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## AN ONTOLOGY-BASED APPROACH TO CRISIS MANAGEMENT AND BUSINESS CONTINUITY PLANNING

**Summary:** The paper describes a concept involving the application of an ontology-based approach to facilitate the utilization of heterogeneous data sources as an essential information resource for the decision making process under emergency. The paper seeks primarily to highlight discontinuity as a multi-faceted challenge for public administration as well as for business organizations operating in specific socio-economic settings. To reduce uncertainty around the process of making decisions affecting the population's physical and economic security, the authors propose a number of solutions founded on hybrid technology for decision support under emergency/crisis. In this context, the paper emphasizes the potential arising from the use of domain ontology for data homogenization.

**Keywords:** business continuity, crisis, decision support systems, domain-specific ontology.

### Introduction

When, in 1946, Peter Drucker published his original account of the corporation [Drucker, 1993] that was, as we would say today, "too big to fall", people were just beginning to appease in the stability and sustainability of economic growth. This confidence was further reinforced by the collapse of the Soviet Union and its military bloc known as the Warsaw Pact [Marples, 2006]. Those developments ultimately erased the threat of war between the opposing blocs (i.e. the Warsaw Pact and the North Atlantic Treaty Organization) from the minds of political and business elites as well as from the awareness of ordinary citizens.

Much less attention was given to the book *The Age of Discontinuity* that was authored by Drucker in 1969. Before, he would rather speak of continuity

and of lasting management concepts and socio-economic institutions; in his 1969 work, he offered recommendations for a society that was soon to be challenged by an unprecedented pace of change. The book was clearly inspired by the changes, including globalization, taking off in economy, and by the rapid technology advances he observed [Drucker, 1969]. It could be said that, to an extent, Drucker anticipated some problems that were likely to crop up and that indeed materialized in the 21<sup>st</sup> century. The most significant social and economic changes are usually brought about by crises, that are powerful enough happen to interrupt the functioning of a number of business organizations and country-level administrative structures.

Almost every year, the population of the world, or at least of one of the countries around the globe, faces discontinuities that jeopardize people's lives and undermine the survivability or stability of businesses and economies at large. To be able to effectively mitigate the impact of such incidents, or at least prepare for these, societies need to develop tools supporting decision-makers at crisis management bodies. This perception has led to the emergence of such concepts as: risk management, emergency planning, business continuity management, or corporate governance [Simonovic, 2011]. The innovation proposed in the paper combines or addresses all the above-mentioned approaches.

The paper consists of three chapters. The first one outlines the fundamentals of crisis management and business continuity management (BCM) theory. The second chapter employs the example of the Hybrid Decision Support System for Disaster/Crisis Management (HDSSCM) to illustrate the applicability of ontology in the area of crisis management and business continuity management. A use case is also provided, based on procedures sourced from authorities responsible for crisis management, this case was built during the workshops, which were provided by the authors to choose the most important elements of Four Lights Platform. The third chapter presents the authors' plans for further research focusing on the use of ontologies and semantic modeling in crisis management and business continuity management.

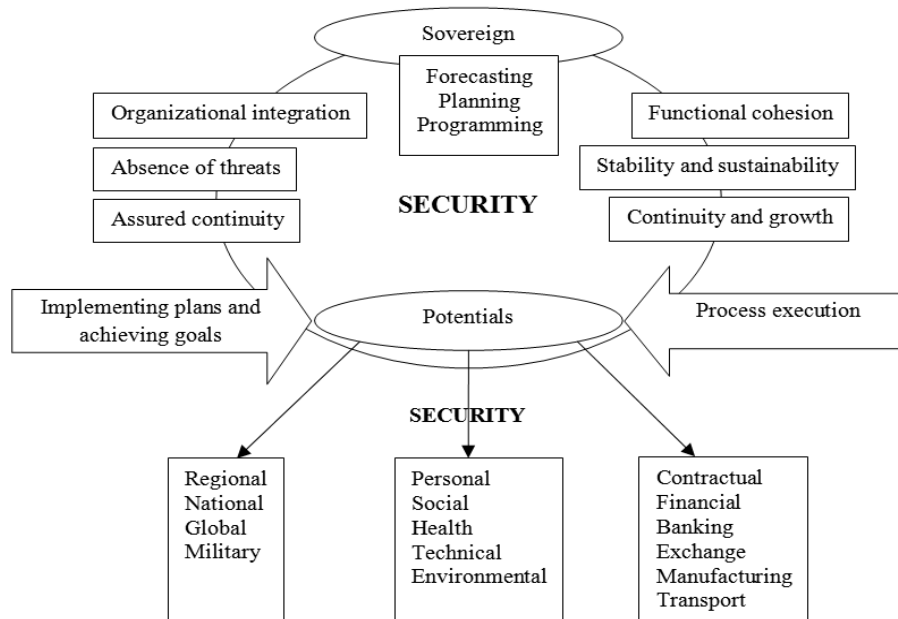
## **1. Fundamentals of crisis management and business continuity management**

Concept of the command chain originates from military science. It was the military that first recognized how critical it might be for commanders to be able maintain continuity in the battlefield, deploying their units effectively enough to defeat the enemy. The cold-war arms race also demonstrated that an efficient use of communication and command technology can substantially enhance the performance of troops in combat [Polak, 2003, p. 37].

Decisive evidence for the validity of these observations was contributed by some contemporary armed conflicts, such as the two Persian Gulf campaigns, which marked a clash of two different business continuity management approaches: the obsolete post-Soviet model represented by Iraq vs. the modern and efficiently managed (led) troops of the US Army and its allies, supported by the latest information technology [Polak, 2003, p. 40].

Managing an enterprise, or a part of an enterprise, closely resembles what commanders do to accomplish an objective using available, usually limited, resources. A local or central government official responsible for continuity management in a certain area has to cope with similar decision problems. At the same time, it must be borne in mind that in any such area there will be inseparable links between local business entities and local government bodies. Public authorities will do their best to maximize the safety of both individual citizens and businesses in their precincts, which is supposed to translate into overall stability and continuity [Act on Crisis Management, 2007, p. 4]. It is plausible then to coordinate continuity management efforts undertaken by business entities and local government units.

Figure 1, illustrating the praxeology aspects of security, is provided to depict the level and extent of complexity found in the area under investigation, and to categorize the notion of security so that it can be referenced in subsequent parts of the paper when discussing its specific types and categories.

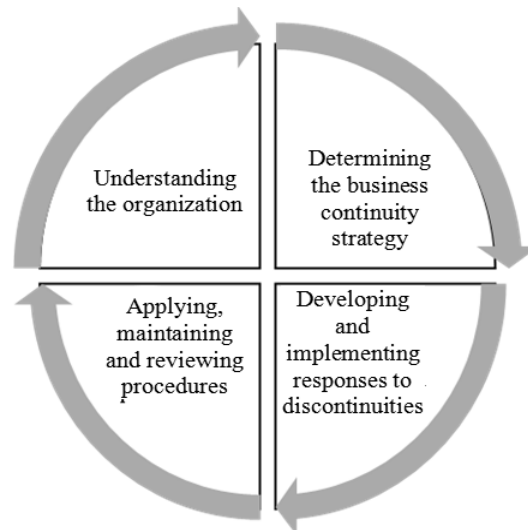


**Fig. 1.** Praxeological aspects of security

Source: Ficoń [2007, p. 18].

It is assumed, in line with the praxeological strand in systems theory and the principles underpinning business continuity management methodology, that a management system can be seen as secure when it is capable of fully implementing its own plans and making sure that vital processes are executed and targets are achieved, including the operational goals of the system or organization. Therefore, the security of a system should not be solely seen in the context of impacts and perils coming from the outside, but it must take note of how the system influences its immediate surroundings and, in particular, how it impinges on the security of the environment in which it operates [Ficoń, 2007].

In order to underscore the correspondence between business goals and governmental goals under crisis management and continuity management theory, we have chosen to anchor our discussion in the British standard BS 25999 (which is already withdrawn and replaced by ISO 22301) established by the Business Continuity Institute, which serves as a blueprint for lawmakers and legal systems worldwide in regulating crisis management and business continuity issues. The British standard, which has spawned many international and national standards (e.g. ISO/IEC 17799 and ISO/IEC 27001 internationally, or PN-I-07799-2:2005 in Poland), sets trends in legislating for unification and promotion of crisis management as an element of continuity management (other crisis management standards and relevant legal acts are referenced in [Cornish, 2011]). It is in this context that the authors will attempt to reveal links and similarities between the legislative (administrative) approach and the business use of crisis management.



**Fig. 2.** The life cycle of the business continuity management process

Source: Cornish [2011, p. 124].

Figure 2 shows the operating cycle of a business continuity management strategy implemented in a business organization. Further in this subchapter, specific stages in the process will be reviewed, bringing up their advantages alongside the linkages between the methodology and the added value to be derived from applying such an approach to crisis management processes.

The basic determinant of a decision to implement continuity management procedures is an explicit message from those in charge of a business organization or governmental institution that initiates the process of organization-wide analysis aimed at understanding the way the organization operates.

An even more complete picture of the parallels between the goals and the situation of businesses and public authorities in the context of continuity management and crisis management will come into view in Table 1, pinpointing the ample synergies to be exploited by the beneficiaries of an integrated approach to crisis/disaster management.

**Table 1.** BCM methodology vs. the crisis management modeling process

Step in Business Continuity Management methodology	Element of the Crisis Management modeling process
1	2
<p><b>Understanding the organization</b> – understanding how the organization operates, engaging and committing everyone in the organization who is interested in the introduction of a business continuity management system. At this stage, key resources must be identified on which the organization’s ability to perform its core activities – providing services, manufacturing products, etc. – is conditional.</p>	<p><b>Preparing and adopting legislation for the crisis management system</b> – a stage where public officials will invite experts and stakeholders to work together on preparing and implementing terms of reference for crisis management bodies. Based on their determinations, a specification of requisite personnel and resources is drawn up.</p>
<p><b>Determining the business continuity strategy</b> – owing to a business continuity strategy, it becomes possible to identify and catalog all operational activities that must be kept going because they are critical to the organization’s ability to continue operations.</p>	<p><b>Developing crisis response plans at various levels</b> – in line with the crisis management structure designed at the previous stage, respective component levels of the system will develop contingency plans prescribing steps to ensure the continuity of public administration in a given area and setting up mechanisms for predicting future hazards.</p>
<p><b>Developing and implementing responses to discontinuities</b> – another step in creating an information resource for business continuity management, at which detailed plans are developed for responding to all likely contingencies. As a result, the organization designs procedures to follow in the event a specific type of hazard or crisis arises, detailing actions to be performed in response to the discontinuity as well as measures to be taken in order to restore normal operations after the discontinuity incident ceases.</p>	<p><b>Developing procedures for dealing with hazardous incidents</b> – under the operational crisis response plan adopted in the previous step, procedures need to be laid down to account for specific types of hazards that are likely to affect government bodies as well as businesses in a given area. The procedures in place should provide for feedback between the business and the government system so that they both become part of a cause-and-effect model of management.</p>

Table 1 cont.

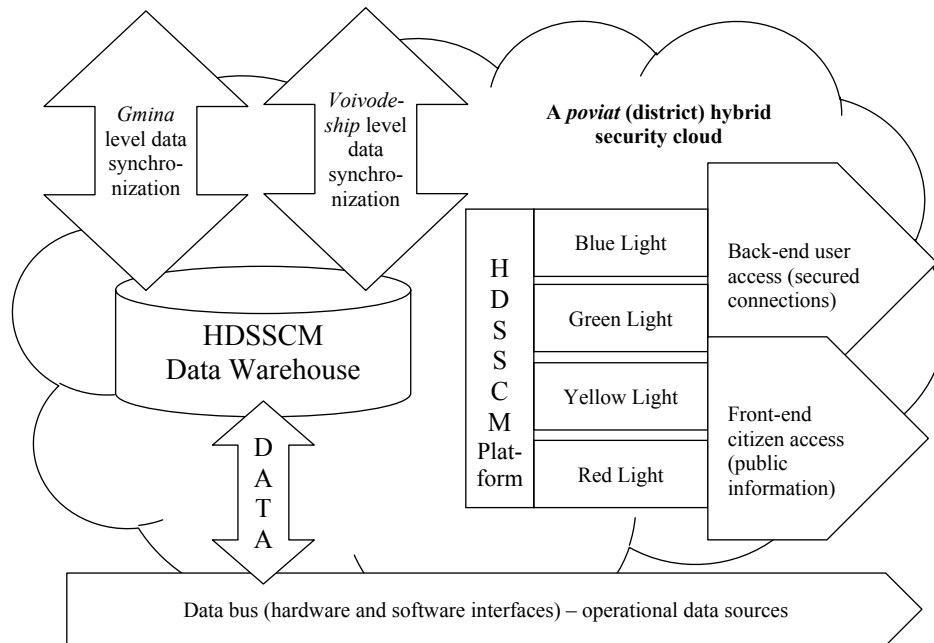
1	2
<p><b>Applying, maintaining and reviewing procedures</b> – this is a stage where procedures are reviewed and exercises are held in order to ensure that all critical operating activities and functional areas have been addresses with appropriate procedures.</p>	<p><b>Auditing, improving and validating crisis response plans</b> – for the system to retain operational capacity and preparedness, the relevant plans and procedures must be regularly updated, which is an obligation placed by the legislature on competent public governance structures. This is to ensure that their content is aligned with changes in the environment and incorporates prior experience from tests and audits. Updates to the government system should entail updates to the corresponding procedures in business organizations.</p>

Source: Own research.

## 2. A hybrid approach to business continuity management

The concept of the Four Lights Platform was first presented at the 2012 conference of the International Federation of Information Processing: Working Group 8.3 [Stanek, Drosio, 2012], and further elaborated into a Hybrid Decision Support System for Crisis Management (HDSSCM) under a research project that the authors conducted in collaboration with local and regional stakeholders in the crisis management process [Stanek, Drosio, Namysło, 2014]. The Platform's benefits were highly appreciated by a group of decision makers who were brought together in a creativity workshop held as part of the project. They agreed unanimously that a data and process integrator like the Four Lights Platform could have a positive effect on the efficiency of crisis management and emergency response services in the area of powiat<sup>1</sup> [Stanek, Drosio, Namysło, 2014]. An overview of the system design and architecture is shown in Fig. 3. From the technical point of view the whole solution will be placed into the hybrid cloud system. Hybrid cloud will provide possibility to establish support for both sites citizens and back – end users. Usage of this technology will give the possibility of achieve high level of security (in crisis management is one of the most important think) the same as easy accessible web application for citizens. Data bus will be constructed on ontology base technology to liaise with heterogeneous data sources.

<sup>1</sup> In Poland, powiat is the second-level unit of local government, consisting of several municipalities (communes) and equivalent to a county or district in some other countries.



**Fig. 3.** The cloud-based architecture of the HDSSCM at the poviats level

Source: Stanek, Drosio [2014, p. 59].

Of the two Platform components that were recognized as crucial by the workshop participants, it is the integration and information component, designated as Yellow Light, that seems most relevant in terms of ontology applications for data homogenization. Yellow Light is supposed to trigger actions on receipt of warning signs (weak signals, strong signals), and is built around a data bus, using an ontology to liaise with heterogeneous data sources. The model was described at length in 2013 in an article treating of mobile decision support [Stanek, Namysło, Drosio, 2013]; more details are also given in the table below.

**Table 2.** An overview of HDSSCM subsystems and used technologies

Platform (subsystem)	Responsibility	Technologies used
1	2	3
Blue Light	Ongoing planning and reporting, involving emergency response operations and critical infrastructure; advising and training of local communities; advising, training and support of personnel, including psychological support	E-video learning, virtual reality, multi-agent simulation system, data warehouse, web-services
Green Light	Monitoring and integrated early warning based on signals from local, national and international detection systems; fusing information from early warning systems	Expert system, early warning system, data warehouse, web-services

**Table 2** cont.

1	2	3
Yellow Light	Analysis and assessment of hazards; selection and adjustment of emergency response plans; organization of and support for crisis command (headquarters) and task forces; estimating demand for external resources and their subsequent deployment and maintenance	Expert system / artificial intelligence, multi-agent simulation system, geographical information system, Unmanned Aerial Vehicles, data warehouse, web-services
Red Light	Providing assistance to task forces (technical support, triage <sup>2</sup> , displacement of persons and property, public order and safety keeping), reconstruction of damaged infrastructure, distribution of funds and settlement of claims	Geographical information system, multi-agent modeling, data warehouse, web-services

Source: Stanek, Drosio [2013].

### 3. Ontology within management concepts

The increasing need to automate data processing has boosted interest in semantic data representation. As a result, semantic approaches to process modeling have become commonly used [Gołuchowski, Smolarek, 2014]. The primary cause behind its widening popularity is the explosive growth of Internet technologies, driving demand for methods allowing unrestrained and effective searches through big data. Semantic Web representation can satisfy much of that demand. Semantic data description standards, such as RDF, OWL, or DAML, are currently believed to be able to become a major tool for integrating multiple data sources and automating the Web search process as well as a mechanism for self-organization of the Internet [Chmielewski, 2008].

Semantic techniques can be highly effective in combining heterogeneous data sources that need to be handled within many decision making contexts, which makes them perfectly fit for use in modeling management procedures. Further in the chapter, the applicability of semantic process modeling in crisis management will be discussed. The use of semantic modeling and ontology seems to pave the path for automating and integrating support for crisis management processes. What is at stake is isolating the implementation pattern and hence making it possible, on the one hand, to create broadly applicable tools enabling e.g. software agents to make inferences based on any ontology, and on the other, to effectively build ontologies for implementing diverse problem solving methods. A difficulty that arises in this context is that, despite ongoing tech-

<sup>2</sup> START – Simple Triage And Rapid Treatment.



nological advances and the impressive growth of intelligent systems, we are still unable to fully automate the integration of information systems. However, consistent semantics and a suitable ontology can substantially add to streamlining the integration process by resolving the issue of data heterogeneity. This approach to integration is referred to as “sharing of conceptualizations” or “shared conceptualizations”, as it allows multiple applications to use this same ontology. The perception of its benefits has encouraged the authors to attempt employing it for process modeling in crisis management. When applied as an element of organization and representation, process modeling aims at performing functions that coincide with those of an ontology [Gołuchowski, Smolarek, 2014]:

- to provide the same insight into specific information structures to people and information systems (e.g. to software agents),
- to make it possible to reuse domain knowledge,
- to ensure an unambiguous perception of domain assumptions,
- to distinguish/separate domain knowledge from operational knowledge,
- to organize domain knowledge,
- to enable inheritance across a hierarchical structure (different levels of generality of each process and embedded sub-processes),
- to provide a basis for reasoning/inference and simulation,
- to increase the effectiveness of searching (mining) for and extracting information from domain knowledge,
- to help arrange information by linking it to other information within a domain,
- to facilitate the discovery of context for information entering the system by establishing a structure and becoming a source of heterogeneous vocabularies.

It should be noted that ontologies are regarded as entities that are beyond data modeling but not beyond process modeling. Developing an ontology is, in a manner of speaking, a process aiming to organize existing processes (according to an ontology development methodology of one’s choice) or to create new processes relating a given area of domain knowledge. As regards the solutions described in the paper, the process involves chiefly analytical and descriptive measures focused on modifying some existing crisis management procedures or developing new ones.

## **Conclusions**

Looking at accounts of research on ontologies found in scholarly literature, one will easily perceive that most authors seek to demonstrate ontologies as arcane thing that can only be used by knowledgeable experts and in systems de-

signed to examine and interpret vast amounts of data. All this having been said, it should be stated that the fundamental assumption or requirement justifying the use of ontologies, i.e. the need to share conceptualizations, is in fact among the characteristics that have to be present in any specification of a conceptualization as long as an ontology is to merit the name. This characteristic, or requirement, was perhaps phrased most accurately by Ascuncion Gómez-Pérez et al., who insisted that a model cannot be considered an ontology unless it represents a consensual knowledge model agreed and approved by a community rather by its authors themselves [Gómez-Pérez, Corcho-Garcia, Fernández-Lopez, 2003]. The nature of crisis management is such that permits a chance to widen the use of ontologies as knowledge sources that can significantly improve the timing and the quality of emergency response decisions assisted by information technology.

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### WYKORZYSTANIE ONTOLOGII W ZARZĄDZANIU KRYZYSOWYM I UTRZYMANIU CIĄGŁOŚCI DZIAŁAŃ

**Streszczenie:** Opracowanie prezentuje koncepcję wykorzystania ontologicznego podejścia do wykorzystania heterogenicznych źródeł danych, które stanowią podstawowy zasób informacyjny w procesie podejmowania decyzji w warunkach zagrożenia kryzysem. Głównym celem artykułu jest ukazanie nieciągłości działań jako wieloaspektowego problemu nie tylko administracji publicznej, ale również organizacji gospodarczych działających w rzeczywistości społeczno-gospodarczej. W celu ograniczenia niepewności podczas procesu podejmowania przez decydentów wyborów mogących mieć wpływ na bezpieczeństwo zarówno fizyczne, jak i ekonomiczne mieszkańców terenu autorzy proponują szereg rozwiązań opartych na technologii hybrydowego systemu wspomagania decyzji w warunkach zagrożenia/kryzysu. W niniejszym opracowaniu przedstawione zostały w powyższym kontekście możliwości, jakie daje zastosowanie ontologii dziedzinowej w celu homogenizacji danych.

**Słowa kluczowe:** ciągłość działań, kryzys, systemy wspomagania decyzji, ontologia dziedzinowa.