Development of a Design Patterns Catalog for Web-based Emergency Management Systems

Pablo Acuña
Departamento de Informática
Universidad Carlos III de Madrid
pacuna@inf.uc3m.es

Paloma Díaz
Departamento de Informática
Universidad Carlos III de Madrid
pdp@inf.uc3m.es

Ignacio Aedo
Departamento de Informática
Universidad Carlos III de Madrid
aedo@ia.uc3m.es

ABSTRACT

The design of Emergency Management Systems is an activity that requires knowledge from various related domains for providing a more complete and usable solution. In this context, design patterns including knowledge from previous experiences can be a useful source of information to support the development of this type of applications. In this paper, we introduce a catalog of design patterns for Web-based Emergency Management Systems collected from design principles, design patterns and existing implementations from involved areas, taking into account requirements particular to this domain.

Keywords

Design patterns, Web design, Information sharing, HCI, Emergency Management Systems

INTRODUCTION

Design patterns collect solutions to common and recurrent problems within a context to record and communicate design knowledge and support the design process (Dearden and Finlay, 2006). In comparison to other forms of design guidance, such as design principles, guidelines or heuristics, design patterns identify specific solutions using real examples so that they rely on real design experience (Díaz, Rosson, Aedo and Carroll, 2009). Our aim is to build up a catalog of design patterns for Web-based Emergency Management Systems (hereafter called WEMS) that compiles the experience distilled from existing implementations and design guidelines in this domain, as well as knowledge and expertise from technological areas involved in the implementation of this kind of systems, including Web sites design (Van Duyne, Landay and Hong, 2007; Graham, 2003), security, accessibility, interaction design (Borchers, 2001) and collaborative environments. The work in progress described in this paper is an evolution of the patterns described in Montells, Montero, Díaz and Aedo (2007) that compiled general purpose design knowledge about WEMS. Our patterns are based on a set of requirements extracted from literature and existing WEMS that implement recurrent, invariant and proven solutions. We represented these requirements by means of a set of scenarios defined by emergency situation phases and user roles. This way, the catalog follows a structure that takes in consideration the characteristics of different emergency phases and types of users, hence compared to Montells et al., (2007) it is easier to identify the pattern required for each design problem. The paper is structured as follows: in the next section, we describe the patterns mining process we followed for creating our catalog and its groups. Afterwards, we briefly present the patterns of our catalog and finally summarize our conclusions and describe the expected future works.

Reviewing Statement: This paper represents work in progress, an issue for discussion, a case study, best practice or other matters of interest and has been reviewed for clarity, relevance and significance.

DESIGN PATTERNS MINING AND CREATION

In this section, we describe the process we followed for discovering solutions in literature and throughout a set of requirements implemented in existing WEMS. First, we performed a requirements analysis for a set of scenarios by combining emergency situation phases and user roles. An emergency situation can be divided in 4 different phases: Preparedness, Emergency Response, Rehabilitation/Recovery and Mitigation (Klenk, 1997). Roles are defined with respect to the event type and the activities performed by users in an emergency situation. We are mainly interested in two roles described in Turoff, Chumer, Van de Walle and Yao (2004): First Responders, who deal with the event on the set usually accessing information through hand-held devices with limited capacities; and Command Control Operators, who are in charge of coordination, command and control of an event from an operation center usually with more powerful terminals. For obtaining the requirements in each scenario, we analyzed aspects such as information necessities, available data, activities to perform and end-users terminals' capacities. The WEMS analyzed are: ESA6[1], GDACS[2], ReliefWeb[3], SAHANA[4], SIGAME[5] and Ushahidi[6]. Finally, we took into consideration a set of design principles defined in Turoff et al., (2004) that serve as a general guideline in the development of Emergency Management Information Systems (EMIS), dealing with concepts like data structure, information content and display, items authority and freshness, and psychological and sociological factors that contribute with the response of the situation. Our design patterns attempt to describe in a structured way specific implementations of these design principles in WEMS.

The scenarios and the functionalities required for each one are summarized in the following list, where each scenario name is formed by the combination of an abbreviation and a number. First Responders are represented by the abbreviation FR, Command Control Operators by CC, and each emergency phase with a number from 1 to 4 in the order stated previously.

- **Command Control Operators during Preparedness phase (CC1):** during preparation for an upcoming event, operators require understanding the complete situation for making the correct decisions (Schafer, Carroll, Haynes and Abrams, 2008). Activities performed in this phase include access to previously created plans, retrieving contextual data from an event location (demographical, geo-spatial), as well as access to archives for obtaining possible related information from past events. Since this information is time-sensitive, additional information including data source and information *freshness* is required.
- **Command Control Operators during Emergency Operations phase (CC2):** users are presented with a large amount of information constantly updated from individuals and organizations collaborating in the emergency event; users have to understand the situation and the activities that have to be performed, so that Activity Awareness is supported (Carroll, Rosson, Convertino and Ganoe, 2006). Moreover, Command Control Operators are provided with more powerful terminals and have a larger response time, meaning more time to take decisions, allowing them to retrieve additional information related to an event.
- **Command Control Operators during Rehabilitation/Recovery phase (CC3):** operators are required to update and monitor data about an emergency that recently finished. Moreover, users need to be aware of the resulting situation and the activities performed in case collaborating individuals or organizations need additional support actions.
- **Command Control Operators during Mitigation phase (CC4):** users are required to store data generated during past events to serve as a source of information that can contribute in future events response, attaching contextual information in order to contribute in decision support and modeling tools (Carver and Turoff, 2007). Contextual information can also contribute for defining relationships between events and items potentially useful for generating statistical data helpful for future planning and preparedness phases.

---

1 http://www.esa6.com

2 http://www.gdacs.org

3 http://www.reliefweb.int

4 http://www.sahana.lk

5 http://www.sigame.es

6 http://www.ushahidi.com

- **First Responders during Preparedness and Mitigation phases (FR1 and FR4):** Not Applicable in our work since we focus on First Responders acting on the set during an emergency.
- **First Responders during Emergency Operations phase (FR2):** users require being aware of the situation and the activities performed to understand how response is developing and to coordinate collaboration with other responders. First Responders require very precise and concrete data to take quick decisions.
- **First Responders during Rehabilitation/Recovery phase (FR3):** similar to scenario CC3, users require usable and effective input mechanisms for updating data about activities performed during a recently finished event, as well as being able to receive information from other individuals and organizations that could need collaboration with unresolved situations.

From this set of requirements we identified common aspects in order to categorize them and define the pattern groups for our catalog. We noticed that some of the scenarios shared some functionality due to their proximity in time of occurrence or data needed by the end-users, allowing grouping them into abstract requirements that describe more generic problems. First of all, both roles during Emergency Operations and Rehabilitation/Recovery phases (scenarios FR2, FR3, CC2 and CC3) require mechanisms to retrieve, display and update data about the situation and the activities being performed by all collaborators during the event. This can allow end-users to obtain a certain level of *awareness* where "*all participants align and integrate their distributed activities in a seamless way for enabling collaboration*" (Schmidt, 2002). We have therefore defined a group named "Group A: Emergency Response and Recovery" for enabling and supporting awareness during an emergency event response for First Responders and Command Control Operators, composed by patterns that address role specific requirements.

Second, we noticed that operators during Mitigation and Preparedness phase (scenarios CC1 and CC4) have similarities in the requirements with respect to data type and management: users in scenario CC4 require mechanisms for effectively storing data from a recent event in the archives, and users in scenario CC1 require mechanisms for accessing stored data from the archives for making correct decisions in an upcoming event. These scenarios deal with information storage and access of an emergency event data; therefore, we defined a group named "Group B: Planning and Mitigation" for addressing requirements of data archives and decision support tools.

Finally, we noticed there are similarities in the requirements across scenarios with respect to information retrieval and display regardless the devices used for accessing the WEMS. Hence, we defined two groups that address these requirements: a group named "Group C: Information Management" for addressing problems with respect to data presentation and interaction; and "Group D: Access for All", for describing accessibility techniques and mechanisms to support access to WEMS through different terminals and devices with diverse capacities. Groups C and D are thought as traversal groups that include solutions applicable to many situations. Solutions from Group C are defined with a lower abstraction level that allows combining them for providing more complex solutions. On the other hand, Group D solutions include accessibility techniques applicable to *all* scenarios.

THE PATTERNS CATALOG

Within the 4 patterns groups listed above, we were able to define 19 design patterns that describe common practices in WEMS design. Each group of patterns is identified with a letter, and each design pattern with a name and a short-code composed by the letter of its group and a sequential number. This way, first pattern from group A is identified with "A.1", second pattern with "A.2" and so on. The design patterns defined are summarized in the following list:

Group A: Emergency Response and Recovery

A.1. Awareness for First Responders: deals with First Responders' requirements of fast, dynamic and accessible interfaces for retrieving data about a current event, improving their knowledge about the situation and allowing the access to the system through hand-held devices.

A.2. Awareness for Command Control Operators: deals with Command Control Operators' requirements for having awareness of the situation and activities performed by collaborators. Operators should be able to retrieve additional data for helping solving the emergency event.

Group B: Planning and Mitigation

B.1. Decision Support Systems for Planning: describes mechanisms to present users with all possible and potentially related information to support decision making for an upcoming event.

B.2. Collective Memory / Data Archives: presents mechanisms for efficient storage and retrieval of information from the archives in order to serve as a source of collective memory for future events.

Group C: Information Management

C.1. Information Presentation: describes tabular presentation for including items with different data types and attaching actions to them.

C.2. Map-based Navigation: describes a map-based schema to present information allowing display of data items in a particular location.

C.3. Search, Sort and Filter Information: presents mechanisms for searching, ordering and filtering data displayed in both presentation schemes described in patterns C.1 and C.2.

C.4. Data Authoring: describes ways for attaching author and source information to each data item with identification purposes, in order to enhance knowledge of the complete set.

C.5. Up-to-date data: presents mechanisms for presenting constantly updated data to users in a manual or automatic way, reloading the complete page or only a portion of it.

C.6. Contextual and Related Data: presents techniques for retrieving and displaying contextual and related data of items in a non-obtrusive way.

C.7. Extended Data: presents techniques for allowing users retrieving additional data of an item.

C.8. Alert Notifications: describes usage of notifications for alerting users about potentially related data or events.

C.9. Fast-loading Pages: describes techniques for speeding up loading time of pages presented to users.

C.10. Contextual Help: describes techniques for presenting users with contextual help for preventing errors in data input or retrieval.

C.11. Direct Manipulation: describes techniques for allowing users manipulate directly and intuitively the elements in a page, considering its limitations and capabilities.

Group D: Access For All

D.1. Style Sheets for Multiple Media Types: describes the use of Cascading Style Sheets (CSS) for enabling development for multiple media and devices.

D.2. Pages Accessibility: summarizes standard techniques for enhancing Accessibility support in Web pages.

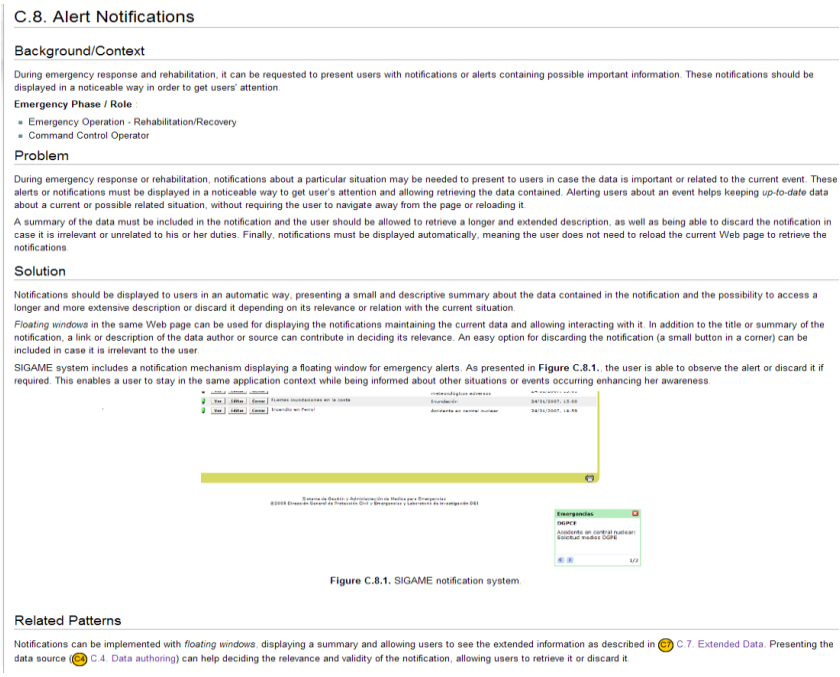
D.3. Printable Pages: presents techniques for presenting print versions of Web pages.

D.4. Hand-held Devices: summarizes mechanisms for supporting access from hand-held devices.

In Figure 1 below we include a design pattern example from our catalog. All patterns follow a structure that includes a background/context describing the scope of the problem, a problem statement, a solution description with examples taken from the WEMS analyzed, and a related patterns section describing all groups and design patterns that can contribute in a more complete solution.

CONCLUSIONS AND FUTURE WORKS

In this paper we present our work in the definition of a valid and useful design patterns catalog for WEMS, in our attempt to collect invariant solutions to recurrent problems in order to enhance knowledge communication and sharing among collaborators in a participatory design process. As future work, we expect to validate the utility and efficiency of our patterns catalog for describing and sharing design knowledge through an evaluation to individuals related in the development cycle of WEMS. Finally, since our catalog is deployed in a Web-based collaborative tool that allows edition and navigation, we expect it to enable participation from individuals involved in the development of WEMS to enhance the content of the patterns catalog, extending it with new patterns or improving existing ones.



C.8. Alert Notifications

Background/Context

During emergency response and rehabilitation, it can be requested to present users with notifications or alerts containing possible important information. These notifications should be displayed in a noticeable way in order to get users' attention.

Emergency Phase / Role

- Emergency Operation - Rehabilitation/Recovery
- Command Control Operator

Problem

During emergency response or rehabilitation, notifications about a particular situation may be needed to present to users in case the data is important or related to the current event. These alerts or notifications must be displayed in a noticeable way to get user's attention and allowing retrieving the data contained. Alerting users about an event helps keeping *up-to-date* data about a current or possible related situation, without requiring the user to navigate away from the page or reloading it.

A summary of the data must be included in the notification and the user should be allowed to retrieve a longer and extended description, as well as being able to discard the notification in case it is irrelevant or unrelated to his or her duties. Finally, notifications must be displayed automatically, meaning the user does not need to reload the current Web page to retrieve the notifications.

Solution

Notifications should be displayed to users in an automatic way, presenting a small and descriptive summary about the data contained in the notification and the possibility to access a longer and more extensive description or discard it depending on its relevance or relation with the current situation.

Floating windows in the same Web page can be used for displaying the notifications maintaining the current data and allowing interacting with it. In addition to the title or summary of the notification, a link or description of the data author or source can contribute in deciding its relevance. An easy option for discarding the notification (a small button in a corner) can be included in case it is irrelevant to the user.

SIGAME system includes a notification mechanism displaying a floating window for emergency alerts. As presented in **Figure C.8.1.**, the user is able to observe the alert or discard it if required. This enables a user to stay in the same application context while being informed about other situations or events occurring enhancing her awareness.

Figure C.8.1. SIGAME notification system.

Related Patterns

Notifications can be implemented with *floating windows*, displaying a summary and allowing users to see the extended information as described in C.7. Extended Data. Presenting the data source (C.4. C.4. Data authoring) can help deciding the relevance and validity of the notification, allowing users to retrieve it or discard it.

Figure 1. Design Pattern example

ACKNOWLEDGMENTS

This work has been partially supported by project IUA4SIGE (Ministerio de Educación y Ciencia 2007/04318/001).

REFERENCES

1. Borchers, J. (2001) A Pattern Approach to Interaction Design, AI & Society, 15, 359-376.
2. Carroll, J.M., Rosson, M.B., Convertino, G. and Ganoe C. (2006) Awareness and teamwork in computer-supported collaborations, Interacting with Computers, 18, 1, 21-46.
3. Carver, L. and Turoff, M. (2007) Human-Computer Interaction: The Human and Computer as a Team in Emergency Management Information Systems, Communications of the ACM, 50, 3, 33-38.
4. Dearden, A. and Finlay, J. (2006) Pattern Languages in HCI: A Critical Review, Human-Computer Interaction, 21, 49-102.
5. Díaz, P., Rosson, M.B., Aedo, I. and Carroll, J. (2009). Web Design Patterns: Investigating User Goals and Browsing Strategies. IS-EUD 2009: 186-204
6. Graham, I. (2003) A Pattern Language for Web Usability, Addison-Wesley.
7. Klenk, J. (1997) Emergency Information Management and Telecommunications, UN Disaster Management Training Programme, DHA.
8. Montells, L., Montero, S., Díaz, P. and Aedo, I. (2007) Mining Patterns for Web-based Emergency Management Systems, Proceedings of the 4th International ISCRAM conference, Delft, The Netherlands.
9. Schafer, W., Carroll, J.M., Haynes, S. and Abrams S. (2008) Emergency Management as Collaborative Community Work, Journal of Homeland Security and Emergency Management, 5, 1, Art. 10.
10. Schmidt, K. (2002) The Problem with 'Awareness', Computer Supported Cooperative Work, 11, 285-298.
11. Turoff, M., Chumer, B., Van de Walle, B. and Yao, X. (2004) The Design of a Dynamic Emergency Response Management Information System (DERMIS), Journal of Information Technology Theory and Applications, 5, 4, 1-36.
12. Van Duyne, D.K., Landay, J. and Hong, J. (2007) The design of Sites (2nd Edition), Prentice-Hall, Inc.