20th International Congress on Modelling and Simulation, Adelaide, Australia, 1–6 December 2013
www.mssanz.org.au/modsim2013

Information Integration for Emergency Management: recent CSIRO case studies

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Abstract:

The CSIRO ICT Centre's Information Engineering Laboratory has been involved in a number of emergency management related projects over the last four years. In these projects we have applied our software engineering expertise in the areas of web technologies, user interfaces and databases along with research capability in machine learning, distributed systems, text processing and data stream management. This process has increased our understanding of the various roles and responsibilities of different government departments at the federal and state level and of the wider emergency services community.

The research agenda of the CSIRO is broad and its application to the area of disaster management is no different. In this field of research, one of the CSIRO's aims is to improve the process and service delivery of disaster management in Australia and to provide high-impact solutions to strengthen the disaster resilience of the nation in the future. As well as the projects reviewed in this paper, there are other research activities underway or completed within the CSIRO that address the issues of disaster management, see Hawkins et al. (2012) for an overview.

The focus of this paper is to present three recent CSIRO projects related to emergency management, highlighting their differences and similarities with a focus on the challenges encountered and a categorisation of the target data items utilised.

The Pilot Impacts Portal, `http://www.fend.org.au/`, is a web accessible user interface to a collection of national data items describing historical fire emergency and natural disaster events and their associated impacts. The project was a collaboration with Fire & Rescue NSW that aimed to better understand the economic, social and environmental impacts on communities due to disaster events.

The Emergency Response Intelligence Capability project, `http://eric.csiro.au/`, is a collaboration with the Australian Government Department of Human Services Emergency Management team who are responsible for intelligence gathering and situation reporting during emergency events. The CSIRO have developed a tool that supports the department's operational tasks by automatically gathering data from a range of sources, presenting the data on a map based website and generating customised situation reports.

The Emergency Situation Awareness system, `https://esa.csiro.au/`, analyses Twitter messages to provide early detection of emergency events. It extracts situation awareness information as the disaster unfolds, effectively crowd sourcing relevant details and providing time critical information that allows emergency services to respond rapidly and appropriately.

A short overview of each project is presented. Each system makes use of different types of information: historical archives, community details, near-real-time authoritative event information and social media content. Combining all of this information will provide emergency management organisations with better quality information for decision making resulting in improved community outcomes. Social media is a new channel of information that can provide further intelligence about emergency events. Authoritative information is being published on Twitter by the emergency services community which can be augmented with non-authoritative crowd sourced social media content to provide a better understanding of emergency events.

Keywords: *Crisis coordination, disaster management, situation awareness, social media*

1 PILOT IMPACTS PORTAL

1.1 Overview

The Pilot Impacts Portal is part of a national initiative to better understand the economic, social and environmental impacts on communities due to fire emergencies and natural disasters. It is a web accessible user interface providing a single point of reference to a collection of national data items describing historical fire emergency and natural disaster (FEND) events and their associated impacts. The aim is to foster an emergency management user community focused on a national resource (the portal).

The portal is based on the Impacts Framework by Stephenson (2010) that defines the process used to determine the economic, social and environmental impacts, loses and benefits resulting from a fire emergency or natural disaster. The portal collates data from various sources to report against the Impacts Framework. The identification and acquisition of these data items were also conducted by the same project team, but managed as a separate project[1]. In total, 25 data items were obtained for use in the Pilot Impacts Portal.

The Pilot Impacts Portal was developed by the CSIRO between July 2011 and June 2012 as part of a Fire & Rescue New South Wales (FRNSW) managed project[1] The portal has been operational since 15 June 2012 and has recently completed a 12 month trial of use by the Australian emergency services community and is awaiting a decision by FRNSW as to its future. As of mid June 2013, 86 users have registered to use the portal from 33 local, state or federal government agencies and emergency services organisations. There have been over 800 visitors to the system however only 144 user logins.

1.2 Features

The portal is available at: `http://www.fend.org.au/` and is referred to as the 'FEND' site. An example of the information available is shown in Figure 1 where historical fire emergency and natural disaster events between the years 2000 and 2005 are displayed with icons showing the events matching the chosen options. Details of a specific fire event from the Australasian Fire and Emergency Service Authorities Council (AFAC) Australian Incident Reporting System (AIRS) database are also shown.

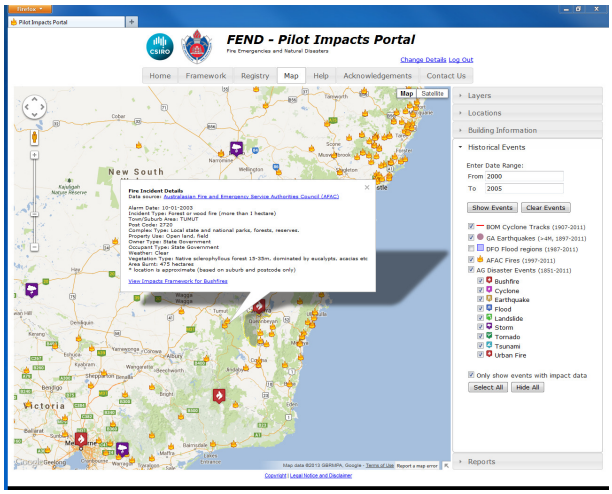


Figure 1. FEND: Displaying Historic Events with Impacts

The website contains a number of user interface features. The contents of the Impacts Framework and the registry listing available data items can be explored. Access to the 'Map View', shown in Figure 1, requires the user to self-register. This requires an email address and users who register with an email address from a *recognised* emergency services agency or a 'gov.au' email domain have access to extra features of report generation and data download.

It is also useful to mention the tasks the portal is not expected to be used for. It does not include modelling or forecasting features; it was not designed to analyse the total impacts of fire emergencies and natural disasters on a community; and it was not designed to be used for monitoring the current situation during a disaster event.

[1]A detailed summary of this activity is described at: `http://www.fire.nsw.gov.au/page.php?id=914`.

All data available in the portal are managed locally: for example, there are no live data feeds or data obtained from web services.

1.3 Highlights

Developing the portal website increased our capability in website design and supporting technologies. For example, Google Fusion Tables[2] allow map layers to be efficiently overlaid on a Google Map. The portal was developed using rigorous software engineering processes. Also, a workshop was held bringing various stakeholders together (potential users, data custodians, the project steering committee and funding agencies) to develop a common vision for the project and the deliverables.

There were some challenges with the project however. From the CSIRO perspective, FRNSW were the client, but were not a user. Although they had a high level understanding of the anticipated features of the system to be developed and the tasks it could be used for, they did not have a detailed understanding of the requirements needed to drive the implementation. Unfortunately, the workshop failed to identify a 'champion' user willing to be closely involved in the development process.

Another issue was the identificaton and acquisition of data items. While data custodians have data, it is not readily available due to cost, licensing constraints, availability or sensitivity of the data. In some instances, existing data was not in an appropriate format and could not be integrated into the portal. For example, the data existed as collections of reports describing specific natural disaster events, post event surveys and risk studies. These reports were usually not managed as a single resource, contained information that is an aggregation of data from other sources and are distributed throughout an organisation. Also, most of the data items identified did not contain the level of detail required by the Impacts Framework Project[1].

2 EMERGENCY RESPONSE INTELLIGENCE CAPABILITY

2.1 Overview

The Emergency Response Intelligence Capability (ERIC) project is a collaboration between the CSIRO and the Australian Government Department of Human Services. The CSIRO have developed a preliminary web based productivity tool that demonstrates the usefulness of data integration for the department's Emergency Management team, who are responsible for intelligence gathering and situation reporting during emergency events. This information is used to help coordinate the department's response to emergencies, with a focus on delivery of services on behalf of the Government for the Australian community. The tool integrates dynamic information from real-time web feeds with background static data to provide a national picture.

Information is obtained from numerous sources. Statistical regions from the Australian Bureau of Statistics, context data including demographics and details of the natural and built environment, departmental regional profile data, dynamic web feeds describing the emergency event as it progresses, the historical record of previous dynamic web feeds, social media, and an archive of previous situation reports. Information for a specific region under investigation can be extracted and collated semi-automatically to generate situation reports. They include information combined from available datasets and extended to include user provided content. A description of the tool can be found in Power et al. (2013).

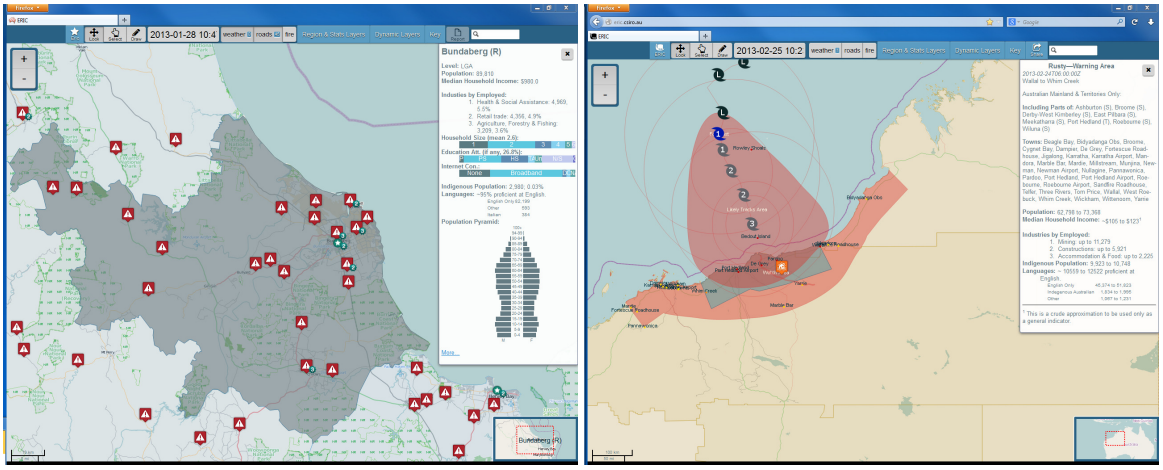
2.2 Features

The ERIC tool automatically gathers information from a range of dynamic data sources, stores it in a database, presents the information online using a map and includes a large collection of static data providing context for the user where access to the context information is easily available using 'popups'. The user is notified when new relevant information is available, they can review details of events that have occurred in the past and customised situation reports can be generated for different types of emergency events at specific locations. The database of recorded events also provides a contingency when the data source is not available.

A public version of the ERIC tool is available at: `http://eric.csiro.au/`. It also demonstrates the benefits of data integration from numerous sources, but excludes data and situation reporting features which are only relevant to the department. ERIC's primary interface is the map, allowing the user to navigate the information spatially. Figure 2(a) shows road closures in Bundaberg on 28 January 2013 due to flooding and demographics information for the region. Figure 2(b) shows the location and expected path of Tropical Cyclone Rusty as recorded on 25 February 2013. The *warning area* has been selected presenting the major

[2] `http://www.google.com/fusiontables/Home/`

towns and details of the region under threat. The user may choose the data sources to explore with events and warnings depicted using icons and overlays.



(a) Web feed events and LGA information

(b) Cyclone Rusty 25 February 2013

Figure 2. ERIC map interface

2.3 Highlights

The ERIC project has been a successful engagement between the department's Emergency Management team and the CSIRO. The intelligence gathering aspects of the ERIC tool have been tested by key users in the team over the disaster season during October 2012 and April 2013. The success to date is a direct result of the close working relationship fostered by the two groups and having access to users who provide useful and regular feedback to the CSIRO team.

The ERIC tool was implemented using an iterative development methodology. The project started by defining the business questions to be addressed and documenting the features to be included. At the same time, two major software 'mock ups' were developed as working prototypes to communicate key features and capabilities. This process provided a clear vision of what the ERIC tool was proposed to be and allowed the CSIRO team to quickly progress the implementation, delivered as an evolving operational prototype.

The challenge going forward will be operationalising the current software. The Emergency Management leadership plan to incorporate the ERIC tool into the standard business processes of the team, using the tool to gather intelligence and generate situation reports. This will require an extensive review and testing of the current implementation and engagement with the department's ICT group to transition the deployment onto internal infrastructure. There has also been interest in using the tool more broadly within the department.

3 EMERGENCY SITUATION AWARENESS

3.1 Overview

The Emergency Situation Awareness (ESA) project[3] is involved in a number of activities investigating the use of social media as a source of information for emergency management. The project started in early 2010 as a collaboration with the Attorney General's Department (AGD) Crisis Coordination Centre (CCC). The focus was on using information from Twitter to gather situation awareness of emergency events for whole of government reporting.

The CSIRO has recently established a community of government innovators with access to prototype social media tools, consisting of ESA and Vizie[4]. This group started in August 2012 and consists of ten participant organisations with the aim of engaging with front line users of the tools to obtain operational feedback, used to develop new features. For example, Geoscience Australia use ESA to monitor earthquake events within Australia and New Zealand. Other ESA examples include reviewing public response to government announcements and monitoring during floods.

[3] https://esa.csiro.au/

[4] http://www.csiro.au/Outcomes/ICT-and-Services/Social-media-monitoring.aspx

3.2 Features

The ESA platform captures, processes and filters Tweets obtained using the Twitter Application Programming Interface[5]. One of the key components is the near-real-time burst detector, presented to the user as the 'alert monitor' shown in Figure 3. Bursting words are identified as described in Yin et al. (2012): a five minute buffer of recent Tweet words is maintained where the word frequencies are compared against a background language model. When an observed word frequency is significantly different from the background language model, a burst is identified and an alert reported. The alert monitor web page shown includes a number of features: a play back control, a 60 minute time navigation control, alert search, tweet search, an alert stem tag cloud, tweet cluster summaries, tweet display, cluster tracking control and alert heatmap. These features are described in Cameron et al. (2012). To date, over one billion Tweets have been processed and we currently collect Tweets at a rate of approximately 1500 per minute.

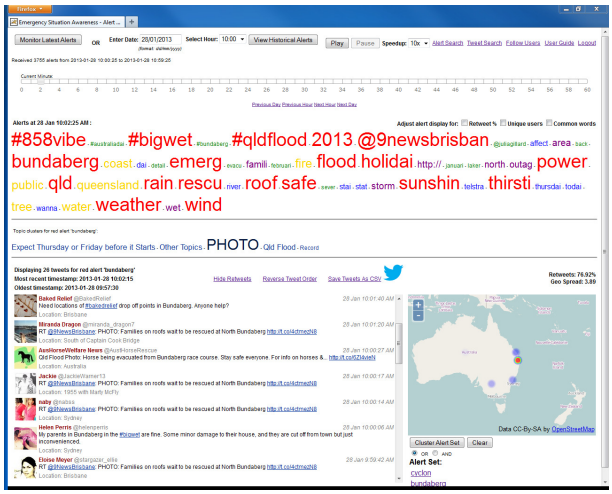


Figure 3. ESA alert monitor for 28 January 2013.

The ESA information presented in Figure 3 can be directly compared to the authoritative web feed information of Figure 2(a). Although the ESA tools are actively monitoring the Tweets for the whole of Australia and New Zealand, the floods in the Bundaberg region were clearly a significant event. A detailed investigation comparing the information available from these two sources, web feeds and Tweets, is reported by Power et al. (2013). They found that the Tweet information contained more specific incident information, was updated more frequently, includes information from the public and is available after the web feed contents are removed.

3.3 Highlights

ESA monitors all words, enabling effective alerting for unexpected incidents within complex events. Collecting and processing Tweets for an extended period provides a large experimental dataset to explore natural language process techniques such as text classification and clustering along with various algorithms for burst detection to improve the ESA system. The tool has been configured to report earthquakes felt by Tweeting populations in Australia and New Zealand, and the average time delay between the earthquake origin time and when ESA sent a notification email is 3:03 (minutes:seconds) as described in Robinson et al. (2013).

ESA can increase crisis coordination centre situation awareness during mass evacuations and it can provide near-real-time briefing material for decision makers. A specific example was the tornado that hit Bargara in Queensland mid-afternoon on 26 January 2013. It was first alerted by ESA at 14:24, with further location reports obtained at 14:35 followed by damage reports and images at 14:45. Briefing material was able to be prepared in under two minutes.

There are challenges also. In the early phase of the project, there was reluctance from some senior managers to use social media for situational awareness: crowd sourced, non-verifiable, non-authoritative information was considered unreliable. Also, the project is dependent on the Twitter social media site. There have been outages due to issues with Twitter meaning that the ESA system could not function for a period of time.

[5] https://dev.twitter.com/docs/api/1/get/search

4 LESSONS LEARNT

There have been a number of useful lessons resulting from these projects, loosely categorised under issues of project management, data access, user engagement and technology access. These are briefly outlined below.

The early stages of any collaboration usually brings together people who have not worked together before and may have different backgrounds, experiences, capabilities, knowledge and a divergent understanding of what the project outcomes should be. Regular meetings are held to discuss expectations, to understand existing work practices, identify needs and possible improvements as well as observation exercises of staff (the identified users) during their day to day business. This has been the case in each of the projects described above and this was supported through rigorous project management processes.

Specifically, the outcomes from the initial collaboration are documented in the complementary System Requirements Specification (SRS) and Concept of Operations (ConOps) reports. The SRS describes what the system will do, not how it will be done while the ConOps provides a non-technical description of the proposed system from the viewpoint of specific users. The time and effort undertaken to produce the SRS and ConOps allows the vision of the project to be described early so that a common, clear, complete and unambiguous understanding of the system to be developed is defined.

This process does not impose a 'waterfall' development methodology where phases are performed in sequence. Concurrent to the above process, operational 'agile' mock ups are developed to help clarify with the users the concepts being discussed. The aim is to *release often and release early* where 'release' refers to working prototypes to demonstrate functions and to *fail fast*: try out ideas to quickly see if they work; if they don't, identify this quickly and try something else. Related to this is the notion of *adopt, adapt, build*: use solutions that already exist, modify them to suite and only write software when you need to.

The identification of and access to the right data has been critical for these projects. In summary, effective emergency management requires the right information in the right format to the right people in the right place at the right time. The ERIC and ESA projects have been successful in this regard but the same cannot be said for the FEND project. Early on in the project, anecdotal evidence suggested that relevant data existed and the project commenced without verifying this information. This assumption turned out to be incorrect for numerous reasons[1] which significantly influenced the project outcomes.

Similarly, the identification of and access to the users has also been critical for these projects. Part of the success of the ERIC project is that it is a productivity tool for it's users: it does not aim to change the way they work, but instead leverages and enhances their existing work practices. Providing early working prototypes was also critical. This allowed a common understanding of the project goals to be quickly established.

ESA has experienced a mixed reception from different users. Some are willing to embrace social media content as a useful and new source of situational awareness. Others are reluctant viewing it as unreliable information. Emergency managers operate under a command and control structure and while drivers exist to embrace this new technology to improve situational awareness, there are still barriers to adoption based on organisational constraints. It is our belief that these barriers will be overcome with the increasing acceptance of social media, so long as the veracity of this information is suitably characterised.

The FEND project was unable to directly identify a specific user. This was resolved by documenting who the users are likely to be and the tasks they were expected to perform[1]. The lesson here is to clearly identify and document the assumptions up front and where possible include them in the project contract.

Finally, in terms of the technology used, the web browser is a ubiquitous platform ideally suited for delivering software solutions. Unfortunately, supporting different browsers (Firefox, Chrome and so on) and versions of them have been problematic. Also, modern browsers are required to take full advantage of advanced features, such as HTML5 and improved CSS stylesheet support, necessary for an engaging user experience but some of our collaborators do not have ready access to them. For example Internet Explorer 7 is the standard browser in some instances. We have also had issues with some organisations having restricted Internet access. This has caused problems with browser certificates, CAPTCHA images and third party mapping sites, such as Google Maps and Open Street Map.

5 CONCLUSION

Combining historical data with authoritative web feed content and crowd sourced social media will provide emergency management organisations with better quality information for decision making resulting in improved community outcomes. Evaluation of these tools is planned future work.

The potential exists to progress the current ESA and ERIC tools to include aspects of each available in the other and to integrate the historical information available in FEND. This will expand the tasks that these systems can support. For example, by combining information of the previous impacts a region has experienced in terms of historical natural disaster events along with demographics data can help profile the region in terms of community resilience and vulnerability. This information is useful to help measure the effectiveness of mitigation undertaken prior to a new disaster event and the outcomes from recovery efforts on communities.

ACKNOWLEDGEMENTS

There have been many CSIRO staff involved in the projects described. The authors thank the contributions of our colleagues Carrie Bengston, John Colton, Iftah Gideoni, Steve Giugni, Charlie Hawkins, Mark Horn, Ron Jones, Sarvnaz Karimi, Michael Kearney, Andrew Lampert, Geoffrey Lee, John Lingad, Peter Marendy, Leorey Marquez, Saguna, Brooke Smith, Allan Yin, Jie Yin and Emily Zhou. We have also had support from senior CSIRO management: Alan Dormer, Dimitrios Georgakopoulos and Ian Oppermann.

There have also been numerous collaborators from agencies supporting this work, too many to list in full. Special thanks to Nick Nicolopoulos and Melanie Stutchbury (Pilot Impacts Portal); John Dickinson, Karen Fedke and Lucy Tate (ERIC); Jim Dance, Daniel Jaksa and Adam Moss (ESA).

The authors would also like to thank the reviewers for their comments and suggestions.

There have been numerous funding arrangements supporting this work. The Pilot Impacts Portal was funded as part of the Impacts of Natural Disasters and Fire Emergencies project which was managed by Fire & Rescue NSW. ERIC is funded under the Human Services Delivery Research Alliance between the CSIRO and the Australian Government Department of Human Services. The ESA project was originally financially supported by the Australian Government through the National Security Science and Technology Branch within the Department of the Prime Minister and Cabinet.

This support does not represent an endorsement of the contents or conclusions of these projects or this paper.

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