DEFEDNING AGAINST BUSINESS CRISES WITH THE HELP OF INTELLIGENT AGENT BASED EARLY WARNING SOLUTIONS

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Abstract: In the practice of business management, there is a pressing need for good information management instruments that can constantly acquire, monitor and analyze the early warning signals of business crises, thus effectively support decision makers in the early detection of crisis situations. With the development of advanced computing methods and information technology, there bring new opportunities for the construction of such instruments. In this paper, we proposed the use of business life cycle model as a larger framework of guidance for an early warning system of business crises. We also developed a framework for an intelligent agent based early warning system.

1 INTRODUCTION

"…It is not a question of if or whether an organization will experience a crisis; it is only a matter of what types of crisis will occur, what form it will take, and how and when it will happen" (Mitroff et al, 1996).

In the age of globalisation, information explosion, fast-paced technology development and market changes, uncertainty abounds. As a result, the possibility grows considerably for various crises to emerge. Thus, crisis management is becoming an increasingly important item on the agenda of many organizations, public and private, large and small.

Crisis is an event or a situation that has considerably negative affects on an organization as a whole. A crisis may have the potential to even destroy an entire organization. To be more specific, in this paper we shall focus on business crisis that happen in the corporate world. By business crises we refer to the highly abnormal, risky, and difficult situations (e.g. severely shortage of key resources - human, money, material) that are threatening or could threaten to seriously interrupt or harm business, and to bring tremendous damage to the company, its employees, its product, service, assets, as well as its reputation (cf. Barton; Bernstein Crisis Management). Examples of the events that can put a company into different types of crisis situations include: environment pollution, product defects, inappropriate merger and acquisitions, senior management staff moving to competitors, break-down of information system that result in halt in business operations, legal cases, fraud that ruins business reputation.

Crisis management usually encompasses a chain of activities that enable a business to plan for, to respond to, and to recover from a crisis event, so that eventually it can avoid a crisis to happen, or reduce the damages as much as possible, or even turn crises into opportunities (Mitroff et al, 1996; Augustine, 2000; Gao and Yuan, 2003). These activities can be generalized as three important parts: *pre-crisis*, *in-crisis* and *post-crisis* activities. *Crisis early warning* is a pre-crisis activity. It aims for the early detection and alerting about highly risky and harmful future events, so as to prevent crisis to happen as early as possible. It is also the focus of this study.

Crises like less harmful risks are a natural companion of any business development. They are sometimes simply inevitable because the development of anything is never linear, there are always ups and downs. Crisis creates complicated management situations, and they will become more and more complicated if not controlled at an early stage (Mitroff et al, 1996; Gao and Yuan, 2003). So

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the very nature of crises makes an early warning system that is constantly functioning much important and desirable. An early warning system will form the very first defense against any foreseeable crises and it implies a proactive approach to crisis management. Without an early warning system, even if a company is already in crisis, the management team may still be unaware of it. Thus, sufficient ability in the early detection and warning of various types of crises is a must for the healthy and sustainable development of any business.

In this paper, we will elaborate on how can IT and IS help in improving an organization's early warning capability, and how intelligent computing methods and intelligent agent technology can be applied to build crisis early warning solution that will better manage the early warning tasks. We shall first draw upon existing theory and empirical knowledge on business crises and early warning signals, and then discuss the relevant methods and models for early warning analysis. Based on that, we will examine the role of soft computing methods and intelligent agent technology in the construction of computer based early warning support instruments for constant acquiring, monitoring and analyzing of the early warning signals, and further the prediction of impending crisis.

2 EARLY WARNING OF BUSINESS CRISES

Business crises can be originated from inside a company or outside the company. Crises situations caused by sudden changes and devastating events outside the company, for example in the political and economic environment, the natural environment and the social environment, are uncontrollable by the company. But crises caused by particularly harmful events happened inside a company are often attributed to mistakes and failure of the management structure and management function (Mitroff et al, 1996; Gao and Yuan, 2003).

Although the importance of early warning may seem too obvious, in reality it is usually a step skipped altogether in the corporate world (Augustine, 2000). There may be many reasons behind it, for example, a top management mind that believes that they are somehow luckier than others, or that they can handle whatever crises that may come. Other than that, the inherent challenge in establishing an appropriately large early warning system is definitely also an important contributing factor. *Firstly*, the number and form of the crises that an organization may encounter are practically unlimited. In this sense an early warning system can never be perfect because it is impossible for any such system to not overlook every possibility, even with the best resources. *Secondly*, organizations are constantly bombarded with signals of all kinds. This implies that the efforts of probing and scrutinizing into business operations and its management structure must be made constantly instead of only a one-time effort in order to capture early warning information. And, the various signals need to be accurately assessed to discern the critical ones from the disguising ones. *Thirdly*, crisis warning signals may come from different sources and they may present conflicting contradictory evidence. How to integrate various information, to understand the connection between the seemingly isolated information, and to correctly understand the "situation" thus to recognize whether there is a crisis or not, are even more challenging tasks. *Fourthly*, warning signs of crises are often dispersed throughout the organization as well as in the business environment. However, to be effective, early warning efforts as well as other crisis management activities need to be systematic. *"…Effective crisis management is not a function of how well early warning is done in one part of an organization, or the sum of separated parts, but a coordinated integrated whole… In a crisis, poor performance in one area is not compensated by exceptional performance in another."* (Mitroff et al, 1996).

2.1 The Early Warning Signs of Crises

Hidden-ness is an innate characteristic of crises. Very often crises are hidden underneath a seemingly normal surface and invisible to us until it already comes into strong appearance, which is why crises always take us by surprise. Nonetheless, crises do not just form overnight. In fact, crises are often presaged by various visible or invisible signals. As described by Mitroff et al (1996), *"with very few exceptions, crises send out a trail of early warning signals before their actual occurrence"*. The pity is that such warning-signs are often widely spread across the organization and embedded in various information thus are not so easy to recognize. In some cases, they are neglected even if they already present themselves in front of people, or some already identified warning signs may be intentionally or unintentionally blocked in its way to reach the appropriate management attention.

Crisis warning signals may be early or late, visible or hidden, strong or weak, physical or informational. In the theory of crisis management, there are generally four types of crisis early warning pattern: (i) economic crisis may signal business crisis (economic life cycle); (ii) trade and industry crisis may signal business crisis (decline progressively; excessive production); (iii) business crisis may signal industry crisis; (iv) catastrophic events may signal business crisis (Gao and Yuan, 2003). This very generally informs us where we could look for signals of crises. However, this is first a too general a theory to guide further implementation, and second we regard such signals as only rather "strong" (or late, some are accidental) instead of weak (or early, non-accidental) indicators of crises. Obviously it does not provide enough advice. In fact, in the literature of crisis management, we often find crisis cases that are usually a gas leak in chemical plant, a call from media, or similar signals that are already pretty strong indicators. Of course it is important to attend to strong signals; but as important we must also try to attend to weak signals that are early indicators. But, after all, where else do early warning signals come from?

To be able to define what are the possible early warning signs of certain types of crises that an organization may especially be vulnerable to is perhaps the most important step in establishing an early warning system. In Fink's words, at the pre-crisis stage, "small, seemingly insignificant warning signs can signal an impending disaster for those who know where to look". One intuitive solution may be to look at the "sources of crises" for "sources of early warning signals". "Sources of crises" may be external or internal as mentioned above. Inside a company, "sources of crises" may be from those directly related to key aspects in business "operations" and business "management". On the "operation" side, crises may be resulted from all aspects along the supply and demand chain, for example: decreased sales, deteriorated financial status, damaged customer/supplier/partner relationships, core technology failure linked to key product and services, etc. On the "management" side, crises may be resulted from poor decisions and management actions on key operational factors along the supply-demand chain or any other aspects of the corporate life, unexpected harmful consequences in the implementation of certain decision management structure, mis-managed public relations, HR/occupational issues, inappropriate company culture and corporate values, and so on. In addition to sources of crises as the direct/immediate "sources of warning signals", the close causal-effect relationships among various early warning factors need also be attended.

To a crisis management team, the physical "sources of early warning information" often include internal and external sources such as: (i) externally: media, police, health department, government, industry bodies; (ii) internally: public affairs, health/safety, security, legal, operations departments (Mitroff et al, 1996). As a complement, early warning information can also be discovered systematically from large volumes of sales data, financial data, customer information, supplier information that can be found from various credible and complementary sources. For example, average sale revenue (per employee) compared with a standard value, its percentage changes, and sale revenue change compared with profit change, are often the sales indicators of a crisis situation. When sales revenue is decreasing, it may signal some risky situations such as the industry is in recession; the competitor is growing strong; customers' indemnity claim increase; customers change frequently; customers stop increasing; major products are not welcome on the market; inventory increases, etc. Looking at the financial figures, certain degree of shortage in cash flow can cause crisis situations (e.g. continuous in deficit for 5 years together with non-improvement in sales or continuously decreased sales); increased cost, too much human resource cost, too much equipment investment, inappropriate large investments resulted in to much liability. A crisis can also be the result of dangerous customers and suppliers. Signals of dangerous customers include for example absent managers, key manager goes to the hospital, customer's customer turn away, etc. (Gao and Yuan, 2003).

Then, how far we should go to look for early warning signals? The ideal way is of course try to be vigilant to all possible leaks of warning signals with a 360° radar monitoring system. This is however often restricted by the resources available. In Mitroff et al (1996), they established a concept of "crisis family", and suggested that any crisis portfolio of an organization should contain at least one crisis from each crisis family. It acknowledges that each type of crisis may be either the cause or the effect of another type of crisis. An organization that wants to be well prepared for dealing with possible major crises must have the capability to handle at least a crisis portfolio. This to some extent could be a useful guidance for limiting the scope of warning signal searching. Another tool that can be applied to help us roughly prioritize our attention is the framework of business life cycles.

2.2 Business Life Cycle and Crisis Early Warning

The theory of business life cycle tells us that, with the passage of time, in the process of its development, all businesses will go through various life-cycle stages from conception to cessation, similar to the cycle of life of human beings or the cycle of life for products and services. In 1979, Ichak Adizes proposed his ten-stage corporate life cycle model describing business development as including the stages of *courtship, infancy, go-go, adolescence, prime, stability, aristocracy, recrimination, bureaucracy,* and *death.* Some other models describe a business life cycle as having seven stages including the seed stage, start-up stage, growth stage, established stage, expansion stage, decline stage and exit stage (Zahorsky, 2003), or four phases including Start-Up (covers Courtship, Infancy), Growth (covers Go-Go, Adolescence, Prime), Maturity (covers Stable, Expansions), Aging and Decline (or Transition), then return to the Start-Up stages. Each stage of the business life cycle may not occur in chronological order. Some businesses quickly go from Start-up to Exit. Some may choose to avoid expansion and stay in the established stage. External environment factors (such as economic life cycle, industry life cycle) can directly affect the course of a business life cycle and cause shifts in life cycles. Whether a business is a glowing success depends a lot on its ability to adapt to its changing life cycles.

Business life cycle is the more stable rule in the corporate life. The characteristics of a business at each phase are usually well known. For example, at the early stage, resources are very limited and cost or expenses control is critical. The growth stage is characterized by strong profits as well as emerging competition. At its established stage, a business has matured into a thriving company with a place in the market and with loyal customers. Business life has become more a routine. But new issues such as macro economic environment, competitors or changing customer tastes will call for attention. The expansion stage is characterized by a new period of growth into new markets and distribution channels. But moving into unrelated businesses can be disastrous. Finally, changes in the economy, society, or market conditions can cause sustainable decrease in sales and profits that will lead the business into the decline stage, which eventually may end a business (Zahorsky, 2003).

The relevance and importance of business life cycle to crisis early warning is that the life cycle's predictable patterns help managers to develop insight as to what problems need to be corrected first. Risks or possible crises associated with different stages of the business life cycle will differ. At different stages of its life cycle, a business will be especially vulnerable to different threats. What a business needs to heed and overcome today will change in the future. Life stage information can thus be used as one of the frameworks for prioritizing signals, or guiding our attention to various signals. For example, while there is always the possibility of running into crisis situations, companies over 30 years history and business at the time of transition can be especially vulnerable and at very high risk because of reasons such as lack of successor managers, or outdated rigid systems (in Gao and Yuan, 2003).

In addition, the life cycle model thus provides useful basis for understanding more about organizational change. Especially related with the life cycle analysis are also the risks arising from the management of the life cycle: the control of the speed of business development, especially the speed of growth and expansion. Crises may happen if a new product or service moves into growth phase too slowly, move out of it too quickly, or if a business cannot move back to growth from the maturity. The risks associated with mergers and acquisitions are often high, and at the transition stage, there may generate very risky situations associated with business decline, when a crisis may happen if the business can not exit a particular market in time or it cannot support a negative cash flow for long enough (in Gao and Yuan, 2003).

2.3 Early Warning Analysis: from Warning Signs to Crisis Alerts

Earlier business failure models are mainly financial models applying statistical methods to financial ratios as the tool for the analysis of business failure risks, which would give an early indication of potential financial difficulties. The most popularly known conventional models for early warning include Beaver's univariate analysis using dichotomous classification test (1967), and Altman's Z-Score model (1968) and its extension, the ZETA model (Altman, Haldeman and Narayanan, 1977). The Z-score model is based on a statistical multivariate discriminant method. The ZETA model was developed to further improve the forecasting accuracy of the Z-score model, and to account for the changes and developments in the macro economic environment over time. Marked by the work of Lapedes and Fayber (1987), neural network

models have found wide application in the more recent studies of business failures, and they have shown much potential in dealing with non-linear, complexity, dynamics and uncertainty in forecasting (in Gao and Yuan, 2003).

Nowadays, it is easy to find numerous studies that have shown a definite potential of financial ratios as predictors of corporate financial distress or bankruptcy, with profitability, liquidity, leverage, solvency as the most significant indicators. In our opinion, however, such a financial-figure based approach is better suited for post-crisis analysis to gain a better understanding of the forces behind crises. From crisis early warning point of view, the financial ratio approach alone would seem too insufficient because financial figures only reflect the symptoms or results of problems rather than the real causes. When the effect of potential problems is already reflected in financial figures, it may have become too late to avoid a crisis situation or to have it quickly under control. There is definitely the need to watch and analyze as well all other types of warning signals such as from sales, customers, suppliers, raw materials, and other critical operating factors, as described earlier. Besides the primary early warning indicators, an early warning analysis should also pay attention to relationships between various crises, crisis chains, as well as possible vicious cycles of crises.

3 INTELLIGENT AGENT BASED EARLY WARNING SOLUTIONS

3.1 The Roles of IT and Intelligent Agents in Crisis Early Warning Systems

Early warning, as part of a crisis management and decision-making process, is a process of problem identification, rather than alternative design and choice making. A crisis early warning system is bound to be a data-driven system. In order to effectively support decision makers in the early detection of crisis situations, an early warning system needs to be first of all an information management instrument that can constantly acquire, monitor and analyze the early warning signals of crises. In addition, the assessment of risks is at the core of an effective early warning system.

To be able to provide early warnings of emerging crises in a timely fashion has proven to be very challenging tasks due to many reasons. First of all, crises are usually the result of continuous interactions among multiple risk factors. Due to the complicated nature of the interactions, there are inherent difficulties to formally and precisely capture and describe the causal-effect relationships between these factors and a crisis situation, especially when it is acknowledged that such causal-effect relationships are not always the same but instead can change over time. This leads to difficulties in evaluating even the already visible signals using conventional statistic tools and mathematical model based on domain theories. Second, it is not an easy task either to collect information on early warning signals in the first place, not to mention to keep them up-to-date all the time, and to absorb and make sense of the collected information in time. Modern IT or ICT can contribute to crisis management by providing process support, communication support or intelligence support. For early warning in the age of information overload, the effective application of information technology is at the heart of intelligence analysis. The importance of the role of IT system for early warning is especially due to the “systematic nature” of crisis management. A computer based early warning systems can enforce the early warning guidelines into a consistent system. It can also remove some of the blocks between the crisis manager and the early warning signals. The collected information related with crisis is a valuable resource for supporting the assessment of damages when crises do happen.

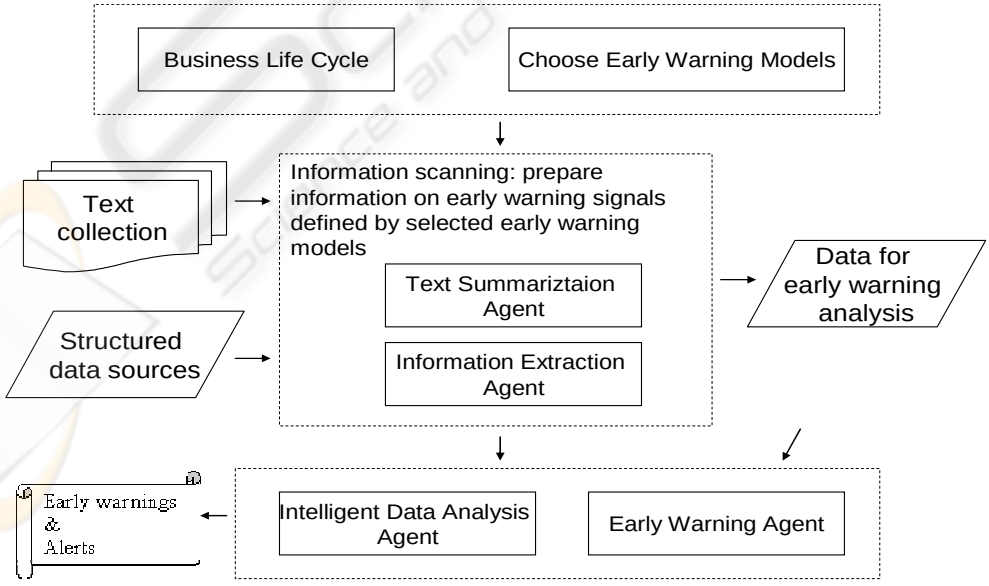
Although various efforts have been made to and much progress has been achieved in improving the information search, query, retrieving and scanning techniques, they only helped in coping with the issue of high irrelevance, particularly at the “file” level instead of the “information” level. As far as the content is concerned, as far as the effective absorption and use of information is concerned, severe information overload remains a critical issue. Especially, it is more often the case that the collected data are in the form of long text or large document collections that contain much qualitative information rather than numeric data, or that contain a mixture of both. It can become an extremely time-consuming, labor-intensive and costly process (if not an impossible process) when trying to grasp the major content of large amount of news and reports, to extract important information from them, and subsequently make effective use of them in decision making.

An intelligent agent is a computational program that inhabits in a computing environment, and act on behalf of users to accomplish delegated tasks.

Central to the notion of software agents are the automation of work and the automation of computer usage. They are able to take initiative, to solve problem without direct intervention and constant step-by-step guidance from the user. They are able to customize assistance and service, according to what is learned about the user, and are able to improve performance based on previous experience. When deemed appropriate, an agent is able to interact and collaborate with other agents, or humans in order to complete their own problem solving and to help others with their activities; agents work in background and serve round-the-clock. Agent technology has found various applications in broad fields. Especially in information and knowledge management related tasks, agent based solutions have played many important parts and have much potential. In comprising a crisis early warning system, agents that act on behalf of human surveillance can save human resources. With the deployment of multiple software agents, we can make an early warning system move one step closer to 360˚ comprehensive radar system.

3.2 Agent Based Early Warning Systems: A Framework

Based on the domain analysis in previous sections, we propose to adopt a business life-cycle analysis based approach to early warning. The business life cycle model provides the information basis for the correct selection of early warning methods and models that may take into account different groups of early warning signals or implements different analytical methods. Effective early warning requires the acquisition and delivery of critical information in a robust fashion. Technically, such instruments should be able: (1) to quickly sum up key information from text data sources (e.g. news text or business/government reports); (2) to quickly extract specific pieces of information from text documents; (3) to discover from large structured data bases the meaningful hidden information or patterns; and (4) to make these functionalities easily accessible and usable for decision makers. In the figure below, we present a conceptual framework for an intelligent agent based early warning system. The Text Summarization Agent and Information Extraction Agent are responsible for the raw data supply for the early warning system. They will draw up the relevant data from credible sources (text sources such as media, business reports; structured sources such as corporate databases). There can deploy a number of text summarization agents as well as information extraction agents as needed. These agents will embrace the differences in sources inside themselves, but will communicate with a coordination agent to integrate the data, or with the user to present the summary of long text documents.



The Intelligent Data Analysis Agent will conduct mining operations to derive the value of early warning indicators, to prepare the input to early warning agent. The Early-Warning Agent will apply risk assessment and crisis identification rules (e.g. fuzzy if-then rules) to generate risk warnings if there are crises impending, or establish the degree of exposure or vulnerability to dangerous consequences even if there is no crisis situation yet. Again multiple agents can be deployed to specialize in different types of crises, such as proposed in the crisis portfolio by Mitroff et al (1996).

3.3 Soft Computing Methods for Early Warning Analysis

Fuzzy logic and neural network methods have found many successful applications in risk assessment from financial markets, environment control, project control, health care. Fuzzy method allows the use of qualitative indicators. In the analysis of early indicators of business crises, we often have very limited knowledge of the quantitative relationships between the variables as well as between the variables and a crisis situation, and these relationships may be intrinsically non-linear and very complex. Especially, it can be a very difficult task to tell when does the sum of various business difficulties become critical enough to trigger sudden worsening of business situation, i.e. the occurrence of crises. We believe that there is a good potential in applying intelligent data analysis methods such as fuzzy set theory and SOM (Self Organizing Maps) based clustering methods to automatically determine the “critical levels” or threshold levels of early warning indicators based on empirical data.

Clustering analysis help us to group data points that represent multidimensional data into natural clusters such that the clusters will show an underlying pattern hidden in the data. There is no need to assume anything about the functional form of a hypothesized relationship between the variables. Fuzzy clustering analysis then allows us to describe classes or clusters that can at best be imprecisely articulated. Data points can be partitioned into overlapping natural groups (i.e. fuzzy clusters), where each data point belongs to each cluster to certain degree that is specified by a membership value. With these analyses of early warning information, we shall also be able to add to existing theoretical knowledge of financial crises and business crises and the descriptive type of case studies around them. In our previous work, we have applied the FCM fuzzy clustering method to group multiple economic time series data into overlapping clusters, and at the same time to inform us the degree of membership for each data point in each of the clusters. This not only helps us to grasp the feature of economic fundamentals over the crisis period, but also makes it possible for us to tell the extent to which one or more warning signals were perhaps visible already during the normal development period. As frequently used subjective categories in crisis analysis are also often imprecise and do not have sharp boundaries, a fuzzy clustering approach thus seems to provide a simple and natural way to capture hidden patterns relationships in an easier and very flexible way. There is no reason why such a method cannot be applied in analyzing business crises.

SOM is a powerful neural network technique that is very good at dealing with vast multidimensional data, finding structures in them and visualizing the data on special map displays. It is better suited in cases when there are sufficient large empirical data sets. Comparing with other computer based analytical methods, fuzzy methods excel in the ability for dealing with uncertainty, imprecision, qualitative information, meaning and knowledge representation for language processing. Neural networks then offer us powerful means to handle large amount of data units and to handle complexity. SOM models, with self learning and self organization capability, can improve its result according to changes in the environment, offer solutions in situations when explicit mathematical models are difficult to be determined.

Finally, to prioritize the identified crises, multi criteria ranking facility can be used (based on e.g. likelihood of damage, criticality of the asset, severity of the threat, and so on).

4 CONCLUSIONS

It is perhaps true that the most effective way of being well-prepared for crises is to “foster a corporate culture that people feel free to express their opinions” (Mitroff et al, 1996). This however does not imply that the establishment of a formalized early warning system is less important. The importance of early warning system cannot be overstated. Too often people realize that even stronger warnings of impending crisis go unheeded in many organizations. In reality, some crises are inevitable no matter how well prepared an organization is. This, however, does not imply any insignificance of early warning and prevention of crisis either. It only indicates that “complete

prevention" of crisis is not the goal. An early warning system can also help a business in the process of recovering from crisis as fast as possible and to learn from past crises.

An effective early warning system can be expensive and time-consuming to establish. This does not mean that businesses should abandon the idea of early warning simply because of that. In the practice of business management, there is a pressing need for good information management instruments that can constantly acquire, monitor and analyze the early warning signals of business crises and economic crises, thus effectively support decision makers in the early detection of crisis situations. The key questions are what kind of early warning system a company should have, to watch out for what signals, for which crises? With the development of advanced computing methods and information technology, there bring new opportunities for the construction of such instruments. In this paper, we proposed the use of business life cycle model as a larger framework of guidance for an early warning system of business crises. We also developed a framework for an intelligent agent based early warning system, and discussed the application of soft computing methods in the intelligent analysis of early warning information. This will provide a starting point for the development of intelligent agent based early warning solutions.

As Mitroff et al (1996) pointed out, crisis management both as a research field as well as a corporate function in general is still new and is neither completely understood nor systematically explored. In the process of building crisis early warning systems, there is also the opportunity for us use the tool to get a better understanding of the early warning task and process, as well as other crisis management issues in an organization.

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