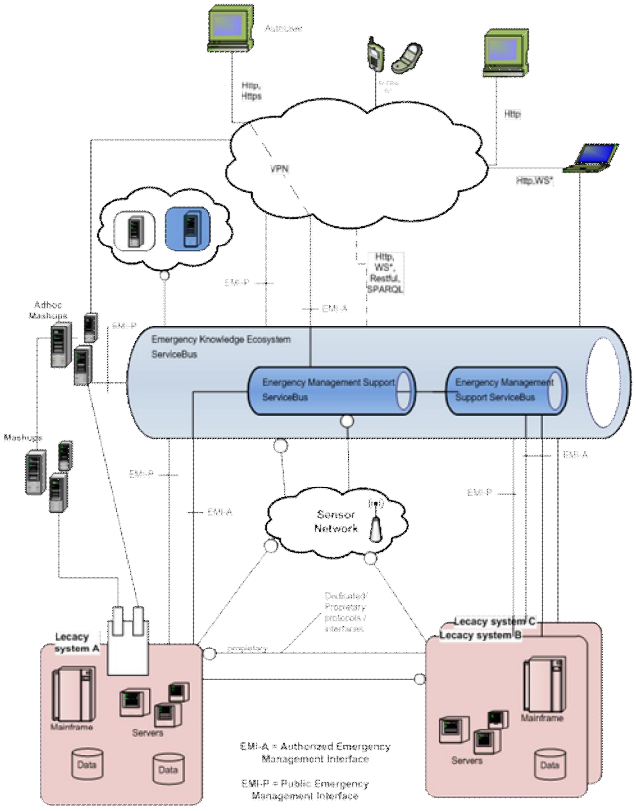

Figure 3. Service-oriented system architecture for Emergency Management Knowledge Ecosystem [6]

The legacy systems (authorities, research organizations etc.) located at the bottom of Fig. 3 interoperate with a large service-based architecture via open standards. They can preserve their proprietary interfaces and they can open new standard interfaces implemented by means of an appropriate technology (WS-*, RESTful, http, etc.) [10]. Sporadic and temporary users can be connected as an information service provider or to a normal user via a public and open service interface like EMI-P in the Fig. 3. A more permanent connection to the ecosystem is established using either the common emergency service bus (EMI-P) or a more controlled interface for authorized users (EMI-A), which supports the coordination and supervision of shared business processes." As mentioned above, an emergency management knowledge ecosystem consists of different types of stakeholders. Only some of them work in close relationship / interaction daily and have thus established routine ways of working and created shared concepts and mutual understanding. The coordination of the shared (and modeled) business processes could be based on the special control and service mediation layer described in Figure 4. Some of the services should be especially designed for supporting the modeled emergency management processes, in other words controlling the performance of the use cases, data and message translations, and routing messages to the correct endpoints.

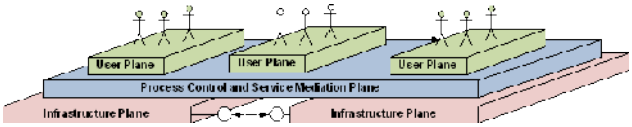

Figure 4. Shared business process supported by service bus and process control engine.

According to Fig. 3 and 4, we have the main user interfaces (the "views" in MVC model) in the user plane, the task-centric supervision ("control" in the MVC model) in the process control and a service mediation plane implemented by a service bus. Finally, the core data access ("model" in the MVC model), which is a composition of different types of entity and utility services and legacy systems, is positioned in the infrastructure plane in order to achieve the interoperability between the different stakeholders, as described in Figs. 1 and 2.

III. SERVICE DESIGN PROCESS FOR DECISION SUPPORT SERVICES

In this section, we will give a proposal for a service design process that is based on process models of the collaboration in major emergencies and disasters. The given proposal is comprised of an identifying process and a detailed checklist due to the various needs of the stakeholders on the field. We also believe that our approach might be valuable complement to domain analysis methods like presented in [8]. The main concern for the intended stakeholders is now a proper situational awareness for a decision maker. The decision points are not limited only to the hectic response phase of the emergency lifecycle. Instead, we believe that our approach might have a much wider applicability during the other emergency management phases (prevention & mitigation, preparation and restoration). The decision points (or moments in time) in different lifecycle phases [1] can be identified from accident investigating reports, by interviewing people and reviewing guideline documents, current practices, plans and process models. All processes must be analyzed and modeled for collaboration from the viewpoint of interoperability. The service design process for decision support services we propose is currently the following:

A. Identify the main decision points:

1) Choose some known disaster type.
2) Identify the main stakeholders, their tasks, and concerns.
3) Identify the main decision situations and decision makers at different levels e.g. strategic/operational/tactical (defined in [7]) and in corresponding phases of the lifecycle e.g. preparation, response, recovery, prevention and mitigation (defined in [1]).
4) Analyze whether it is possible for decisions to be also made by others (persons / roles) and/or at a different

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moment of time – if the required information and decision-making power were available to them.

5) Document the options using B1 – B4.

B. For each decision point (A3, A4) also try to discover:

1) Which data, information and knowledge are most essential for this situation?

2) Is it possible to support the analysts and decision makers merely by presenting only that information?

3) Do the currently used decision data and information need prioritizing and/or reduction?

4) Is it possible to enhance and/or accelerate the decision-making process by filtering, composing, or otherwise preprocessing the data before showing it to the analysts and decision makers at a tactical, operational, or strategic level?

It should be crystal clear for the service designers that many of the earlier practices may have sub-optimal solutions that are caused by tight organizational limits and/or rigid information ownerships. In order to achieve optimal solutions, the design plans may need several iterations before the desired interoperability for enhanced collaboration and efficiency. Additionally, the cultural differences between the stakeholder groups, organizations, and agencies should be understood and elaborated in order to be able to introduce new services. The service design process could be further supported by detailed guidance and checklists. In the next section, we will give a preliminary checklist of issues that should be noted during the design and deployment processes of the services.

C. Checklist for decision support service designers and managers:

1) What sort of decision has to be made? (What sort of situation is to be followed or anticipated?)

Is the decision to be made tactical, operational or strategic?

Is the decision to be made a routine decision, kind of ad-hoc or is it somehow special?

Is the decision based on guidance or normal procedures or is it based on the experience or intuition of the decision maker?

Is the decision to be made classified or is it public?

Who has to be informed of that decision?

Who has the authority to make this decision?

2) What sort of data and information is needed for the decision? (Which data and information are useful, worthwhile, and wanted?)

Where is that data and information?

Who will have it now?

Who else needs it?

What are the types of that data and information?

How this information could be brought from its origin?

Is it time dependent?

Is it location dependent?

3) What information and data might be or need to be swapped between different agencies?

Who are the peers of the information exchange and data swapping?

Who has the authority to start the information exchange?

What are the reasons for the information exchange?

What are the specific impacts that are tried to be achieved?

4) What are the exact situations and the moments in time when certain data and information are exchanged and needed?

How often does it happen?

Who will be the initiator?

Who owns that data and information?

Who will be responsible for the maintenance of the data sources?

Who will be the overall coordinator of the data and information?

Who will be responsible for the reliability of the data?

Are the access rights of the different user groups to the data clearly defined?

5) What are the main obstacles and barriers to each type of information?

What languages and character sets are available?

To what extent is the data and information confidential?

What are the actual information packages and containers?

What are the technical formats and protocols?

What is the availability of the needed codecs and transformers?

6) What are the types of messages are required for interoperability?

Are the messages:

- Alert messages?
- Summons?
- Request for more resources messages?
- Letters of request?
- Notification messages?
- Announcement and information messages?
- Bulletins and press releases?

What is the confidentiality of the messages?

7) What are the available information and data networks and communication protocols at the decision time?

What are the alternatives for the primary networks (POTS, LA, SMS, CDMA, GSM, UMTS, etc.)?

Are the available networks secure enough for each type of message?

Is it possible to ensure that classified information is also secure on the end users' desktop or handheld?

The checklist is still preliminary and has not yet been tested in a practical situation. However, the list is composed based on the author's experience and research on interoperability issues in emergency management. It is practically impossible to give any references to the items of

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the list. The questions: What? (Data), How? (Function), Where? (Network), Who? (People), When? (Time) and Why? (Motivation) are elaborated from the different viewpoints that were presented in Zachman Framework by Sowa and Zachman [9]. The framework [9, 11 and 12] has been one of the inspiration sources when formulating the checklist.

IV. SUMMARY

The main stakeholders of the emergency management knowledge ecosystem were described as different groups in a service-based interoperability domain. The main types of subservices supporting different levels of interoperability between the various stakeholders were introduced. The service-based system architecture for decision support services aiming to enhance disaster and emergency management was also briefly presented. Finally, a proposal for a general service design process for emergency management decision support was described followed with a checklist for designers and managers.

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