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Application of Knowledge Management and the Intelligence Continuum for Medical Emergencies and Disaster Scenarios

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***Abstract*—The world has recently witnessed several large scale natural disasters. These include the Asian Tsunami which devastated many of the countries around the rim of the Indian Ocean in December 2004, extensive flooding in many parts of Europe in August 2005, Hurricane Katrina (September 2005), the outbreak of Severe Acutre Respiratory Syndrome (SARS) in many regions of Asia and Canada in 2003 and the Pakistan Earthquake (towards the end of 2005). Such emergency and disaster situations (E&DS) serve to underscore the utter chaos that ensues in the aftermath of such events, the many casualties and lives lost not to mention the devastation and destruction that is left behind. One recurring theme that is apparent in all these situations is that, irrespective of the warnings of imminent threats, countries have not been prepared and ready to exhibit effective and efficient crisis management. This paper examines the application of the tools, techniques and processes of the knowledge economy to develop a prescriptive model that will support superior decision making in E&DS, thereby enabling effective and efficient crisis management.**

I. Introduction

CHANGING weather patterns, rapid urbanization, expansion of industry not to mention development of air and ground transportation networks, population growth and migration, and, recently, acts of terrorism, are associated with an increasing frequency of major disasters involving multiple casualties [1].

Emergency Healthcare management is a complex process which has to be tackled on various fronts [2,3].

Such situations require effective crisis management capabilities, i.e. pre-hospital and emergency/trauma, "in-hospital", medical services, firefighting, disaster-related law enforcement operations and superior decision-making capabilities [1,4,5].

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Most of these services are governed by different local or national agencies or are subject to different rules and regulations and develop independent operational plans. In turn, this leads to the gathering and storing of data in disparate databases. Given the interdependent nature of these elements, any decision-making process based on only one, or a few, of these data elements will logically provide only a partial picture and, thus, an inferior decision.

Hence, it is necessary to collect multi-spectral data, analyzed in aggregate, in order to develop a complete picture if we are to truly support superior decisions. To do this effectively and efficiently it is imperative that stakeholders embrace the tools, techniques and processes of the knowledge economy [5-11].

Advances in IT, coupled with the advent of Knowledge Management (KM), can facilitate better processes for efficient and effective healthcare [12].

II. The Intelligence Continuum

The intelligence continuum is the collection of key tools, techniques and processes of the knowledge economy (including data mining, business intelligence/analytics and knowledge management) which are applied to a generic system of people, process and technology in a systematic and ordered fashion [13]. Taken together, they represent a very powerful instrument for refining the data and raw material stored in data marts and/or data warehouses, thereby maximizing the value and utility of these data assets.

The intelligence continuum is applied to the output of the generic information system. Once applied, the results become part of the data set that are reintroduced into the system and combined with the other inputs of people, processes, and technology to develop an improvement continuum. Thus, the intelligence continuum includes the generation of data, the analysis of which provides a "diagnosis" and the reintroduction into the cycle as a "prescriptive" solution. In this manner, continuous learning is invoked and the future state always builds on the lessons of the current state while the extant knowledge base is always increased.

The key capabilities and power of the model are in analyzing large volumes of disparate, multi-spectral data

so that superior decision making can ensue. This is achieved through the incorporation of the various intelligence tools and techniques which, taken together, make it possible to analyze all data elements in aggregate. Currently, most analysis of data is applied to single data sets and uses at most two of these techniques [5,6,13-17]. There is therefore neither the power nor the capability to analyze large volumes of multi-spectral data.

The benefits of applying the capabilities of the intelligence continuum to E&DS scenarios are profound. E&DS scenarios are concomitant with complex, unstable and unpredictable environments where the unknown or position of information inferiority prevails. Hence, these scenarios are chaotic and sub-optimal decision-making typically results.

In contrast, the tools and techniques of the intelligence continuum can serve to transform the situation of information inferiority to one of information superiority in real time through the effective and efficient processing of disparate, diverse and seemingly unrelated data. This enables decision makers to make superior decisions which, in turn, lessens the chaos and facilitates the restoring of order. In order to appreciate the power of the intelligence continuum in such scenarios, it is necessary to briefly describe its key elements.

A. Data Mining

From a micro perspective, data mining is a vital and non-trivial step in the broader context of Knowledge Discovery In Databases (KDD) that transforms data into knowledge by identifying valid, novel, potentially useful and ultimately understandable patterns in data [18-21].

B. Business Intelligence/Analytics

Another technology-driven technique, connected to knowledge creation is the area of Business Intelligence (BI) and the newer term of Business Analytics (BA). BI has become synonymous with an umbrella description for a wide range of decision-support tools, some of which target specific user audiences [6,13]. At the bottom of the BI hierarchy are extraction and formatting tools (also known as data-extraction tools). These tools collect data from existing databases for inclusion in data warehouses and data marts.

Existing healthcare information systems are not generally designed to cater to new needs [22]. Because the data come from so many different, often incompatible, systems in various file formats, the next step in the BI hierarchy is formatting tools; these tools and techniques are used to "cleanse" the data and convert it to formats that can easily be understood in the data warehouse or data mart. Next, tools are needed to support the reporting and analytical techniques. These are known as enterprise reporting and analytical tools. Human intelligence tools form the next level in the hierarchy and involve human expertise, opinions, and observations to be recorded to create a knowledge repository. Such tools are at the very top of the BI hierarchy and serve to amalgamate analytical and BI capabilities along with human expertise [13].

C. Knowledge Management

Knowledge Management (KM) is a management approach that is aimed at solving current business challenges to increase efficiency and efficacy of core business processes whilst simultaneously incorporating continuous innovation. Specifically, KM - through the use of various tools, processes and techniques - combines germane organizational data, information and knowledge to create business value and enable an organization to capitalize on its intangible and human assets so that it can effectively achieve its primary business goals as well as maximize its core business competencies [5,6,13-17]. The importance of knowledge management is confirmed by the increasing attention that the subject has received from both researchers and practitioners [23]. KM broadly involves four stages:

- creating/generating knowledge
- representing/storing knowledge
- accessing/using/re-using knowledge
- and disseminating/transferring knowledge [5,13].

D. Knowledge Generation In Dynamic and Unpredictable Environments: The OODA Loop

Information gathering hierarchically precedes transformation of information into useable knowledge [24, 25] and the rate of information collection (and the quality of the information collected) will have a major impact on the quality (usefulness) of the generated knowledge [26]. In order to make effective decisions the decision maker must rapidly process seemingly irrelevant data and information into relevant and useable knowledge [14,17,27-30]. This necessitates a process perspective to Knowledge Management [5,31]. The cornerstone of such a perspective is the OODA Loop (Figure 1) which provides formalized analysis of the processes involved in the development of a superior strategy [29,32,33].

The Loop is based on a cycle of four interrelated stages revolving in time and space: at the Observation and Orientation stages, multispectral implicit and explicit inputs are gathered (*Observation*) and converted into coherent information (*Orientation*). The latter determines the sequential *Determination* (knowledge generation) and *Action* (practical implementation of knowledge) steps. The outcome of the latter affects, in turn, the character of the starting point (Observation) of the next revolution in the forward progression of the rolling loop.

The Orientation stage specifies the characteristics and the nature of the "center of thrust" at which the effort is to concentrate during the Determination and Action stages. The Loop exists as a network of simultaneous and intertwined events that characterize the multidimensional

action space (competition space), and both influence and are influenced by the actor (e.g., an organization) at the center of the network.

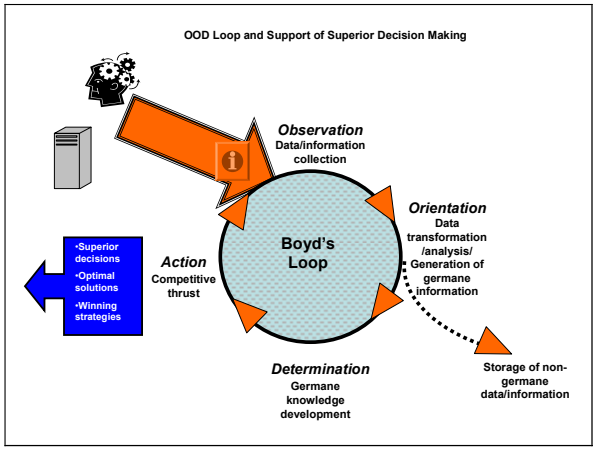

Figure 1: The OOD loop [4,5]

It is the incorporation of the dynamic aspect of the "action space" that makes the Loop particularly useful to environments that are inherently unstable and unpredictable i.e., medicine, business, war and emergency and disaster scenarios [4,5,33]. By not only supporting and enabling these four stages of the OODA Loop (but also bringing together the key tools and techniques of the knowledge economy), the intelligence continuum provides the decision maker the possibility to make superior decisions in times of crisis.

III. Conclusion

When we analyze the recent natural disasters, a common recurring and unfortunate situation is that countries and regions are never as prepared and ready for the eminent disaster as they perhaps could have been. It is too late once the disaster strikes to have an organized and systematic fashion for contending with the aftermath.

What is required is to be able to analyze past crises and develop appropriate lessons to apply to future events.

In the advent of a health crisis,the tools and techniques of knowledge management especially as presented in the intelligence continuum offer the possibility to improve information sharing and coordination. This is because the intelligence continuum model coupled with a process perspective of knowledge management can be applied to critically analyze existing and disparate data elements from past disasters in order to build a predictive model that can facilitate in the development of sound procedures and protocols to facilitate preparedness and readiness *a priori* so that *ex ante* operations can in fact be more effective and efficient, decision making superior and order replace much of the chaos.

What is required for E&DS is to be both ready and prepared; this requires not only the possession of pertinent information and germane knowledge but also the ability to apply it successfully; evoke superior decision making. Efficient flow of information is necessary in managing an outbreak [2].

Hurricane Katrina serves to highlight how vulnerable and insufficient existing crisis management techniques are [34-36] as well as to underscore that developing better techniques - through the utilization of critical data sources - should be remedied immediately. We argue that the Intelligence Continuum offers such a possibility and urge for its incorporation in E&DS decision making.

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