Towards an Integration of Process Modeling and GDSS for Crisis Management

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***Abstract*—Crisis situations impose a number of special challenges for group decisions including separation of decision participants by time and/or location, difficulties in obtaining and maintaining a proper understanding of the crisis situation, time pressure, and a high workload. Based on predefined process templates for group decision making Group Decision Support Systems (GDSS) can effectively support crisis management teams. The GDSS can, for example, bridge the separation of the decision participants, perform information management and information sharing tasks, and even automate specific group moderation activities. In this article, first results of a research project that targets a combined use of process modeling technology and enhanced GDSS are described. A new general feedback-driven and iterative process pattern for group decision making is proposed. When a prompt decision is not required, several group decision cycles can occur and every cycle may benefit from better information quality, as well as training and learning effects.**

Keywords-Crisis Management; Process Modelling; Process Automation; Group Decision Support Systems

I. INTRODUCTION

Collaborative work processes are common in crises management situations. Typically the members are drawn from disciplines such as fire, police, health, and hazardous materials management. The members of the group are expected to complete actions together. For example, the team members need to collaboratively keep track of the crisis situation and assess the severity of the crisis, make recommendations to others, find different courses of actions to handle crisis issues, and to solve problems. From the actors it is expected that they make and communicate decisions together. Two important types of crisis management decisions are selection decisions (e.g., selection of the best fitting response plan from a set of predefined plans) and allocation decisions (e.g., determination of resources to be sent to the crisis scene).

The design and use of Group Decision Support Systems (GDSS) as a decision making aid for crisis management organizations has been investigated by several research groups [2][5] [10][13]. Crisis management teams can obtain a number of benefits from GDSS including an instant access to shared information, support of remote members, support of crisis communication plans, and coordination support for group decision making processes.

The still ongoing research that is described in this article is focused on asynchronous group decisions in crisis situations. A novel general decision pattern is proposed that can help to overcome the spatial and temporal separation of crisis management actors. The proposed iterative adaptive group decision pattern especially targets crisis situations that do not require a prompt decision. In each process iteration cycle, the group decision is obtained based on a revised decision model and/or a revised set of process execution steps. The revisions are driven by feedback that is gathered from the participants. A human moderator based on the feedback determines if a further process re-iteration should be completed or if the process should terminate. This approach can lead to better decision results because iterations will be performed based upon a broader information base with an improved information quality. Also learning and training effects can contribute to better results.

In the next section, different general patterns of group decision making and especially the adaptive group decision pattern are described. It is then exemplified through corresponding models how such patterns can be encapsulated as process models using the BPMN standard [7]. Following that, how these models can be used in combination with an enhanced GDSS in crisis management scenarios is described. The current status of the ongoing research and concluding remarks are contained in the last section.

II. CRISIS MANAGEMENT AND GROUP DECISIONS

Crisis management often involves the use of crisis management plans. These plans describe the actions and considerations to be followed by the crisis management organization [8]. This can include the action to set up an infrastructure that is needed by the crisis management team such as a stationary or mobile control center, Information and Communication Technology (ICT) equipment, or unmanned aerial systems. It is often the case that in different crisis management plans identical actions and even identical arrangements of multiple actions can be found. Our research is focused on decision patterns where several different courses of actions and criteria to evaluate these alternatives are defined in a corresponding decision model.

Multi-criteria decision models based on the Analytic Hierarchy Process (AHP) of Thomas Saaty [9] are often considered for solving complex selection problems [10]. The decision model serves as basis for the selection of the best alternative by the completion of a multi-person decision process. It is expected from the participants that they score the available alternatives in terms of given evaluation criteria. The total score corresponds to the group decision result. One major advantage of group decisions over single person decisions is the fact that group decisions are based on

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a broader expertise and also a broader information base. Another advantage is that group decisions impose a lower risk for a bad decision due to human factors (e.g. the responsible decider can be over-challenged by the decision problem). Of course, there exist also drawbacks of group decisions such as the needed extra time, a relatively large coordination effort, and the demand for a professional moderator. Furthermore, group decisions can be biased by so-called Group Think Effects [3], such as a lower attention to risks as compared to single person decisions.

Crisis management plans can include the pattern of a synchronous group decision which requires a face-to-face meeting. They can also include an asynchronous group decision in which some participants are separated by time and/or location from other participants. For example, in crisis situations, it can be required that some of the group members have to stay where they are due to legal regulations or because they are indispensable somewhere else. Sometimes even in crisis situations time and/or budget restrictions may not allow a personal meeting. For some group decisions, it can be a rather natural approach to use an asynchronous decision process in order to adequately cope with a crisis situation. In general, the consideration of remote participants can lead to more complete and accurate information and, henceforth, to a better decision. For example, first-hand information and impressions of the crisis status can be gained through dislocated decision participants that are situated close to the crisis scene and that are equipped with mobile communication devices [6].

Group decisions to select the best course of action for crisis handling are an interesting subject of research especially when focusing on groups where participants are separated by both location and time. For these cases that we refer to as “complete asynchronous group decisions” – the word “complete” is used to signify that the focus is on a dual separation (time and location) and not on a partial separation – special novel ICT solutions are required.

The pattern of complete asynchronous group decisions is certainly not applicable to all crisis situations. Apart from the dual separation of the group participants at the time and space dimension, the time pressure is another major criterion to be considered. When a prompt decision is demanded and the actions are to be carried out right away then the pattern is not applicable. However, when neither a prompt decision nor directly following actions are required the pattern can prove to be useful. The decision can be post-phoned and other tasks can be completed in the meantime. Instead of just shifting the (start) of the decision process to a future point in time, for certain situations another approach can be more suitable. To start the decision process and to iteratively obtain decision results in which changes of the situations are considered can lead to certain benefits. Because of the longer time spend on the decision process and other advantages it is more likely that the best choice will be made. We refer to a correspondingly refined process pattern as “adaptive complete asynchronous group decision”.

Through an iterative adaptive process approach it is possible to improve the probability that a group decision will lead to a well-fitting choice. By “iterative approach” in this context it is meant that a group decision process is repeated several times. The process repetition terminates when the crisis situation demands a prompt action. The re-iteration can contribute to training effects in the form of faster iteration times for the group decision making process. Learning effects are another type of effects that can be obtained from the process repetitions. It can be assumed that these effects promote improved decision results as compared to non-iterative decision processes. It is the underlying idea of the iterative approach to not just repeat the same group decision process as completed earlier. It is expected that specific adaptations that will presumably improve the result are applied before a next iteration is completed. One possible adaptation is the use of a richer information basis that includes additional new information found in the previous iteration. Further modifications can be a more accurate process model and more accurate decision model. In our approach, the particular set of modifications to be considered is driven by feedback obtained from the previously performed process iterations. Among others, the feedback from the participants can include important background information, background knowledge, opinions, judgments, additional decision alternatives, new evaluation criteria, or a proposal for additional group members. The participants’ feedback can be the result of learning progress, new insights, new ideas inspired by shared information, and other intellectual effects of re-considering a decision problem.

III. PROCESS MODELS FOR CRISIS MANAGEMENT UNDER CONSIDERATION OF ENHANCED GDSS

To demonstrate the general approach of adaptive complete asynchronous group decisions two corresponding generic process models (i.e., process templates) are described in this section. The models are given in the popular BPMN standard modeling notation [7]. A possible organizational context for these crisis management models is a chemical plant in which a too high concentration of hazardous particles has been detected in a production hall. A more complete description of this case study is available in an earlier article [12]. The templates may also be helpful in river flood situations where crisis managers need to decide about the evacuation of river regions. Apparently, there exists a good fit between the typical characteristics of such evacuation decision and the properties of the proposed adaptive group decision patter.

Crisis management organizations typically include a crisis incident manager, further crisis management staff with specific roles, and specific ICT equipment. The process templates prescribe the flow of actions to be performed by the crisis management organization in order to effectively cope with the crisis situation. Furthermore, the templates supply a decision model to support needed group decisions.

Through a description of the generic process models not only the modelling approach for the proposed adaptive group decision pattern is exemplified in this article. Especially the description of the second process model provides insights into the GDSS enhancements that are targeted in our research. It is assumed that the GDSS is able to create and manage individual process instances (proxies for real world

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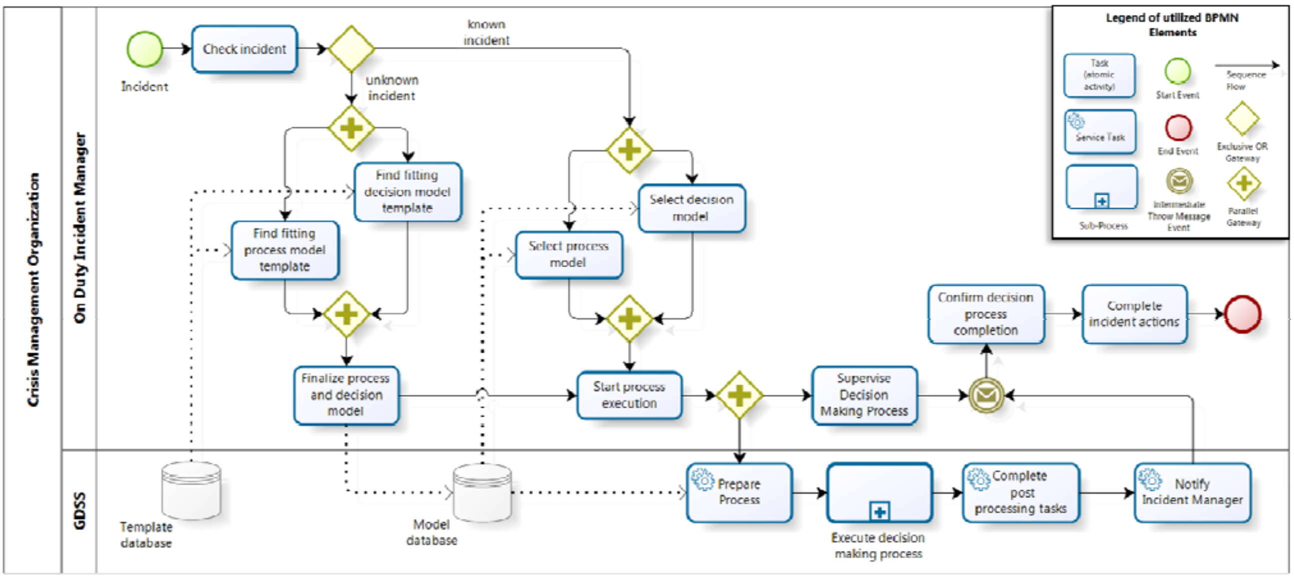

Figure 1. BPMN Model of a crisis incident management process.

group decision processes) from process templates. Managing the execution of individual process instances involves GDSS actions, such as the notification of participants, the collection of the participants' decisions, the aggregation of the single decisions to a corresponding group decision, and also central data management and group moderation tasks (e.g. sending reminders). An example of such an enhanced GDSS is the GRUPO-MOD system [11].

Note the connection between the two models. The on duty crisis incident manager of the first model initiates an adaptive complete group decision process as given in the second model. Depending on the process template database other kinds of processes with other, group decision patterns can also be initiated by the crisis incident manager.

Crisis incident management. The outer frame of the BPMN diagram in Figure 1 (called pool) represents the crisis management organization which consists of two actors (called lanes). There is first of all a human on duty incident manager. The second actor is a GDSS system with the above described enhancements. This includes a template database that stores templates for crisis management processes and templates for group decision models. In case of an unknown incident, the template database services as a repository from which a best-fitting process model and decision model is obtained as starting point. In a subsequent second further step, the models are refined and adapted in order to reflect the conditions of the given crisis situation. The model database of the GDSS stores ready to use process and decision models for known crisis situations.

In the initial activities of the process model in Figure 1, the fitting templates for the group decision process and the group decision model are determined. When the incident is not known the best fitting process template and best fitting decision template are selected from the template database. This selection task can for example be supported by a proper decision tree. After the process model and decision model are selected, the incident manager starts a partially automated execution of the asynchronous group decision process. The GDSS plays an active role in this process execution by performing the activities defined in the process model (blue rounded boxes positioned in the lane "GDSS") labeled Prepare Process, Execute Decision Making Process (this activity is modeled as a BPMN sub-process), Complete Post Processing, and Notify Incident Manager.

During the GDSS-based execution of the decision process, the incident manager supervises the process and performs actions that cannot be handled by the GDSS. Also, the process completion is confirmed and the incident actions

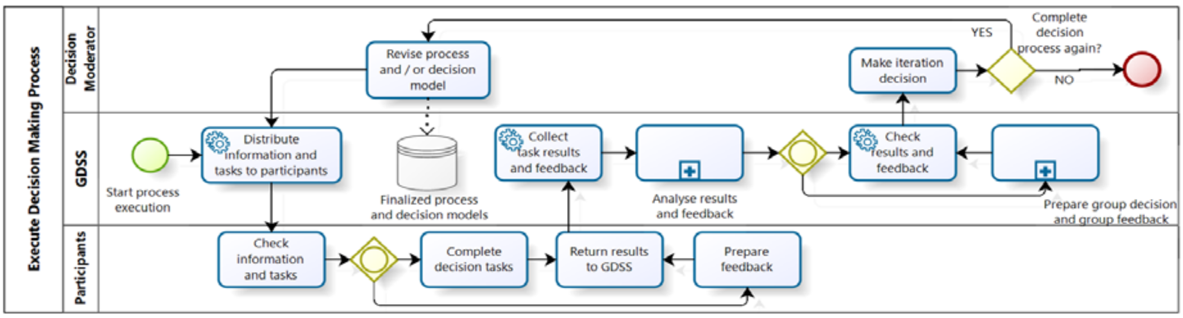

Figure 2. BPMN Process model of an adaptive complete asynchronous group decision.

are completed by this person.

Adaptive complete asynchronous group decision making. The process model of Figure 1 contains an activity labeled "Execute decision making process". The little plus sign as part of the graphical symbol marks this elements as a so-called sub-process. In general, the details of sub-processes are modeled in separate self-contained process models. Figure 2 contains the process model of the mentioned sub-process and it exemplifies an adaptive complete asynchronous group decision process. The two activities of the decision moderator reflect the aspect of adaptation that can contribute to the earlier described advantages of the proposed new adaptive group decision pattern.

The pool consists of three lanes referred to as Decision Moderator (not necessarily the same person as the Incident Manager), GDSS, and Participants. Note that the latter lane does not mean that there is only one participant involved. The GDSS distributes the relevant information and decision tasks to the participants. It also collects the decision results and feedback, applies respective analysis such as consistency checks on the results, and prepares the group result through an aggregation of the individual decision results.

The participants check the information and decision tasks assigned to them by the GDSS. Following that they complete the decision tasks, prepare feedback, and return all results (such as judgments of the decision alternatives) to the GDSS for further processing. Recall that the participants' feedback will influence the further process continuation. The next steps of the decision process are performed by the GDSS. Following the collection of the participants' tasks results and feedback an analysis of the now available information base is performed. The analysis result is used to compute the group decision and corresponding feedback information for the group members. The sub-process "Prepare group decision and group feedback" subsumes that the GDSS distributes the group decision and feedback information to the participants who are called to give further feedback. The system collects and checks the participants' feedback and uses the further updated information base in order to prepare the iteration decision. It is the decision manager's responsibility to decide if the process is terminated or if it is re-iterated again.

IV. CURRENT STATUS AND CONCLUSIONS

The research focus has, so far, been on a high-level integration framework for the combined use of process modeling techniques and GDSS. In the next steps, the framework will be refined especially in two directions. First, the BPMN standard will be investigated. It will be studied if group decision processes in the crisis management domain can be properly modelled based on BPMN. For this purpose international crisis management studies will be considered, by including the Deepwater Horizon case [1] and the Elb River Flood [4] of the year 2002. Also, the possibility to combine BPMN-based process models with other modeling concepts such as decision trees will be evaluated. The possibility to include domain specific modeling primitives will be an area of the intended study, too.

Another direction of future refinements will address technical integration issues and novel enhancements of GDSS systems. New concepts are required that will enable GDSS systems to act like process execution engines. This includes the GDSS capabilities to perform information distribution activities, domain-specific feedback gathering and processing activities, and group moderation activities. In this context we will investigate if the GDSS enhancements can be achieved through the common approach to map BPMN models into the execution oriented BPEL language.

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