Towards a Business Continuity Information Network for Rapid Disaster Recovery

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ABSTRACT

Crisis Management and Disaster Recovery have gained immense importance in the wake of recent man and nature inflicted calamities such as the terrorist attacks of September 11th 2001 and hurricanes/earthquakes i.e. Katrina (2005), Wilma (2005) and Indian Ocean Tsunami (2004). Most of the recent work has been conducted for crisis management under terrorist attacks and emergency management services under natural disasters with private business continuity and disaster recovery a secondary concern. In this paper, we propose a model for pre-disaster preparation and post-disaster business continuity/rapid recovery. The model is utilized to design and develop a web based prototype of our Business Continuity Information Network (BCIN) system facilitating collaboration among local, state, federal agencies and the business community for rapid disaster recovery. We present our model and prototype with Hurricane Wilma as the case study.

Categories and Subject Descriptors

H.3.4 [**Information Storage and Retrieval**]: Systems and Software – *Current Awareness Systems (Selective dissemination of Information SDI), Distributed Systems, Information Networks, User Profiles and Alert Services.* H.4.2 [**Information Systems Applications**]: Types of Systems – *Decision Support Structures.*

Keywords

Crisis Management, Disaster Recovery Support, Business Continuity Systems

1. INTRODUCTION

Natural calamities such as hurricanes and earthquakes along with terrorist attacks and activities are chaotic events that pose immense threat to businesses, human lives and properties and can inflict huge economic damages. Recent examples of such events include terrorist attacks of September 11th 2001, Madrid Train bombings (2004), Indian Ocean Tsunami (2004), London public transport system bombings (July 2005), Hurricane Katrina (2005), Hurricane Rita (2005), Hurricane Wilma (2005) and the South Asian Earthquake (2005). The potential reoccurrence of such events indicates a need for crisis management and disaster recovery tools and resources that can assist the local, state, federal emergency management officials along with the business community in ensuring rapid recovery thus, minimizing losses while employing the best available precautionary plans and measures to prepare against an impending threat.

Hurricanes pose a constant threat to the South Eastern and Gulf regions of USA specifically the state of Florida. In 2005, Hurricane Wilma alone caused widespread damages along with financial and economical losses to the state of Florida. Lack of preparation before the storm and post-storm delayed business continuity and recovery process were among the major reasons for these financial and economical losses. Inefficient and delayed business continuity and recovery processes affect the small and medium sized businesses the most, since they do not have the resources to easily resume their operations. These small and medium sized businesses make a significant contribution to the local and state economy and their failure would impart economic and job losses to disaster struck communities. Studies have shown that 80% of the companies that do not recover from a disaster within a month are extremely likely to go out of business [1] while companies that do not recover within 10 days of a disaster are not likely to survive [2]. Moreover, most of these small and medium sized businesses lack effective business continuity plans which can lead to a total failure within 3 years of a disaster for 75% of such businesses [3]. Apart form these small and medium sized businesses, large businesses and corporate enterprises are also affected by such natural disasters. Delayed recovery can also result in disruption of operations and business for these large businesses thus, inflicting financial damages and causing temporary or permanent workplace shut downs. Such shutdowns can also effect the overall economy as workers might not get paid or lose their jobs eventually resulting in a loss of revenue for the local, state and federal government.

Current crisis management and disaster recovery systems/methodologies are aimed at collaborating among the local, state and federal agencies for preparation and recovery process. These systems and methodologies have failed to include private businesses in the preparation and recovery processes. Access to time critical information about an impending hazard or under post disaster conditions for business community is extremely limited and is made available to them after considerable delay which inhibits effective and efficient preparation along with planning and execution of precautionary and disaster recovery measures. Collaboration among the emergency management officials and the private business owners can assist in rapid recovery after a disaster and help mitigate the financial and economical losses associated with such disasters. Hence, there is an imperative need for a comprehensive business oriented disaster recovery information network that can facilitate collaboration among emergency management officials and private businesses, thus ensuring availability of and access to time critical information. Thus, we propose a model for pre-disaster preparation and post-disaster business continuity/rapid recovery. The model involves elements from Emergency Operations Centers in the South Florida Region along with the business community to provide a collaboration and communication channel facilitating disaster

preparation and recovery plan execution, critical communications, local and regional damage assessment, dynamic contact management, situation awareness, intelligent decision support and identification/utilization of disaster recovery resources. The model is a good fit for the digital government paradigm as it enables collaboration and communication among major role players for effective disaster preparedness, and recovery efforts. We utilized our model approach to design and implement a web based prototype implementation of our Business Continuity Information Network (BCIN) for rapid disaster recovery system, employing hurricane Wilma as the case study. BCIN illustrates the pre/post disaster information exchange among the participants and helps in analyzing the effectiveness of such collaboration. The goal of BCIN project is to utilize the latest advances in database integration, data mining, Web, and GIS software technologies to create a user friendly, Internet-based, information-rich service that provides businesses with effective and timely disaster recovery information; facilitates collaboration and information exchange with other businesses and government agencies supplementing digital governance via information dissemination and rapid response; enables intelligent decision support; and acts as a vital part of a company's business continuity process, thus potentially reducing closure time. Our analysis shows that, if this network helped 5% of the companies in South Florida area to speed up their hurricane recovery by 1 week, it would prevent $219,300,000 of non-property economic losses which would result from that week's closure.

The rest of the paper is organized as follows. Section 2 presents related work, section 3 illustrates our model architecture. Finally, Section 4 gives an overview of the prototype for the BCIN system for the case study (Hurricane Wilma) along with the necessary research issues that need to be addressed during system design and implementation.

2. RELATED WORK

In recent years, numerous research efforts have been conducted in the crisis management and disaster recovery support paradigm. However, most of these have focused on time critical information sharing among emergency management officials and emergency service providers such as hospitals and ambulatory medical response (AMR) units. Others have focused on information sharing and collaboration among government agencies. Although, all such works support the digital government paradigm allowing for better disaster preparedness and recovery plans, however till this date, we lack an effective and comprehensible system that not only supports collaboration amongst the government agencies but also enables communication channels for time critical information exchange among private businesses, Non Governmental Organizations (NGOs) and government agencies allowing for rapid disaster recovery for both government agencies and business community related operations. Additionally, most of the currently available systems rely on legacy technologies such as telephone systems, two-way radios and tele-text technology via Television etc. Such systems do allow for the ingest and dissemination of disaster related information but lack the necessary support and level of control for identifying and disseminating user specific data which can play an important role in timely execution of disaster preparedness and recovery plans.

Siegrist indicates that currently there are numerous systems that facilitate crisis management for terror attacks or natural calamities. Most of these systems are funded by the U.S. Department of Defense (DoD) and support communication and information exchange among government authorized agencies [4]. The US Defense Threat Reduction Agency (DTRA) has one such system which utilizes data from sensor sites across different locations along with other information tools such as message boards/email to warn government agencies about any potential bio-terror threat [4]. Although these sensors do have the capability to report data in real time, however, the effectiveness of such a system is quite limited since it can only be effective under pre-disaster conditions and the lack of post-disaster collaboration among private businesses and government agencies limits its applicability and usefulness for rapid recovery.

Another research effort presents a time critical information services framework implemented for the Emergency Management Services in San Mateo County, CA [5, 6]. The framework involves collaboration among public/private entities such as the 9-1-1 system, Police Department, Fire Department and Hospitals. The authors indicate that the implementation of such a framework assisted in improving the overall response time and performance across different organizations [5]. The framework utilizes multiple modes of information exchange and communication such as two way radios, telephones and interfaces for patient data sharing. The patient data is shared only to a limited extent due to HIPPA regulations. Such a system is rendered ineffective for information sharing and exchange among private businesses and government agencies under disaster conditions as it relies too much on human assistance and input through the 9-1-1 system and does not provide methodologies and techniques for effective collaboration and information exchange among businesses for rapid recovery. Additionally, it lacks GIS enabled technology that can facilitate business and user specific information identification and data retrieval.

Palen and Liu indicate that persistent citizen communications under pre/post-disaster conditions assist in sharing information amongst the affected population and helps in effective preparation and disaster recovery [7]. Such communications include web based wikis, web logs and SMS text messaging. The utilization of such communication methodologies and their effectiveness in information dissemination further strengthened the need for a web based system for information sharing and dissemination amongst private businesses as well as government agencies. The inclusion of government agencies in such interactions would thus minimize the spread of rumor and misinformation.

Agarwal et. Al., stress upon the impact of GIS data and maps for crisis management and disaster recovery [8]. The system presented in their research work utilized disaster related information from Emergency Operations Centers at local, state and federal level assisting first responders such as emergency management officials and disaster recovery managers/workers to take necessary precautionary measures or disaster recovery actions. However, the above systems lacked collaboration amongst businesses and emergency management officials necessary for effective and efficient disaster preparation and recovery efforts. SAHANA presents a system for collaboration among emergency relief camps across South Asia in the wake of South Asian Earthquake of 2005 [9]. Although, SAHANA does

provide GIS maps and supports collaboration for locating missing persons, however, it still lacks a model for effective collaboration among private businesses and government agencies for disaster preparedness and recovery.

The model presented in this paper attempts to address all the weaknesses of the aforementioned research efforts and utilizes upon their strengths facilitating the design and development of a Business Continuity Information Network for rapid disaster recovery.

3. MODEL FOR BUSINESS CONTINUITY AND RAPID DISASTER RECOVERY

Considering the shortcomings of currently available systems, methodologies and approaches for crisis management and disaster recovery, we propose our model for effective collaboration among private business entities and government agencies for business continuity and rapid disaster recovery. The model was designed by improving upon the ideas presented in [7] for implementing new technology-based information pathways for knowledge and information exchange. Since, BCIN aims at addressing the business community and Emergency Operations Center needs rather than an individual in distress, hence we collaborated with the business community along with the Emergency Operations Centers in the South Florida region to identify the necessary information that can assist the business managers and emergency management officials in business continuity and rapid disaster recovery. We analyzed the necessary information requirements for the business and emergency management community which included businesses (IBM, The Quantum Group, Office Depot, Wal-Mart and Beckman Coulter), local commerce centers (Greater Miami-Dade Chamber of Commerce), Emergency Operations Center (Miami-Dade County, Palm Beach County, Broward County and Monroe County), Utility providers (FP&L), Patient Care Providers (VITAS) and South Florida Banking Consortium (FloridaFirst). Based on our collaboration, we revised the idea of information pathways as presented in [7], for general public assistance to fit our needs. Our revised methodology focuses on web based technological information pathways for the following types of communication

1) Communications within the Business Community affected by a crisis/disaster
2) Communications between Business Community affected by the crisis/disaster and the Business Community outside the disaster area.
3) Communications between the Business Community and local Emergency Operations Center affected by the crisis/disaster
4) Communications between the Emergency Operations Centers, Non-Governmental Organizations and media outlets affected by the crisis/disaster
5) Communications between the Emergency Operations Centers affected by the crisis/disaster and the Government Agencies both within and outside the crisis/disaster area

The model is designed to assist the aforementioned communications and supports intra-company collaboration, inter-company collaboration, collaboration between the business community and the government agencies such as County Emergency Operations Centers and the communication between the Emergency Operations Centers and government agencies both within and outside the crisis/disaster area. Figure 1 shows our model for the Business Continuity Information Network for rapid disaster recovery.

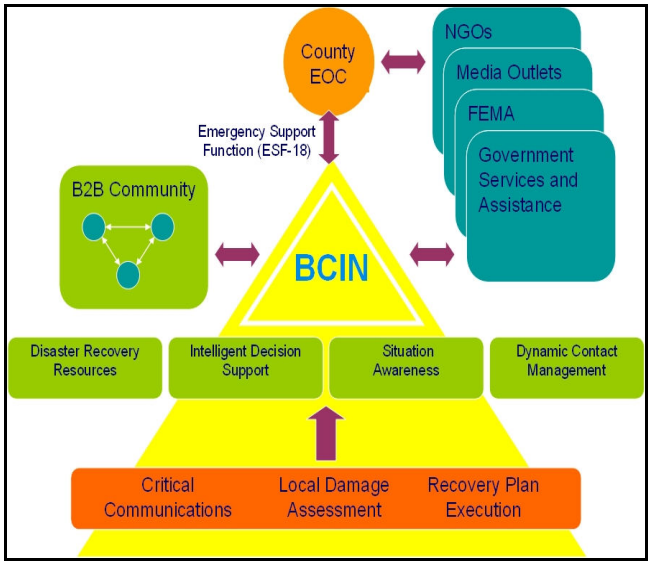

Figure 1. Business Continuity Information Network for rapid disaster recovery Model

The model (see Figure 1) identifies the key information elements that assist business continuity and rapid disaster recovery. These elements are:

1) Critical Communications: Communications within and between Business Community and Emergency Operations Centers within and outside crisis/disaster area.
2) Local Damage Assessment: Damage assessment conducted by businesses and emergency management officials.
3) Recovery Plan Execution: Identification and execution of recovery plans

These key elements are then utilized to identify primary components of an effective continuity and rapid disaster recovery information network. The following components are deemed necessary as per our model, for a practicable business continuity information network.

1) Disaster Management Dataspace: To acquire, ingest and organize data available in various formats from different sources
2) Disaster Recovery Resources Identification: To ensure that essential resources can be identified and utilized for preparation and recovery
3) Situation Awareness: To effectively update business managers and emergency management officials with information about the overall and location specific crisis/disaster conditions and threat levels
4) Dynamic Contact Management: To facilitate communication within and among businesses and

emergency management officials for effective pre-disaster preparation and rapid post-storm recovery

5) Intelligent Decision Support: To assist business managers and emergency management officials in devising and executing effective preparation and recovery decisions based on the overall conditions and information available from previous profiled data for their specified items/locations of interest

As evident from the above discussion, inter-company, intra-company communications along with the communications between emergency management officials, business owners and non-governmental organizations is an integral element for disaster preparation and recovery process. The communication aspect of our BCIN model not only has to ensure an effective, easy to use, user specific, near real-time communication between the collaborators but also has to provide technological tools and methodologies that can leverage the current tools, methodologies and problem solving approaches utilized by the stakeholders for data acquisition, disaster preparation assistance, and recovery process. Such an approach will allow for faster acclimatization and acceptance without over burdening the users with a plethora of complex technological interfaces. Section 4, discusses the issues encountered during the implementation and enablement of such a communication framework along with its primary components i.e. Disaster Management Dataspace, Disaster Recovery Resources Identification, Intelligent Decision Support, Situation Awareness and Dynamic Contact Management.

4. BCIN OVERVIEW

In order to provide near real time support for the aforementioned elements and components (Section 3), thus enabling communication and collaboration both within and between business and emergency management community for local damage assessment and recovery plan executions along with the pre-disaster preparation and planning, the model needed to be realized into an easily accessible, highly scalable and robust system. A web based information system that takes into account the collaboration and communication among all these stakeholders seems to be the most appropriate choice since it not only can allow for the necessary control and support for users to identify key items/locations of interest but also allows them to report on the status of their business and near by surroundings in near real time. Other forms of implementations for such a model such as voice based telephone responder systems and tele-text over televisions lack the necessary detail and the level of control needed for effective pre-disaster preparation, business continuity and post-disaster recovery.

Tele-text over television fails in addressing these concerns since the information follows a sequential order and missing some piece of information would require the stakeholders to wait until the information is displayed again. Such delays can prove to be crucial under crisis situations as even minor delays can spell chaos/disaster for the government, businesses and general public. Voice based telephone responder systems would require phones to be manned by human beings in addition to some basic information technology infrastructure which can assist in storage and retrieval of disaster related data. Even with manned telephone responder systems, the number of incoming calls could easily exceed the number of available responders, thus delaying the communication, collaboration, and information exchange while further jeopardizing the overall disaster preparation and recovery process. Moreover, in order to ensure that users can relate to and better identify the effect of an impending or recent threat, the components and elements of our model discussed in Section 3, need to be embedded together with some geo-spatial data allowing for the use of maps for the purpose of quick analysis and identification of worst hit areas and their surroundings. Hence, the prototype for BCIN model involved the utilization of Asynchronous JavaScript and XML (AJAX) [10] and J2EE (predominantly Java Server Pages (JSP) and Servlets) based technologies for the implementation of an easily accessible, highly interactive web based interface. We utilized Google Maps [11] for embedding geo-spatial data along with other relevant information assisting in intelligent decision support and situation awareness. A PostGre SQL database was used as the knowledge base including data storage and retrieval. The interface provides web 2.0 based elements such as collapsible frames and maps while allowing the user to customize the interface elements (position, size) and the corresponding data based on their specific needs and requirements. The aforementioned technologies assist in the design and implementation of the primary components of the BCIN model (section 3), discussed below in detail.

4.1 Disaster Management Dataspace

Disaster management requires methodologies for data aggregation of disaster related data available from different sources. Our collaborations with business and emergency management community have enabled us in identifying the different kinds and formats of data available from these communities. The appropriate storage and retrieval methodologies for such data are critical for an effective and efficient disaster preparation and recovery process.

The data from Emergency Operations Center (EOC) includes pre/post storm information via Incident Action Plans and Situation Reports (available in .doc and .pdf formats), post storm damage analysis reports and images, open/closure status about roadways/highways/bridges/airports/seaports and other infrastructure such as fuel, power, transportation, emergency services (Police stations, Fire stations etc.), schools and hospitals (available in .doc and .xls spreadsheet formats). Moreover, information from businesses and non-governmental organizations is available through .xls spreadsheets i.e. information about bank branches with teller and ATM services status, information about grocery stores openings/closings, and information about the gas stations openings/closings etc. The availability of data in different formats poses a challenge for the design and development of effective strategies for data acquisition, ingest and organization. Hence, we developed methodologies for data acquisition, ingest, organization, and representation of such data which essentially establishes the disaster management dataspace. Our methodology is represented in Figure 2. As illustrated in Figure 2, the data acquisition phase is composed of three components

1) Dynamic data acquisition from EOC
2) Spreadsheet based report upload from businesses/NGOs
3) Disaster related Event update

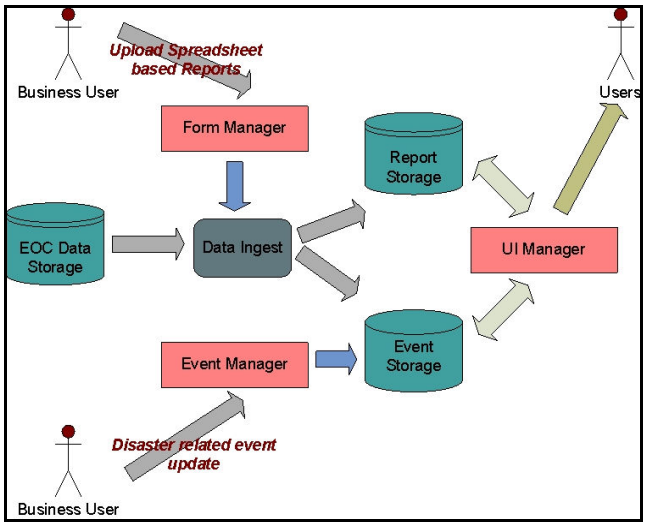

Figure 2. Data Acquisition, Ingest and Organization Architecture

Dynamic data acquisition from EOC for BCIN prototype involved setup of directories at BCIN servers similar to that of EOC along with periodic data pull operations for maintaining data across these two locations in sync. For the current prototype, we are utilizing the local BCIN server copy of the EOC data for Hurricane Wilma, however we have devised a dynamic pull policy for future incorporation of EOC data as discussed in Figure 3. Moreover, BCIN provides Business/NGO users with a flexible interface allowing them for uploading disaster related information as spreadsheets (common among business recovery managers) along with updating certain disaster related information such as planned meetings, status reports, and recovery goods/services availability. Upon receipt of such data, our data ingest mechanism then processes this data and stores them in a central repository. The data ingest phase also processes data from different types of EOC reports and stores in a database table the information related to open/closure status about roadways, highways, bridges, airports, seaports and other infrastructure such as fuel, power, transportation, emergency services (Police stations, Fire stations etc.), schools and hospitals. Information provided by the business/NGO users such as open/close status, employee return to work and damage status is processed and stored in different database tables thus providing a separation of concerns related to the data update and removal. The spreadsheet data provided by such users is also parsed and stored in related tables while the actual reports are stored on the server with timestamp and user information for information tracking and non-repudiation purposes. The UI manager then utilizes this data based on customizable user profiles for data presentation across the BCIN user interface to the end users which in turn could either be emergency management officials, business owners/recovery managers or NGO officials. Figure 3 and Figure 4, show the algorithms devised for future dynamic extraction of data from EOC and user driven event/ report based data upload and ingest respectively. The disaster management dataspace is then utilized by disaster recovery resources identification, intelligent decision support and situation awareness components of our business continuity information network.

1. Pull data from EOC Data Storage;
2. Save last modification times for each of the directories and their sub directories;
3. Save list of files for each directory;
4. Identify data formats and parse EOC reports accordingly;
5. Categorize parsed data based on semantics and contexts and store in the database;
6. Store actual reports in centralized storage for non-repudiation purposes;
7. **IF** last modification times for any of the directories or sub directories is more recent than its previous last modification time **OR** list of files for any directory has changed (File additions)
   THEN
   - 7.1. Pull data from that file/directory;
   - 7.2. Update last modification times;
   - 7.3. Update list of files;
   - 7.4. Identify data format;
   - 7.5. Parse and categorize data based on semantics and contexts and store in DB;
   - 7.6. Store new reports in storage for non-repudiation purposes;

   END IF
8. **REPEAT** step 7 after each system invocation due to add/updates to the directories/files

Figure 3. Algorithm for Dynamic Data Extraction from EOC along with User driven Event and Report based data upload/ingest

1. **IF** user uploads a spreadsheet based report via web interface
   THEN
   - 1.1. Parse, categorize and store business status/infrastructure information in the database;
   - 1.2. Store reports in centralized repository;

   END IF
2. **IF** user adds/updates an event via web interface
   THEN
   - 2.1. Store event in the database;

   END IF

Figure 4. Algorithm for User driven Event and Report based data upload/ingest

4.2 Disaster Recovery Resources Identification

An integral component of any disaster recovery related digital governance enabling system is to assist in identification of disaster preparation and recovery resources locally, ensuring that local available resources are fully utilized, thereby providing a much needed kick-start to the economy after a disaster.

Our BCIN prototype system addresses the disaster recovery resource identification problem by utilizing the user profile information added to the system. BCIN allows users to identify/track the disaster preparation and recovery related items they are mostly interested in. Based on their choices, the system then presents them with the list of these items and identifies the locations of their availability via Google Maps API based maps that can assist in preparation and recovery efforts. These items might include tarps, shutters, generators, bottled water, ice and fuel etc. The disaster recovery resources identification component performs a search on the disaster management dataspace and discovers the information related to the items included in the users profile. We also have devised algorithms for identifying the most requested and recently posted items along with a search by zip

code, city and county wide granularity based functionality for resources, that can further assist the emergency management officials and businesses outside the disaster affected areas in identifying the needs of disaster affected area. The identified resources are sorted by their proximity to the location of the user defined primary asset extracted form the user's profile. The closer the item the higher is the ranking across the sorted list. Hence, the user is dynamically presented with all related items based on their distance from the user's primary location, thus assisting in minimizing the logistics related delays and enabling faster preparation and recovery. Figure 5, shows the algorithm for location specific resource identification. Our disaster recovery resources identification methodology thus establishes a virtual marketplace where businesses and emergency management officials can collaborate to expedite the pre-disaster preparation and post-disaster recovery process.

Figure 6, shows a snap shot of the disaster recovery and preparation resources marketplace as implemented in the BCIN prototype. In Figure 6, the left hand panel provides the item search functionality along with the items requested by the user as well as other managers belonging to the same business organization. The reason for presenting a user with all the items requested by his organization is to facilitate the understanding of business managers in identifying the key resources that have been requested at different business locations across the disaster affected area. The right hand panel in Figure 6 shows a map and a descriptive report about an item. The small elliptical icons on the map indicate the availability of the resources requested by the current user and his/her counterpart disaster preparation and recovery managers across the disaster affected area. Business managers and emergency management officials can also narrow down or widen the search criteria to determine the availability of items of interest in their localities, neighborhoods and surrounding areas. Moreover, we also implemented a "browse by category" feature that can assist in identification of the items/resources available and/or requested by categories.

1. Identify geo-coordinates for user's primary location entered in the profile;
2. Identify user's disaster recovery related resources of interest;
3. Search the database and find relevant resources;
4. Identify geo-coordinates for the list of locations where the relevant resources are held;
5. **FOR** each location in the list of relevant resources
   5.1. Calculate distance from the user's primary location;
   END FOR
6. Sort the list of relevant resources in ascending order depending on the distance from the user's primary location;
7. Return the sorted list in response to a system query;
8. **FOR** each newly inserted resource with a new location
   8.1. Identify geo-coordinates for the new location;
   8.2. **IF** the newly inserted resource is among the list of user's items of interest
   THEN
      8.2.1. Calculate distance of new location from user's primary address;
      8.2.2. Use binary search to insert the location coordinates in the list of relevant resources;
   END IF
   8.3. Store resource information along with address in the database;
   END FOR

Figure 5. Algorithm for Resource identification by location

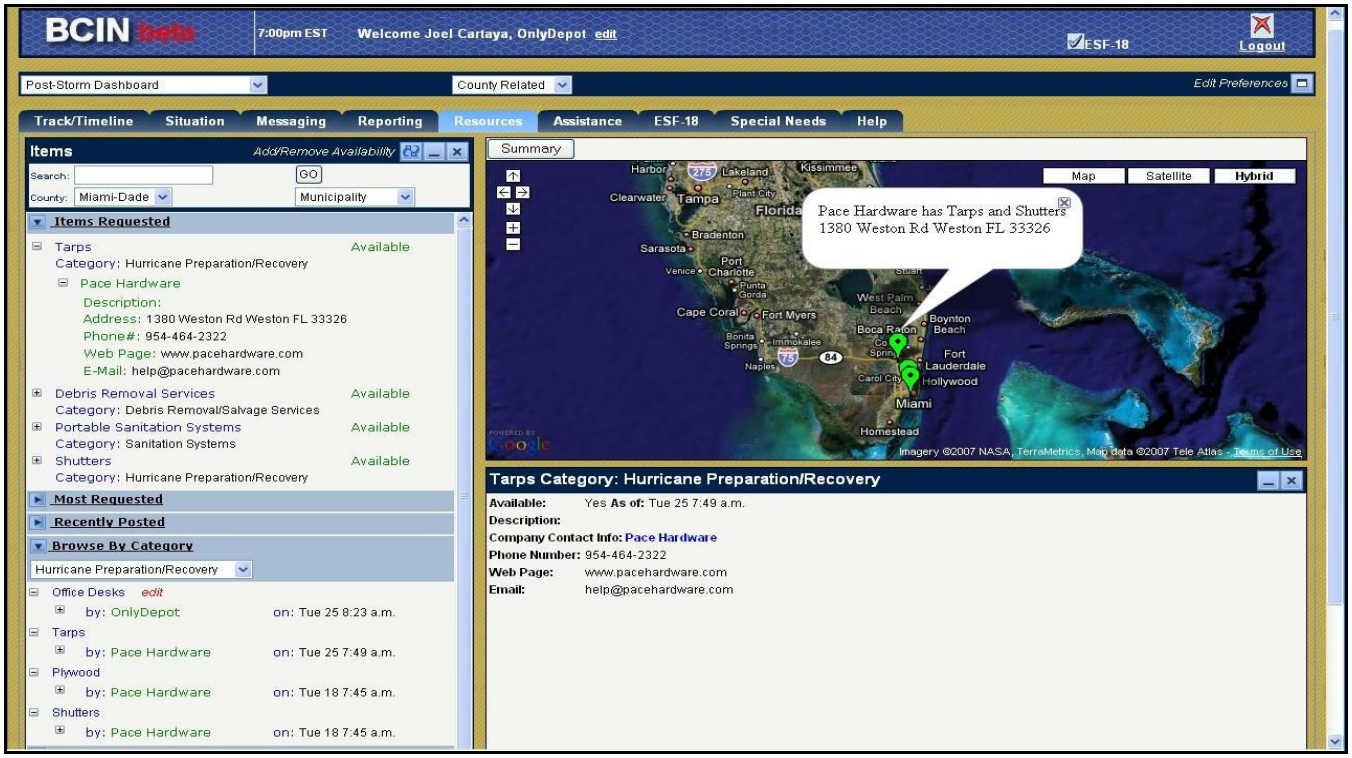

Figure 6. BCIN Disaster Recovery Resources Identification Interface

4.3 Situation Awareness

One of the major issues in implementing disaster preparation and recovery efforts is to keep the users abreast of the ongoing location specific and overall crisis/disaster situation. The needs of a community can vary drastically under pre and post disaster situations. Our model was devised keeping the above in mind and the disaster management dataspace is setup to cater for these varying needs.

The BCIN prototype thus facilitates situation awareness by utilizing collapsible and editable dashboards or frames based approach where information elements to be displayed on each of these dashboard or frames can be defined and customized according to the user needs. As mentioned earlier we provide different dashboards and frames for both pre and post disaster situation along with map based elements for location specific and overall disaster/crisis related data analysis. Since our current prototype works with Hurricane Wilma data hence, we provide pre and post storm information related to important infrastructure and items of interest via the aforementioned dashboard and frames. Figure 7, shows a snap shot of the pre storm interface, while Figure 8 shows a snap shot for the post storm interface.

As indicated in Figure 7, the dash board keeps track of any impending storm along with the relevant storm data such as tropical storm wind speed arrival time and location, hurricane wind speed arrival time and location, and hurricane intensity/wind speed at arrival. The data is archived and can be reviewed through the interface. The pre-storm dashboard also keeps track of the key infrastructure and services important for disaster preparation and planning. These include open/closure status regards schools, emergency services, public transportation, evacuation shelters, seaports, bridges, hospitals and power.

Figure 8, shows the dashboard for the post storm case where the recovery effort status is emphasized upon. The post storm dash board includes informational elements from the pre-storm dashboard deemed necessary for recovery efforts along with additional infrastructure/services status data such as fuel availability, points of distribution sites and curfews. We provide numerous post storm dashboards presenting aggregated or customized information as requested by the user. Additionally, the left hand panel in Figure 7 and 8, keeps track of storm track along with NHC advisory reports (only for pre-storm case) and a categorized chronological list of events/reports added to the disaster management dataspace, thus allowing users to effectively monitor the ongoing preparation and recovery progress. Any infrastructure/asset that has a physical address and for which information has been uploaded to the disaster management dataspace is also linked to the map panel in Figures 7 and 8 to better assist the stakeholders in the decision making progress. We have also utilized algorithms similar to the location specific recovery resource identification (section 4.2), to provide users with preparation, damage, and recovery related information regarding services and infrastructure in close proximity to the user defined assets/locations. The map panels in Figure 7, 8 and 9 show snapshots of such an interface where the users are attempting to identify open gas stations within Miami-dade county, overall damage status after the storm as damage reports become available and status of gas stations within a 3 mile radius of a user defined asset along with the user defined business recovery status dashboard respectively.

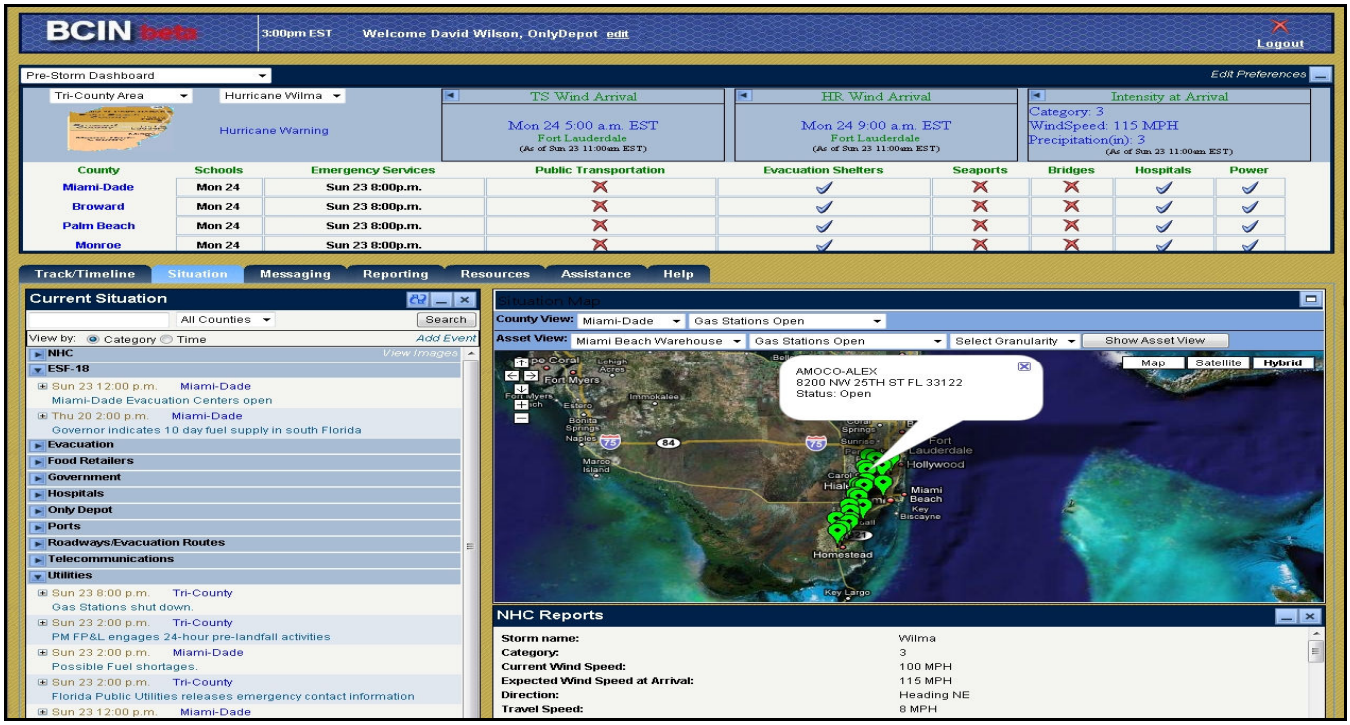

Figure 7. BCIN Pre-Disaster Situation Awareness. Red "X" indicates closure. Check marks indicate open. Time indicates the expected closure of the infrastructure/service

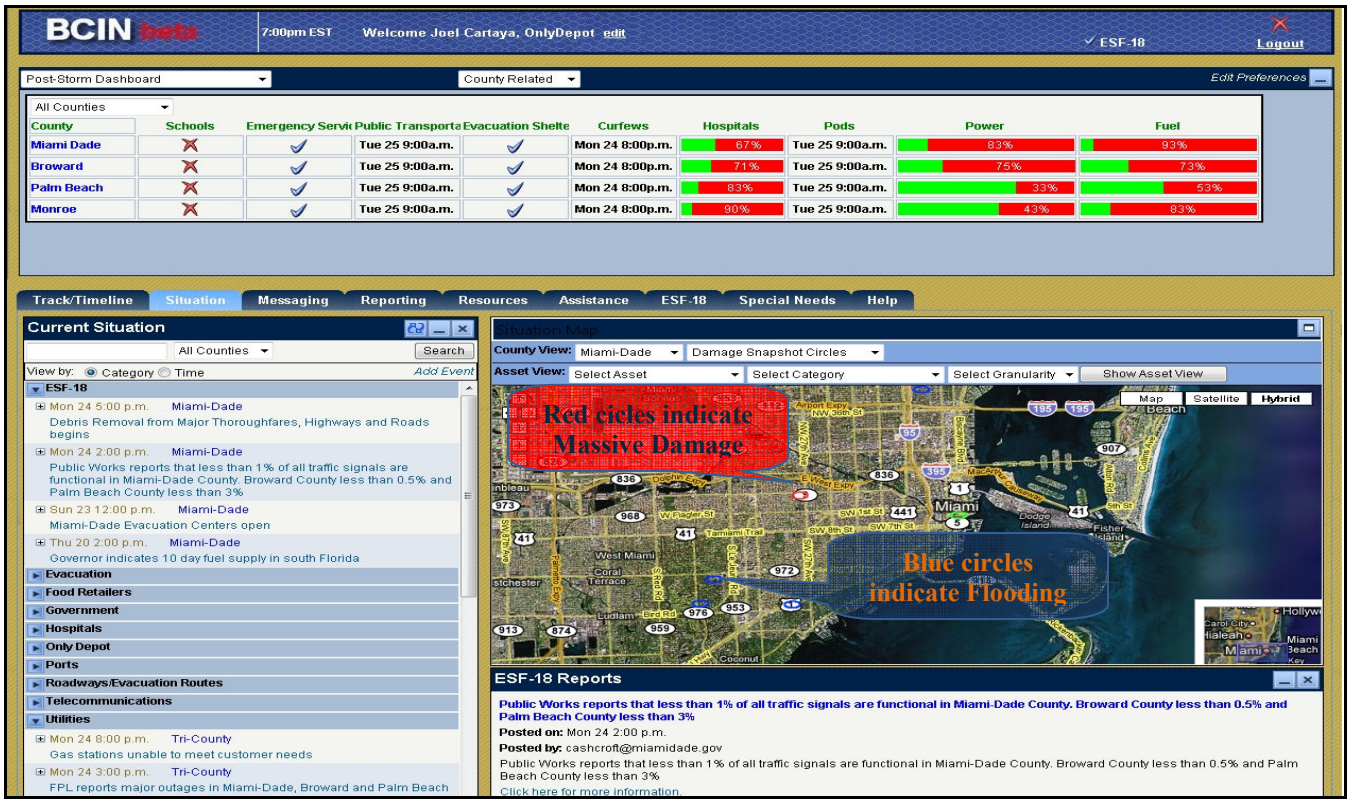

Figure 8. BCIN Post-Disaster Situation Awareness. Red "X" indicates closure. Check marks indicate open. Percentages indicate the overall availability or open/closure status of services/resources/infrastructure.

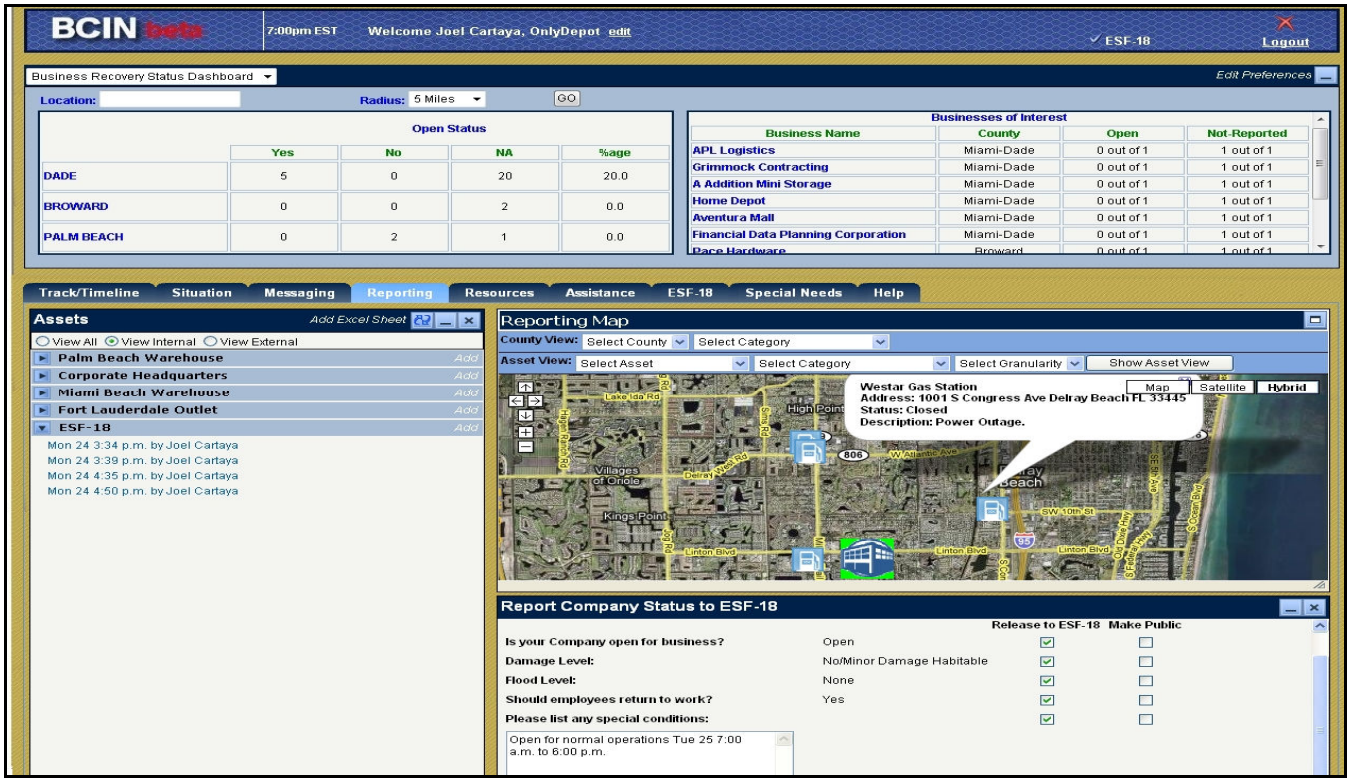

Figure 9. BCIN Post-Disaster Situation Awareness with Business recovery dashboard. Gas station icons indicate gas stations within a 3 mile radius of user defined assets. Information about gas stations can be viewed through the information window

4.4 Dynamic Contact Management

Digital governance and other related tools such as disaster preparation and recovery systems can only be successful in achieving their desired goal if an effective collaboration and communication channel exists between the stakeholders. The collaboration and communication channel should support dynamic contact management allowing for users to identify/add new contacts and communicate or share information with the already established contacts facilitating better and informed plans and decisions. Moreover, like any other system the communication channel should have the capability to address information privacy concerns. The users should have the ability to identify the contacts and organization with whom they would like to share the information. Such data control is essential in ensuring participation from business and emergency management community.

Our model has been designed keeping in mind the concerns and issued related with dynamic contact management. We thus, implemented our prototype to support all of the aforementioned contact management and information sharing elements. Our disaster preparation and recovery system provides a simple email /social networking based communication facility where users can send/receive messages, search for contacts and add them to their contact lists. We also provide the users with an ability to accept or deny a request for contact establishment. This further ensures privacy. We have further devised a methodology that allows the system to keep track of any updates to the public contact information of a user's contact. Again, the users have the ability to identify the information they want to be made visible and our system dynamically keeps track and notifies of any updates to each user's contact information. Figure 10, shows an interface for our dynamic contact management approach.

BCIN further grants control to the users over the information related to preparatory or damage status of their organizational assets. The users share this information among all the other users from the same organization but can control the elements that they would like to report to the Emergency Operation Center and other businesses. There may be concern with the provision of such ability as it can hinder the sharing of information among and between businesses and emergency management centers. However, we stress upon the fact that we are simply an aggregator of data and the users must decide what information they would like to share with the community. We provide them with all different venues for the sharing of such information. Moreover, based on our collaboration with the business and emergency management community, we have found that businesses have full confidence in our approach and have indicated their willingness to share the necessary information such as open/closure, employee return to work, key preparation/recovery resources and damage status. Bottom right hand panel in Figure 9, shows a snapshot of our information privacy interface where the users can decide what information to share with the BCIN community and Emergency Support Function-18 (EOC responder for hurricane and other disaster situation).

4.5 Intelligent Decision Support

A disaster preparation and recovery assistance system such as BCIN can be extremely effective if it can support intelligent decision making and suggest possible preparation and recovery plans based on the latest damage status and historic disaster profiles. Such support requires a knowledge base that holds damage status information for assets/infrastructure and can utilize this aggregated information along with the latest damage status of these assets/infrastructures to advise possible recovery plans and strategies for speedy recovery. Additionally, the historic damage data along with the storm track and intensity information can also

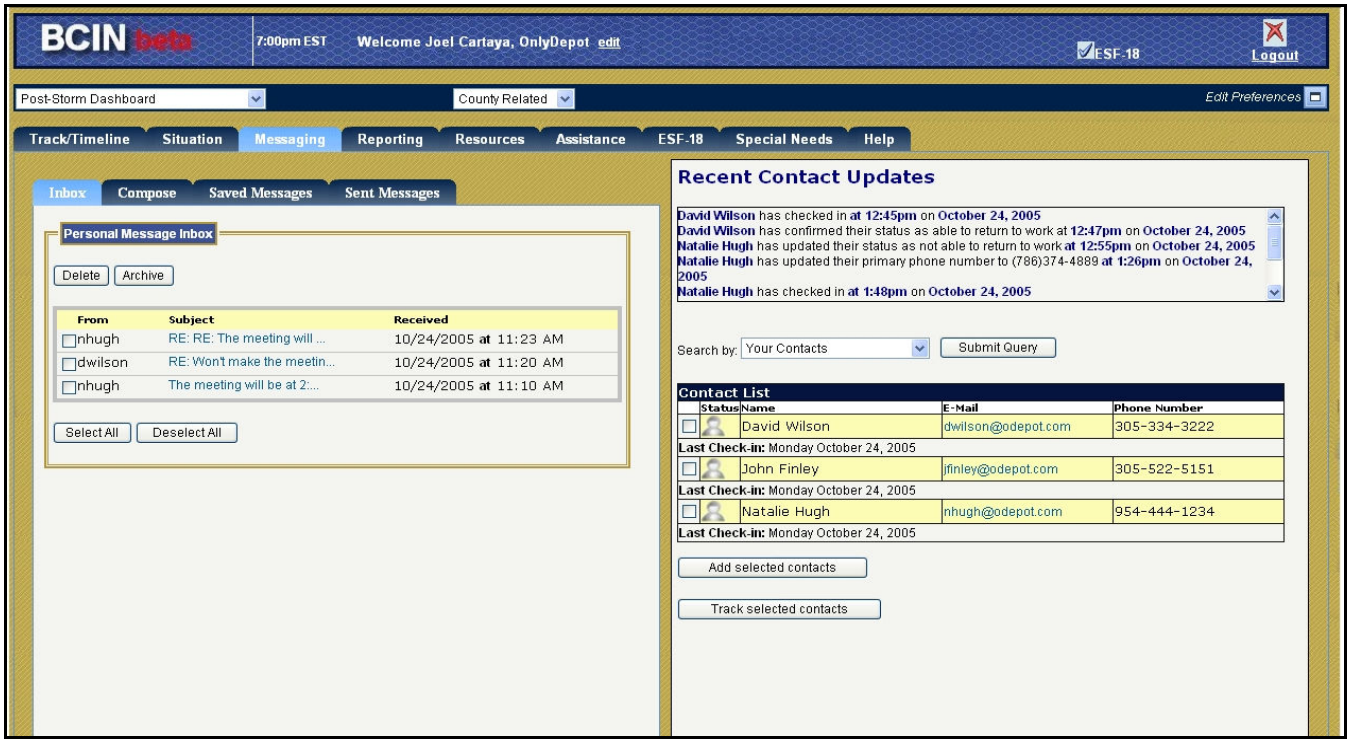

Figure 10. BCIN Dynamic Contact Management Interface

be used to recommend better preparation strategies against an impending threat such as a hurricane. Such Intelligent decision support can thus incorporate information from businesses, NGOs and emergency operations centers facilitating digital governance and business to business collaboration for better, improvised and effective preparation and recovery plans.

Our current prototype system lacks the necessary knowledge base for supporting such an intelligent decision support as discussed above however; we consider it as an integral element of our disaster preparation and recovery model. Hence, we have devised a methodology for advising users regarding the necessary loans, insurance refunds and employee assistance plans along with the necessary updates to these programs. The users can then utilize these suggestions to advise employees, other businesses and NGOs etc. about the assistance plans helping them in recovering some portion of the disaster inflicted damages. We also have embedded some level of intelligent decision making regarding preparation and recovery resources by utilizing our local area and location specific resource identification algorithm. We plan to incorporate intelligent decision support for both pre and post disaster situation in our future implementations along with improvement to our existing methodologies.

5. CONCLUSION AND FUTURE WORK

We have presented a model for communication and information sharing among businesses and emergency management community under disaster/crisis situations. The model identifies the key components for rapid disaster preparation, recovery and business continuity while stressing upon the need of better and improved tools and technologies for rapid recover. We then utilize our model for the implementation of a web based Business Continuity Information Network (BCIN) that creates a disaster management dataspace based on the communication among the stakeholders and enables businesses, emergency management community and NGOs to effectively communicate, identify and assist in the execution of preparation and recovery plans; identify user relevant and location specific disaster preparation and recovery resources along with the business/employee loan and assistance programs facilitating intelligent decision support; and dynamically disseminate location and user specific information regarding key inhibitors to preparation and recovery process such as open/closure status of schools, businesses, transportation, roadways and emergency services etc.

We have collaborated with numerous businesses ranging from retail industry to disaster recovery along with the emergency operations centers in the South Florida counties. All the collaborators have shown their interest in the utilization of this tool for rapid business continuity and disaster recovery efforts and have validated the importance of our model. We believe that a web based system such as BCIN provides the necessary control and support for expediting the preparation and recovery efforts.

We plan to extend our BCIN system to improve upon our current functionalities and implement the devised methodologies discussed in the paper to ensure a disaster preparation and recovery framework that can be utilized under different disaster conditions and that has the ability to incorporate and utilize multimedia data elements such as videos, audios along with text based input. We also plan to provide a beta version of our system for the 2008 hurricane season to better assess the capabilities and to improve upon any possible weaknesses of the system.

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