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A Formal Framework for Crisis Management describing information flows and functional structure

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Abstract

Crisis management is a very empirical activity, most of the time based on human ability to deal with the unexpected and to fusion all kinds of information to provide the best decision and the best associated action. However, the information flows and the high level activities are not so well described. This article aims at providing a formal framework describing these elements. The presented framework is the base for the establishment of a software suit dedicated to formally manage information flows in crisis context and exploit them to provide crisis managers with a computerized decision support system. Even if this software system is not the topic of the paper, it is the justification for the presented structuring framework. The framework is based on two main structuring elements: the nature of available or required information and the functions that should be able to use them to provide crisis management domain with a relevant decision support system.

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1. Introduction

There are several definitions of Crisis ([1] and [2]). In this article, we consider the following one (from [3]): Crisis can be considered as *a disruption within the state of a system, which reveals instability and discontinuity and which requires a specific treatment to deal with the unwanted consequences and to obtain a new acceptable state of the considered system*. Besides, this article considers the notion of *Crisis Management* from a functional perspective, considering consequently that there is a knowledge background necessary as input to perform this global function. Therefore, the overall purpose of this article is to define a formal framework dedicated to define (i) main functions and (ii) information flows of crisis management.

The article is structured according to the following parts: Section 2 describes a formalized vision of crisis in terms of required information to characterize significantly such a situation. Section 3 presents a functional decomposition of crisis management. Section 4 introduces the information flows associated with the functions presented in section 3. Section 4 draws some conclusions and consequences of the framework described in the previous sections.

2. Characterization of crisis concept

For the last ten years, there have been a lot of research works attempting to formalize knowledge in the field of crisis management (see for instance [4], [5], [6] and [7]). In this article, the background metamodel is the one presented in [3] (that inherits mainly from [7]) but can be considered as ensuring consistency with most of the others. Based on this result, the characterization of a crisis situation, in the perspective of crisis management, requires to describe: (i) the *context* of the crisis situation (where? What perimeter? What stakes are concerned? Etc.), (ii) the potential *partners* that can be mobilized and

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invoked (who? What capacities? Which availability? Etc.) and (iii) the *objectives* associated with the faced situation (what? Which facts on the crisis site? Which risks on the crisis site? Etc.). As a minimal vision we need to describe the following elements:

- *Context*: including the description of *intrinsic risks* (risks specifically associated to the impacted part of the world) and *stakes* (population, goods and others valuable elements of the impacted part of the world).
- *Partners*: including the description of the *functions* the partners are able to provide the crisis management with.
- *State*: including the actual *effects* on the crisis site (such as injured people or destroyed facilities) and the *emerging risks* (risk specifically appeared with the crisis situation and which were not conceivable before).

Furthermore, in a very classical meaning, *Crisis* may be considered from the three following points of view:

- *Location and Perimeter*: This is usually the easiest criterion to obtain. Actually, it describes the geographical area impacted by the crisis situation.
- *Gravity*: This criterion describes the importance of the crisis. However, it is difficult to have rigorous and relevant evaluation, especially in terms of used units. Some authors suggest to use money or victims or even minutes on TV news shows.
- *Type*: This criterion describes the nature of the crisis. It is also very difficult to define due to the different taxonomies and hierarchized structures of disaster types. Besides, it is also difficult to have a continuum of crisis types (it is easy to define a list of independent types). Some authors suggest using the level of human responsibility to build this continuous scale of crisis types.

Finally, the crisis concepts can be characterized easily with (location, gravity, type) but for crisis management, it should be characterized with (context, partners, objectives).

3. Functional description of crisis management

To perform a relevant and efficient crisis management, the three main objectives are: to *define the response*, to *realize the response* (considering that it is not because the response schema is correctly described that it will be performed) and to *maintain the response* (considering also that the crisis situation may evolve or the crisis response may not have the expected consequences). In the following, these three objectives will be described as functions, based on the description of a crisis situation from section 2.

First, let's consider O as a set of crisis management objectives O_i (mainly "prevent a risk" or "treat an effect"), F as a set of partners functions F_i and P as a set of crisis management business processes p . So, we can describe:

$$\text{Define: } O^n \times F^n \rightarrow P$$

$$([O_1, \dots, O_n], [F_1, \dots, F_n]) \mapsto p = \text{the process reaching the objectives with the available functions}$$

The *Define* function is in charge of taking into account the actual objectives of the management of the crisis situation (the objective vector) and the available functions of partners (the function vector) to build the business process dedicated to reach these objectives with these functions. Obviously, there might be several processes built through several invocation of the *Define* function.

$$\text{Realize: } P \times F^n \times O^n \rightarrow O^n$$

$$(p, [F_1, \dots, F_n], [O_1, \dots, O_n]) \mapsto [O'_1, \dots, O'_n]$$

$$= \text{the status of the objectives updated on the fly, according to the progress of the process}$$

The *Realize* function is in charge of performing the process built by the *Define* function. Consequently, it is dedicated to invoke the relevant functions of partners according to the schema proposed by the process. Furthermore, the *Realize* function continuously provides as well a set of updated objectives. These objectives are the expected status of the crisis situation according to the progress of the process (*i.e.* the expected situation at this stage). There might be several executions of several processes through several invocation of the *Realize* function.

$$\text{Maintain: } O^n \times O^n \times F^p \rightarrow P$$

$$([O_1, \dots, O_n], [O'_1, \dots, O'_n], [F_1, \dots, F_n]) \mapsto p' = \text{the process that fits the best with updated objectives}$$

The *Maintain* function is in charge of performing agility in the response. Actually, this function aims at comparing the expected situation (objectives provided by the *Realize* function) and the real situation (objectives from the picture of the situation). So, this function compare both these sets of objectives and then, according to the potential differences between these sets of objectives, it uses the *Define* function, the set of current objectives and the set of functions to infer a new process, more adapted to the current situation.

These three functions are absolutely not obvious. However, they are delimitating and defining the exact functional actions to be performed in crisis management context. They are also describing the inputs and outputs of such functions to contribute to define information flows.

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