Paper title

Towards Standards-Based Resource Management

Systems for Emergency Management

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Towards Standards-Based Resource Management Systems for Emergency Management

Abstract

A key challenge in emergency management is the efficient management of resources – both human (e.g., response teams) and material (e.g., tents and food supplies). A large-scale event such as a cyclone/hurricane, earthquake or tsunami can potentially involve tens of thousands (or more) of resource requests and offers. Sophisticated information systems are required for managing the necessary information exchanges between resource requesters, owners, coordinating agencies and other parties, and for tracking the status of deployed resources. These systems must be scalable and support cross-organisational cooperation. To meet these requirements, they should ideally be based on open standards that allow interoperation between different Resource Management System (RMS) implementations, as well as interoperation and integration with other types of emergency management, and business-as-usual, software.

While some of the software systems already in use within the emergency sector do provide support for selected resource management tasks, open standards-based software for resource management does not yet exist. This chapter reviews the current state-of-the-art in software for resource management, provides an overview of the Resource Messaging standard under development within the OASIS standards organisation, and introduces a prototypical RMS that we are developing based on this emerging standard.

1 Introduction

Emergency management hinges on successful management of resources – both human and material. Regardless of the scale of incident, resource management generally spans multiple agencies and organisations, and requires basic agreements and protocols between these parties to be in place. A small traffic incident may require resources from police, fire and ambulance departments, while a large-scale natural disaster such as a cyclone may require involvement from local, state and federal government departments, volunteer organisations, critical infrastructure providers, and so on. In the latter case, the number of resources deployed over the response and recovery phases can easily number in the tens of thousands (or more).

Importantly, the "business-as-usual" software systems and services used by the emergency management stakeholders today should be scalable (and usable) during both day-to-day operations as well as major catastrophic incidents. This implies the need to ensure the resource management processes during an emergency incident are contained within the "normal" day-to-day logistics and operations of each stakeholder.

Resource management is a term that can apply at any stage of incident management, and includes:

- *pre-incident*: creating and managing resource inventories; mobilising resources in preparation for anticipated disasters such as cyclones/hurricanes;
- *during response/recovery*: requesting, dispatching and tracking resources; managing resource offers/donations;

– *during and post response/recovery*: deactivating and recalling resources.

For routine, small-scale incidents such as traffic accidents, the protocols governing these tasks are generally well established and corresponding Information and Communications Technology (ICT) support (e.g., computer systems for dispatching and tracking ambulance and fire crews) is in place. However, resource management for large-scale incidents often happens in a more ad-hoc and unstructured fashion, and is less well supported by ICT systems. It is not uncommon for resource inventories to be tracked during emergencies using improvised tools such as whiteboards and spreadsheets; nor is it unusual for resource requests to be exchanged via telephone, email, radio and fax, with no easy means of tracking and coordinating the requests (Iannella & Henricksen, 2007). Following recent large-scale natural disasters such as Hurricane Katrina in the U.S. and Cyclone Larry in Australia, it is increasingly being recognised that better ICT systems are required.

As large-scale events require the involvement of many organisations, these ICT systems must be scalable, and must be able to coexist with a wide variety of existing policies, procedures and business-as-usual systems – including operational policies and procedures, as well as organisations' ICT security policies and legacy software. Open standards that support interoperability will therefore play an important role in the success of future ICT systems for emergency management (Institute for Security Technology Studies, 2004).

This chapter reports on progress towards developing standards-based ICT systems that will support resource management for emergencies, with an emphasis on the

requirements of large-scale events (although these systems will also be applicable to smaller events). We view a Resource Management System (RMS) as a crucial component of a larger Crisis Information Management System (CIMS). As we discuss in (Iannella & Henricksen, 2007), we regard a CIMS as an ICT system that aims to "deliver the right information to the right people in the right format in the right place at the right time". In addition to resource management, a CIMS may support diverse functions such as situational awareness, notification/alerting, document management, and financial management (Iannella *et al*, 2007). Copper and Block (2006) note that ICT systems for resource management was a major failing of the Homeland Security agency in their response and recovery from Hurricane Katrina.

The chapter begins with an overview of current emergency management practices and frameworks in Australia and the United States, and also gives an overview of the current state-of-the-art in ICT support for resource management, focusing on commercial product offerings in the CIMS space (there are currently no examples of dedicated RMS software, to our knowledge). After setting the current context, the chapter proposes some requirements for the development of future CIMS/RMS software.

As part of the OASIS Emergency Management Technical Committee (TC), we have been involved in the development of information standards for use in the emergency sector, including the recent development of a language for exchange of resource messages such as requests, requisitions, offers and returns (EDXL Resource Messaging) (OASIS, 2007a). We present an overview of this language, followed by a discussion of a proposed

RMS based on the standard. Finally, we discuss a set of open challenges and future directions for this area.

2 Current emergency management practices and frameworks

Emergency management practices, including resource management practices, are governed in international jurisdictions by similar frameworks, albeit, under different names. For example, in Australia, the Australian Inter-service Incident Management System (AIIMS) (Australasian Fire Authority Control, 2004) and in the United States, the National Incident Management Systems (NIMS) (Federal Emergency Management Agency, 2007c). Other countries, such as New Zealand and Canada, have similar frameworks under different names.

As AIIMS was originally based on NIMS, there are many obvious similarities. Both describe structured "command, control, and coordination" frameworks that facilitate cross-organisational cooperation by describing common roles, concepts and processes for incident management. In NIMS, this command, control, and coordination structure is called the Incident Command System (ICS). Both ICS and the corresponding AIIMS control structure describe the relationships between the key roles/sections in incident management, including incident command/control/coordination, logistics, planning and operations. Depending on the scale of the incident, there may be one or more people

acting in each of these roles, as well as a number of people responsible for support

functions such as situation assessment, communication planning and management

support. Figure 1 shows the AIIMS control structure for a single incident.

In this structure (and similarly in ICS), the resource management functions are distributed

across the three main sections – planning, operations and logistics. The planning section

(or more specifically, its resources unit) is responsible for establishing a Resource

Management System[1], for tracking resources allocated to the incident, with support from
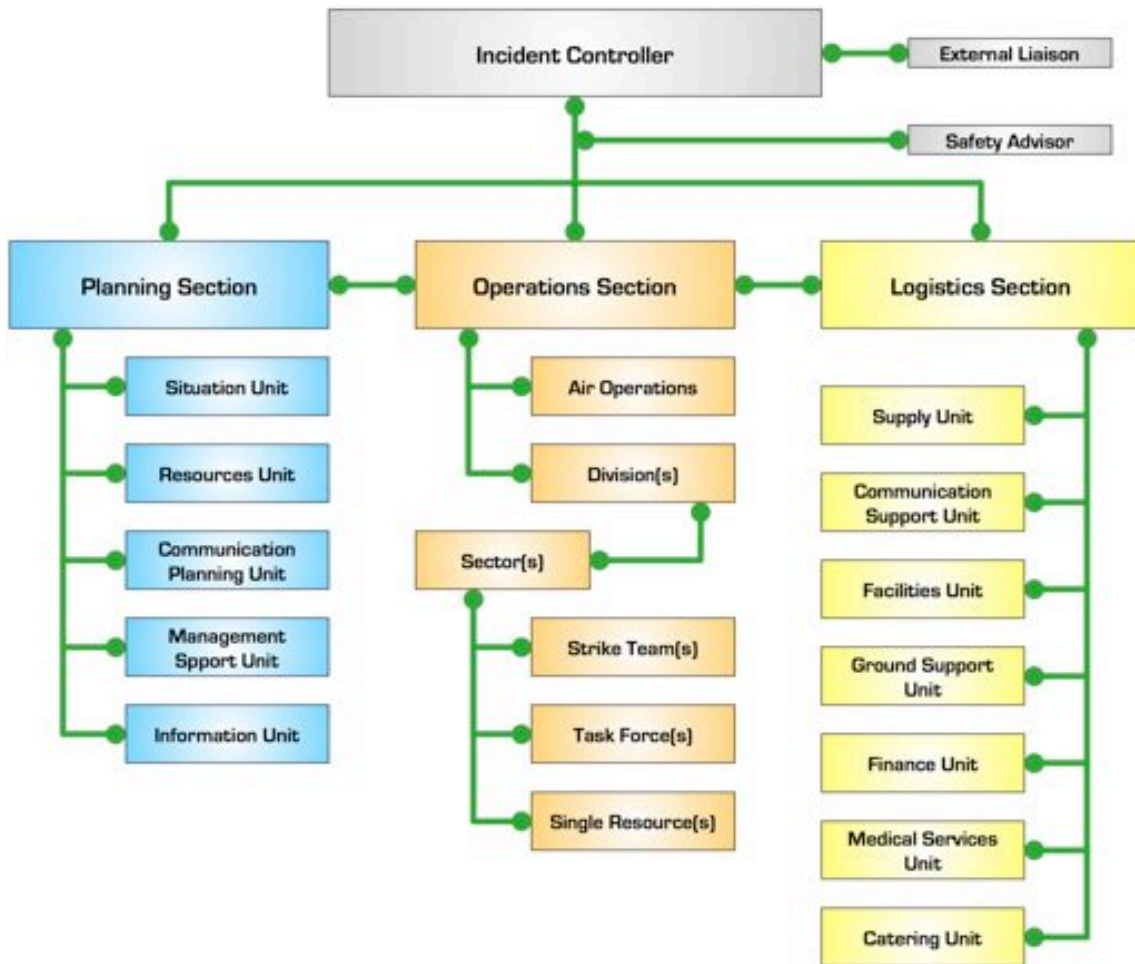

Figure 1. AIIMS structure (adapted from Australasian Fire Authority Control, 2004)

the logistics section. This involves maintaining information about where resources are located and their status (allocated, available, en route, demobilised or unserviceable). It also entails managing lists of key personnel and resources used in the incident, and assisting with planning for demobilisation and changeover of resources.

The operations section is responsible for directly managing and supervising the resources (people and equipment) involved in the incident in accordance with the Incident Action Plan. The AIIMS structure classifies resources as strike teams, task forces or single resources (see Figure 1). In a large incident, resources will be divided into multiple sectors, which in turn will be part of larger divisions. A single identification system must be adopted in each incident to allow resources to be uniquely identified (however, AIIMS does not dictate the form that this identification system must take).

Finally, the logistics section is tasked with acquiring new resources when needed. This may include human and physical resources, facilities, services and materials. The logistics section's supply unit is the primary unit responsible for acquiring, storing and distributing resources, however additional units may be responsible for specialised resource types (for example, a communications support unit may be established specifically for the acquisition, installation and maintenance of communications equipment).

NIMS has much in common with AIIMS (notwithstanding many superficial terminology and structural differences), but is more mature, and in many respects is more specific and

detailed in its recommendations. In relation to resource management, it goes further than AIIMS by establishing a Resource Typing System (US Department of Homeland Security, 2004b) that can be used to describe resource types in a uniform way across all incidents. This provides common semantics and ontologies for describing resources in terms of categories, kinds, components, metrics and typing definitions, and also provides definitions for 120 commonly used resource types across eight categories – Animal Health, Emergency Management, Emergency Medical Services, Fire & Hazardous Materials, Health and Medical, Law Enforcement, Public Works, and Search and Rescue.

The NIMS Resource Typing System has been developed as part of the broader National Mutual Aid and Resource Management System initiative. This initiative also focuses on establishing pre-incident agreements such as mutual aid agreements, creating a national inventory of resources which would be voluntarily maintained by government agencies and private sector entities involved in disaster response activities, and creating an Automated Resource Management System (ARMS) to allow emergency management personnel to access and search the inventory, and to request, order and track specific resources. Since 2006, all U.S. state, territorial, tribal and local jurisdictions have been required to adopt NIMS Resource Typing (US Department of Homeland Security, 2003) for their inventories of response assets, but the ARMS remains under development. In the meantime, the process of locating and ordering resources generally relies on email, faxes and phone calls (Federal Emergency Management Agency, 2007a) – similar to resource management practices in Australia, as we discuss further in Section 4.

Recently, the prototype NIMS-Incident Resource Inventory System[2] (NIMS-IRIS) has been announced. The system will allow emergency responders to enter the NIMS typed resources and select specific resources for mutual aid purposes based upon mission requirements, capability of resources, and response time. Initially, NIMS-IRIS will provide the basic database management tool to enter the 120 typed resources into a common shared single database. Future versions will support advanced functionality in placing resource requests, tracking of resources, and resource recovery.

The fact that Incident Management Systems make few specific recommendations about the use of ICT systems in emergency management (as their focus is at a higher level) has led to varying levels of technology uptake across the many public and private sector organisations that implement the two incident management systems. The state-of-the-art in ICT systems is discussed in the following section, again with a focus on resource management; however, the majority of organisations involved in emergency management use systems that are considerably simpler than the state-of-the-art. The U.S. has established the NIMS Integration Center (Federal Emergency Management Agency, 2007b) to develop data standards, as well as systems such as ARMS, as future components of NIMS.

3   State-of-the-art in software support for resource management

A variety of software products are available today in the emergency sector to support effective sharing of information, decision making, alerting and related functions. These

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[2] See <http://www.fema.gov/emergency/nims/rm/iris.shtm> for details.

are mainly designed to support the tasks of staff working in Emergency Operations Centres (EOCs). Although some of the products are very narrow in scope – such as those that provide specialised emergency alerting and notification services (OVIS 2007, CallingPost Communications, 2007) or Computer Aided Dispatch (CAD) functionality – there are also many broader products that fit the CIMS definition presented earlier.

A comprehensive survey and evaluation of ten CIMS products by the U.S. Department of Justice in 2002 (National Institute of Justice, 2002) revealed that all supported some form of resource management. All ten products enabled the user to maintain an inventory of resources and to assign tasks to resources, while more than half supported related functions such as cost accounting, status tracking and alerts. Today, the CIMS landscape remains quite similar. The following section provides a flavour of the types of resource management functions supported by CIMS software, covering four example CIMS implementations – WebEOC (ESi, 2007), L-3 Crisis (Ship Analytics, 2003), ResponseVision (Emergency Visions, 2007) and Contora (Seros, 2007).

3.1   Four current Crisis Information Management Systems

The CIMS products discussed in this review below primarily serve the United States market, which is currently the most developed market for CIMS products internationally; however, some have also been deployed outside the U.S. The review was based on a comparison of the product technical material available from the specified companies web sites. The review shows that there are still gaps in the current level of support for interoperable resource management, and there are currently no comprehensive RMS

solutions that are based on open standards, specifically for the emergency management sector.

WebEOC provides a number of customisable status boards which enable the tracking and management of information about significant events, tasks, resources, situation reports, press releases, shelters, and so on. WebEOC also manages contact information and provides internal communication using chat and messaging features. It can support GIS integration, and provides a full suite of ICS/NIMS forms for the U.S. market. In relation to resource management, WebEOC provides functionality for:

– maintaining and searching a resource inventory;

– tracking and updating resource deployments, and generation of summary information about the overall quantity and cost of deployments;

– sending simple resource requests; and

– tracking of donations.

Resource typing in WebEOC follows the NIMS Resource Typing System discussed in Section 2.

The status board functions of WebEOC are largely independent of one another – for example, there is no support for using donations information to update resource inventories, nor for translating requests for assistance into specific resource requests. As a result, many resource management tasks remain predominantly manual tasks in WebEOC.

L-3 CRISIS offers a large set of modules that provide similar functions to WebEOC boards, such duty roster, finance, GIS, shelter management and briefing modules. However, it differs from many other CIMS implementations in that it also includes scientific prediction and damage assessment modules. These facilitate tasks such as predicting impact areas for certain kinds of disasters, and carrying out economic and environmental damage assessments.

Its resource management functionality is split across several of the modules. The *acquire* module supports the management of lists of available equipment, supplies, suppliers and personnel, and allocation and de-allocation of resources as required. The *resource/logistics/staging* (RLS) module enables viewing and updating of location and status information for equipment and personnel, including GIS-based support for tracking location. The *organizational* module is used to build a picture of the overall structure of the units involved in disaster operations, and can be used as a basis for assigning equipment and personnel to particular units. Finally, the *message* module is used to transmit resource requests (as well as other types of request and information), and provides a similar facility to email except that it provides centralised message logging and tracking of related messages (so that all messages concerned with a particular resource request can be easily identified, for example). As in WebEOC, management of the overall resource lifecycle remains a largely manual task carried out using a number of disjoint software functions.

ResponseVision is a set of seven software modules designed to serve the needs of U.S. public and private sector organisations by directly implementing various aspects of NIMS/ICS. The modules address cataloguing of human and material assets (ResourceVision), vulnerability assessment (CheckVision), development of emergency response plans (PlanVision), alterting (AlertVision), simulations and exercises (SimDrillVision), incident command and control (CommandVision), and recovery activities including damage assessment and resource/financial management (RecoveryVision). We focus on the resource management component. Like WebEOC, ResourceVision uses the NIMS Resource Typing System. Although it can support integration with GIS systems and real-time location tracking systems based on RFID and GPS, ResourceVision is in essence little more than a relational database with a Web (ASP) interface. It does not provide any facilities for exchanging and managing resource-related messages, such as resource requests.

Contora is designed as a set of distributed Web portals for emergency response, linked together via a messaging infrastructure. This design makes Contora more suitable for distributed, multi-organisational environments than most of the other CIMS solutions. It supports a variety of messaging models, including publish/subscribe and single-destination communications. Using these forms of messaging, portals can selectively exchange information to build up a common picture of the situation, subject to information sharing policies.

The main functions of the Contora portals are concerned with alerting, shared situational awareness, incident reporting and tasking. Contora concentrates largely on map-based presentation of information, as distinct from the status-board or list-based presentations favoured by some of the other CIMS products. For example, incident reports and events from chemical, biological, radiological and nuclear sensors are presented on an incident report map. Maps can also be used to control the area in which alerts are disseminated, with location-based messaging being supported through integration with a third-party phone, email and pager notification service called Message911. Contora's support for resource management is fairly limited: it does not provide inventory management functionality as in the other CIMS products; however, it supports real-time asset and personnel tracking using a GPS-based system called LunarEye. Once again, this feature uses a map-based display.

3.2 Analysis

Many of the current CIMS products, including those covered here, emphasise the need for integration with external software systems – among other features, they provide support for integration with sensor, GIS, public alert, CAD and weather services. To support this integration, they rely on open/standardised interfaces and information formats. One example of the latter is the Common Alerting Protocol (CAP) (OASIS, 2005) an information format for public alerting standardised by the OASIS Emergency Management Technical Committee. WebEOC, for instance, can support CAP-encoded Watches, Warnings and Advisories produced by the U.S. National Weather Service.

Most of the standards in use today – like CAP – are narrow in scope. However, further standards for the emergency sector have recently emerged or are in the pipeline, and the adoption of these in CIMS products in the near future will be crucial to the further development of the sector. As noted earlier (see Section 3.1), many of the current CIMS products are closely tied to the needs of their home market (by using the U.S. NIMS Resource Types, for example). Emerging standards that are designed for international use will help to open up the market so that products can be more easily applied in a number of countries and jurisdictions without customisations that are currently necessary. Further, the standards should create opportunities for interoperability between CIMS solutions from different vendors – not only between CIMS and other specialised systems such as GIS, CAD, public alert, and business-as-usual software.

The resource management functionality provided in CIMS products today mainly supports inventory management, basic resource allocation and tasking, and equipment and personnel tracking using GPS and other location tracking technologies. Exchanging resource-related messages, such as resource requests, typically relies on general purpose messaging systems provided by the CIMS. The L-3 CRISIS messaging system allows related resource messages to be chained together so that it is easier to determine the status of a particular resource request (unlike email-like messaging systems, which make it difficult to piece together a thread of related messages). However, the adoption of standard formats for resource messages – in place of plain-text messages – would represent a significant step forward by increasing opportunities for automation. For example, a resource request could automatically be checked against the current inventory,

and a resource status message could trigger an immediate update to a resource tracking system or status board. In addition, a standard format should reduce the ambiguity of resource-related messages and the number of messages that contain incomplete or inconsistent information.

4   Requirements for future Resource Management Systems

In addition to incorporating open standards, future resource management systems should be developed with business-as-usual resource management practices and frameworks in mind, as well as with a thorough knowledge of the problems, challenges and constraints faced in Logistics and Emergency Operations Centres.   We have already discussed current resource management practices as covered by incident management systems such as NIMS and AIIMS in Section 2. In this section, we summarise some general requirements related to the operational environment in which resource management takes place during an emergency situation. This is based on our observations during emergency services exercises in Queensland, Australia, which dealt with the preparedness and short-term response activities surrounding a mock category 4 cyclone. Exercises provide useful insights into both the challenges faced in EOCs and the processes adopted by EOC staff. Others (Militello *et al*, 2007) have found from similar studies that improved tools can be created to support better coordination and information flows in EOCs.

Exercises allow the "ideal" practices set out in frameworks like AIIMS and NIMS to be tested and evaluated. The challenges would naturally be more pronounced and more

numerous in a true emergency situation, and behaviours would change to some extent under pressure.

Response activities for a natural disaster such as a cyclone generally take place in a distributed fashion, with the involvement of numerous public and private sector organisations. In Queensland, a hierarchy of Disaster Coordination Centres, supported by various government departments and organisations such as critical infrastructure providers, is formed according to the structures of the AIIMS framework. Depending on the scale of the incident, coordination centres are activated at local, district, state and federal levels. The Queensland cyclone exercise involved four Local Disaster Coordination Centres (LDCCs), a District Disaster Coordination Centre (DDCC) and the Queensland State Disaster Coordination Centre (SDCC). The organisation of these coordination centres is described in detail in (Iannella & Henricksen, 2007).

The process of identifying and handling resource requirements typically occurred in the exercise as follows. Requests for assistance came in from members of the public (simulated by the exercise control team), mainly at the local level. These requests – for example, for medical aid or assistance with structural damage – often triggered one or more requests for specific resources (human and/or material). Many of the resource requests could not be handled directly at the local level, and were delegated up to the district or state levels. At these levels, staff in the disaster coordination centres would draw on their networks of resource suppliers and other contacts to source the required resources on behalf of the local communities. Resource requests were mainly

communicated informally via email, telephone and fax, with use also being made of logistics request and order forms prepared using office document templates. Messages and actions taken were recorded manually in an operations log in spreadsheet applications.

This approach to managing resource requests suffered from the following shortcomings:

1. Knowledge about the status of particular requests mainly resided with the one or two people responsible for handling them, and there was a general lack of feedback on progress at the lower levels of the hierarchy. This made it difficult for the staff handling the requests for assistance at the local level to know whether resource requests were still in progress or had been lost.

2. Because there were no centralised repositories of information about the status of resources and resource requests, there could be no overall coordination. This meant that resource requests could be acting at cross purposes or duplicated, and that resource allocations across the incident were in general not as efficient as they could have been.

3. There were a number of problems surrounding shift changeovers in the Disaster Coordination Centres. For example, when personal email accounts and informal communication channels were used, much of the resource management information that had been exchanged with outside people in relation to particular resource requests was lost when another person took over at the end of a shift.

Appropriately designed RMS/CIMS software could easily alleviate these problems – for example, by supporting role-based communications and centralised tracking of messages and resource status information.

Overall, the tasks handled at the various levels in the hierarchy of Disaster Coordination Centres were quite different, as were the operating environments and levels of technology (and other resources). RMS/CIMS software therefore needs to be customisable to support a number of different functional and information views. At the local level, the software needs to manage the very detailed information coming from people on the ground in a high-pressure environment. At higher levels, the software should enable a cohesive view of the "bigger picture" to allow overall coordination and decision-making. This requirement is not well addressed by the currently available CIMS products, and suggests the importance of pursuing standards-based interoperability between a number of different CIMS implementations, rather than pushing for uniform adoption of generic "closed" systems.

5 EDXL Resource Messaging

To date, there have been no generally accepted standards for exchanging resource-related information to support resource management for emergency response. The IEEE 1512 family of standards, which is discussed in (Henricksen & Iannella, 2006), addresses a number of elements of asset management (including requests for assets and exchange of asset status information), but was developed with the U.S. transportation industry in mind and is intended primarily for managing traffic incidents. To address the current resource

management standards requirement, we have been involved in the efforts of the OASIS

Emergency Management Technical Committee to develop a general format for

exchanging resource-related messages, known as the Emergency Data Exchange

Language Resource Messaging (EDXL-RM) specification (OASIS, 2007a). EDXL-RM

provides a suite of closely related messages for:

- requesting resources and responding to resource requests;

- requisitioning and committing resources;

- requesting resource information and responding to requests for information;

- offering unsolicited resources and responding to offers;

- releasing resources;

- requesting the return of resources and responding to return requests;

- requesting quotes and responding to requests for quotes;

- requesting and notifying resource deployment statuses; and

- requesting extended use of a resource and responding to extension requests.

A total of 16 different messages are support by EDXL-RM, all of which share many

common features, but still providing the end users with a complex range of functions.

Such complex specifications will need good software requirements engineering and user-

centred design patterns, which is now being recognised in the emergency sector (Montells

et al, 2006).

The EDXL-RM specification describes the message formats, in terms of the message

elements that are required, optional and conditional (depending on which other elements

are present and their values) for each message type. Message elements are represented as
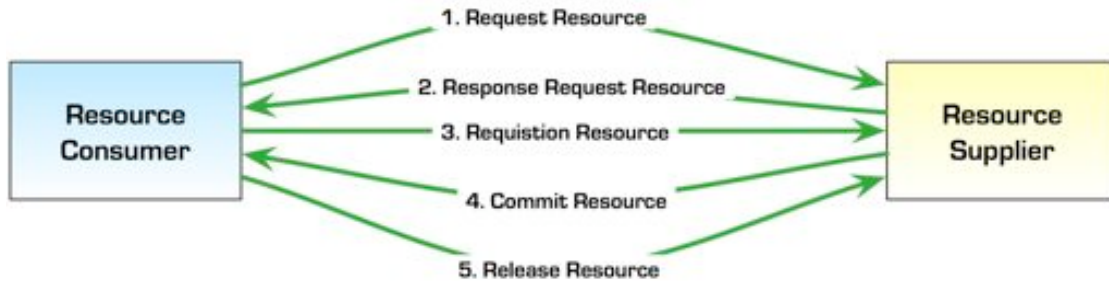
Figure 2. An example EDXL-RM message exchange.

Extensible Markup Language (XML) elements, and each message type is defined by a
distinct XML Schema. The EDXL-RM specification does not dictate the message flow
sequences, except to specify the valid responses for each of the message types. An
example message exchange is shown in Figure 2 for illustrative purposes. This message
exchange involves only two parties – the resource consumer and resource supplier. In
more complex scenarios, other parties (such as additional suppliers and resource
approvers) may be involved, and a larger subset of the EDXL-RM message types may be
required.

An example "Request Resource" message (the first message type in our example
exchange) appears in Figure 3. This shows a request for two electrical power restoration
teams. The example illustrates the core element types; however a wide variety of
optional elements can also be included – such as incident information, further resource
requests, additional scheduling information, and details about required credentials and
certifications. The example shows a resource being identified with a URI. This is also an
important and emerging area dealing with the identification of ontologies that define

resource vocabularies. We expect this to be addressed in the future via the semantic web family of technologies. Detailed examples for each of the EDXL-RM message types can be found in the EDXL-RM specification (OASIS, 2007a).

There are several other areas, besides the message flow sequences, in which EDXL-RM provides a considerable degree of flexibility, allowing for compatibility with incident management systems such as NIMS and AIIMS. In particular, EDXL-RM offers several alternative mechanisms for identifying resources (by identifier, name or an externally defined type structure), enabling the use of resource typing schemes such as NIMS Resource Typing. Additionally, it supports existing standards for describing location and contact information, including a small set of Geography Markup Language (GML) (OGC, 2004) elements for describing geospatial coordinates and areas, and elements from the extensible Party Information, Name, and Address Languages - both developed by the OASIS Customer Information Quality Technical Committee (OASIS, 2007b). The use of these standards helps to make EDXL-RM suitable for international use, despite the fact that its initial development was driven by the U.S.

```xml
<EDXLResourceMessage xmlns="urn:oasis:names:tc:emergency:EDXL:RM:1.0:RequestResource"...>
    <MessageID>3478</MessageID>
    <SentDateTime>2007-05-24T10:16:00+10:00</SentDateTime>
    <MessageContentType>Request Resource</MessageContentType>
    <OriginatingMessageID>3478</OriginatingMessageID>
    <ContactInformation>
        <rm:ContactRole>Sender</rm:ContactRole>
        <rm:AdditionalContactInformation>
            <xnl:PartyName>
                <xnl:PersonName>
                    <xnl:NameElement xnl:ElementType="FirstName">Alex</xnl:NameElement>
                    <xnl:NameElement xnl:ElementType="LastName">Jones</xnl:NameElement>
                </xnl:PersonName>
                <xnl:OrganisationName>
                    <xnl:NameElement>Dept. of Emergency Services</xnl:NameElement>
                </xnl:OrganisationName>
            </xnl:PartyName>
            <xpil:ContactNumbers>
                <xpil:ContactNumber xpil:MediaType="Telephone">
                    <xpil:ContactNumberElement xpil:ElementType="AreaCode">
                        7
                    </xpil:ContactNumberElement>
                    <xpil:ContactNumberElement xpil:ElementType="LocalNumber">
                        1234 5678
                    </xpil:ContactNumberElement>
                </xpil:ContactNumber>
            </xpil:ContactNumbers>
            <xpil:EmailAddresses>
                <xpil:EmailAddress>a.jones@emergencyservices.gov.au</xpil:EmailAddress>
            </xpil:EmailAddresses>
        </rm:AdditionalContactInformation>
    </ContactInformation>
    <ResourceInformation>
        <SequenceNumber>001</SequenceNumber>
        <Resource>
            <TypeStructure>
                <rm:ValueListUrn>urn:x-hazard:vocab:resourceTypes</rm:ValueListUrn>
                <rm:Value>Electrical Power Restoration Team</rm:Value>
            </TypeStructure>
        </Resource>
        <AssignmentInformation>
            <Quantity>2</Quantity>
        </AssignmentInformation>
        <ScheduleInformation>
            <ScheduleType>RequestedArrival</ScheduleType>
            <DateTime>2007-05-25T09:00:00+10:00</DateTime>
            <Location>
                <rm:Address>
                    <xal:Locality>
                        <xal:Name>Cairns</xal:Name>
                    </xal:Locality>
                    <xal:Thoroughfare>
                        <xal:NameElement>Main St</xal:NameElement>
                        <xal:Number>27</xal:Number>
                    </xal:Thoroughfare>
                    <xal:PostCode>
                        <xal:Identifier>4870</xal:Identifier>
                    </xal:PostCode>
                </rm:Address>
            </Location>
        </ScheduleInformation>
    </ResourceInformation>
</EDXLResourceMessage>
```

Figure 3. Example EDXL-RM "Request Resource" message.

EDXL-RM is closely related to another specification in the Emergency Data Exchange Language family – the EDXL Distribution Element (EDXL-DE) (OASIS, 2006). EDXL-DE is used as the container for distributing any message payloads, and supporting the routing of these messages to the appropriate recipients. EDXL-DE provides elements such as the target area for a message (in order to support location-based message delivery); information about the sender; the target address, if applicable; keywords describing the message content; and the type and "actionability" of the message (actual, exercise, test, etc.).

Whereas EDXL-DE is already an OASIS standard (as of May 2006), EDXL-RM 1.0 was released as a Committee Draft for public comment on 9 April 2007, and is expected to become an OASIS standard towards the end of 2007.

6 Towards a standards-based Resource Management System

We are currently developing a demonstrator RMS based on the EDXL-RM standard and the requirements identified in Section 4. This is part of a broader CIMS prototype called CAIRNS (Iannella *et al*, 2007), which also showcases flexible information distribution and alerting using OASIS standards including EDXL-DE and CAP.

The current resource management support in commercial CIMS offerings such as those discussed in Section 3 is primarily concerned with resource/inventory management in individual organisations. Our goal is to show a broader RMS solution that targets collaborative, cross-organisational resource management activities, both for day-to-day

activities and crisis situations. Our proposed RMS addresses the problems of how to coordinate resource supply and tracking across organisational boundaries, assuming a situation where each organisation may already have its own processes and/or information systems in place for allocating, managing and tracking resources. EDXL-RM and EDXL-DE together provide the framework for structured information sharing and negotiation between organisations.

The proposed system incorporates the following functionality:

1. Support for composition of resource messages (resource requests, requisitions, commits, requests for quotes, statuses and returns) based on the standard EDXL-RM message formats.

2. Support for dissemination of resource messages using the flexible addressing mechanisms of EDXL-DE. For instance, resource requests can be delivered to recipients based on resource keywords, role or geographical area, as well as using direct addressing, whereby the sender explicitly specifies the intended recipient(s). This allows opportunistic resource discovery to occur, in addition to conventional discovery and allocation through pre-established supply channels.

3. Support for flexible message subscription and delivery preferences, so that message recipients can control which kinds of messages they receive and by which method (for example, email, SMS alert or RSS feed). Messages can also be diverted to other people or roles as required.

4. Logging and management of message histories to simplify the process of tracking the progress of a given resource request and for accountability.
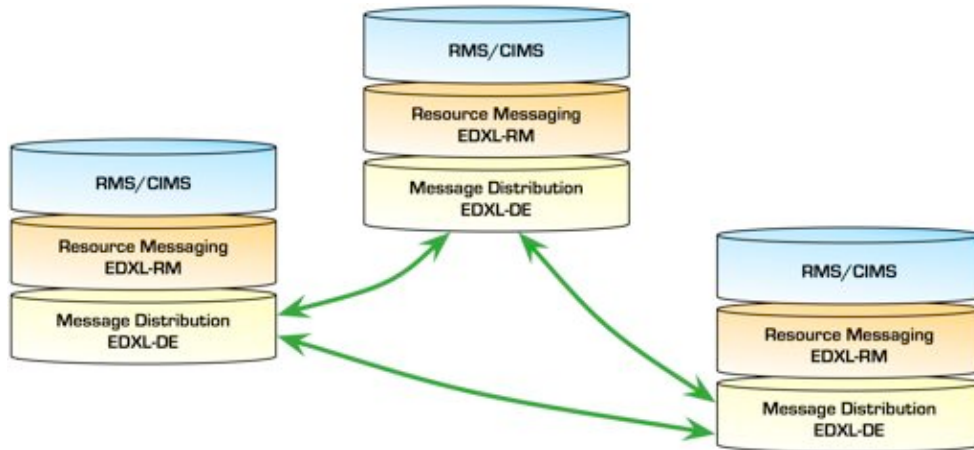
Figure 4. Distributed architecture based on EDXL-RM and EDXL-DE.

5. Support for storing amounts of resources from various agencies, including offers of resources from external parties. This is then used to map with incoming resource requests from which allocations can be generated.

6. The ability to visualise current resource locations onto a geospatial map, including uncommitted and committed resources, and resources in transit.

Architecturally, the system consists of a set of distributed RMS/CIMS systems connected via a common messaging substrate (EDXL-RM) based on EDXL-DE routing services. This design is illustrated in Figure 4. The distribution layer is responsible for routing of resource messages (and other types of information exchanged by the systems) over the network according to users' messaging subscriptions and EDXL-DE message elements such as target area, recipient role, keyword or explicit address. The resource messaging layer supports composition of EDXL-RM resource messages at the sender's side, validation and parsing of messages at the recipient's side, and logging of all messages.

The RMS or CIMS systems that sit above these two layers can be customised according to the requirements of each organisation to provide appropriate user interfaces and integration with existing software. As proof-of-concept, we are developing such a system that demonstrates the resource messaging and subscription features described above, as well as integrated inventory management and "Request for Assistance" (RFA) tracking. The inventory management feature exploits the formal semantics of EDXL-RM resource messages, enabling resource database updates to be performed automatically based on the content of messages that are sent and received via the resource messaging layer. For example, sending a commit message for 100 tarpaulins can trigger a database update that changes the status of the items from "available" to "committed". The goal of integrated RFA tracking is to capture the relationships between incoming requests for assistance and the outgoing resource requests that are triggered as a result, in order to provide better tracking of RFAs through to completion and generate process traces for accountability purposes.

Figures 5 - 7 show a series of screen shots to illustrate a subset of our RMS system's functionality. The system supports a number of views: a *Requests for Assistance* view, which displays RFAs and associated functions for adding, modifying and searching requests; a *Resource Requests* view, which we describe in detail below; an *Inventory* view, which provides functions for browsing, managing and searching the resource database; a *Messages* view, which allows users to manage their incoming and outgoing messages (both resource messages and other message types); and a *Messaging Preferences* view, which allows users to describe their message delivery preferences and
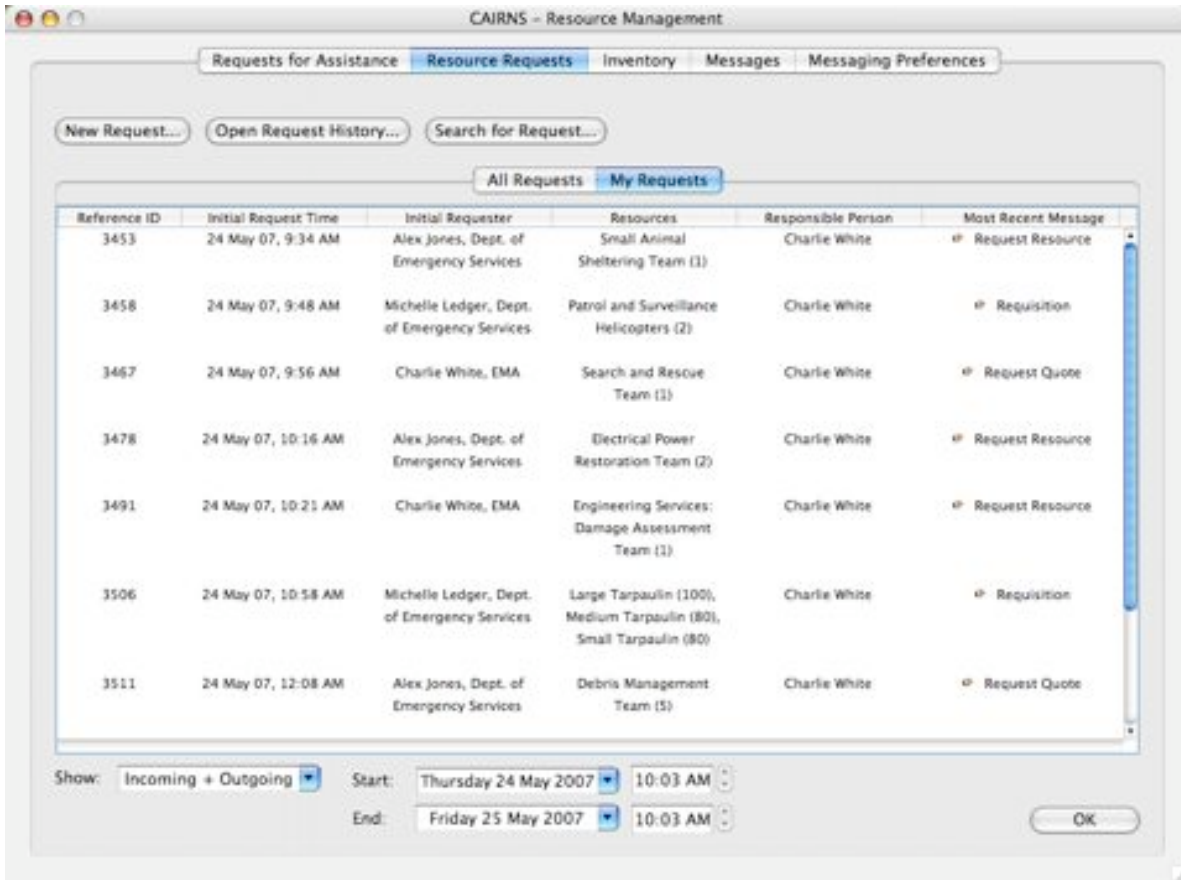
Figure 5. CAIRNS Resource Management - Resource Requests View

create customised message subscriptions by specifying relevant roles (e.g., "EOC Manager", "Logistics Officer"), keywords of interest ("medical supplies", "tarpaulins"), and so on.

The *Resource Requests* view is shown in Figure 5. It provides functions for:

– creating a new resource request, which may be one of several types supported by EDXL-RM, including a "Request Resource", "Requisition" or "Request Quote";

– viewing and managing request histories, where a history is a sequence of related resource messages and associated information, such as the responsible person or role; and

– searching resource requests.

The view also provides a listing of all pending requests (or, more accurately, request histories), either for the entire organisation or the current user. The listing can be filtered according to date and time, and whether the initial request was an incoming or an outgoing one.

Figure 6. CAIRNS Resource Management – New Request Window
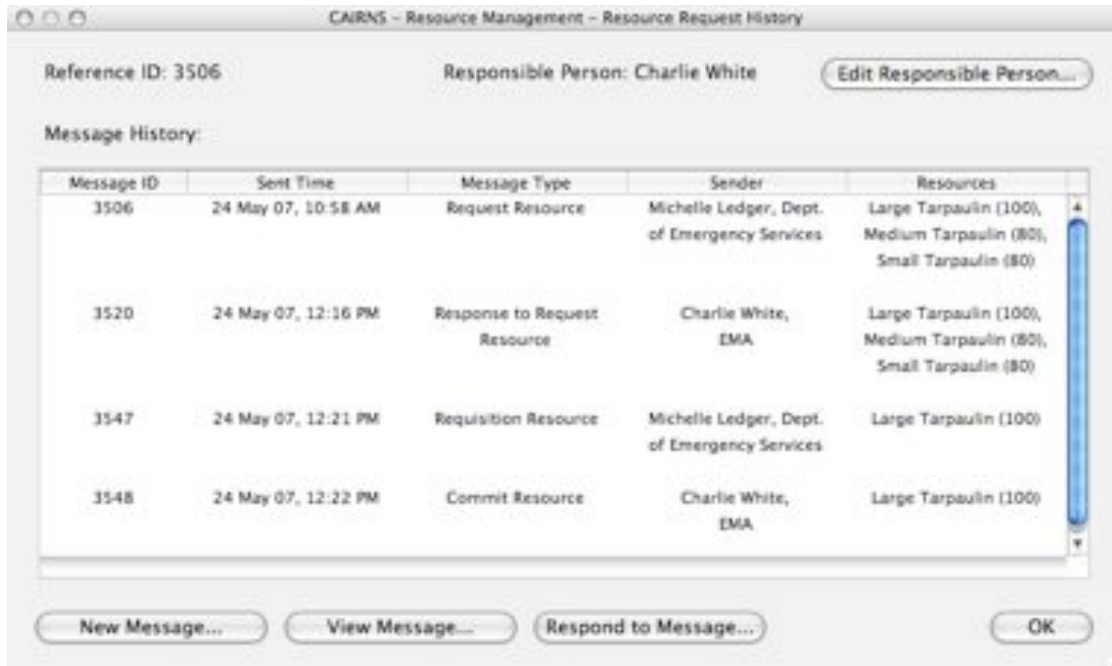
Figure 7. CAIRNS Resource Management – Resource Request History Window

Figure 6 shows the message composition window that appears when the user clicks on the "New Request" button in the *Resource Requests* view – in this case, the request corresponds to an EDXL-RM "Request Resource" message. Figure 7 shows the window that displays a resource request history when the user clicks on the "Open Request History" button.

7   Challenges and future directions

The CAIRNS demonstrator we have described represents a first attempt to build an RMS implementation that is based on open standards and offers a flexible messaging model. Several aspects of the system remain untested and will need to be validated in future

work. First, the EDXL-RM specification is very new, and has not yet been used in any working system. The need for refinements or extensions may become apparent as more experience is gained through the implementation of systems such as CAIRNS. Two areas that EDXL-RM does not address at present are resource allocation methods and management of human resources, including tasking of personnel. Extensions of the EDXL-RM message formats to support humans as "resource" activities are required in the future and could be accommodated within EDXL-RM. A greater challenge is to automate and assist in the allocation of resources. During a major incident hundreds of requests would be likely and this would need innovative mechanisms for real-time planning (Minciardi *et al*, 2007) and resource allocation (Schattenberg & Biundo, 2002) (Ulieru & Unland, 2004) under such crisis conditions to assist the EOC staff.

The use of flexible message delivery mechanisms based on EDXL-DE to address the types of communication challenges described in Section 4 (related to shift changeovers, management of contact lists, and so on) appears promising but requires further research. Emergency management presents a number of critical requirements in terms of timeliness of message delivery, avoiding information overload, and satisfying accountability requirements. Our CAIRNS prototype will need to be carefully evaluated with respect to these issues. EDXL-DE provides a great deal of flexibility about the kinds of message routing that can be supported; the challenge lies in determining the most appropriate ways in which to apply its capabilities. In particular, further work is needed to determine what feedback mechanisms are needed at the sender's side about the delivery status of particular messages, and to what degree it is appropriate for the recipient, rather than the

sender, to control which messages they receive (e.g., via keyword or location-based subscriptions).

We intend to deploy our CAIRNS prototype at future emergency services exercises such as those we reported on in Section 4. This will allow us to evaluate both the current design and the underlying messaging formats (EDXL-RM and EDXL-DE), and to identify areas for refinement and further development.

8 Conclusions

Effective management of resources is a crucial part of emergency management, and resource management functionality features prominently in many currently available CIMS products. However, this functionality is mainly concerned with the management of resources in a single organisation (for example, management of the organisation's inventory and real-time tracking of its deployed resources). There is currently a push, particularly in the United States and Australia, towards more open systems that better support cross-organisational cooperation. Many CIMS products have already implemented information standards such as the Common Alerting Protocol (CAP), but to date there have been no suitable standards related to resource management.

This chapter reported on a proposed OASIS standard to support the exchange of resource-related messages (EDXL-RM), and also on a prototypical Resource Management System that we are developing based on the standard. Our prototype demonstrates the potential of structured resource messages to automate some aspects of resource management, to

reduce the ambiguity of messages, and to improve the tracking of pending resource requests. It also demonstrates flexible types of message routing which enable opportunistic resource discovery and address the communication challenges we have observed in Disaster Coordination Centres during emergency exercises. Although further research and validation is needed – both for our proposed RMS design and the current EDXL-RM specification – this work sets the future direction for standards-based RMS implementations.

9 Acknowledgements

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