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Autonomous Notification and Situation Reporting for Flood Disaster Management

Ku Ruhana Ku-Mahamud (Corresponding author)

College of Arts and Science

Universiti Utara Malaysia

06010 Sintok Kedah, Malaysia

Tel: 604-9284717 E-mail: ruhana@uum.edu.my

Norita Md Norwawi

College of Arts and Science

Universiti Utara Malaysia

06010 Sintok Kedah, Malaysia

Tel: 604-9284788 E-mail: nmn@uum.edu.my

Norliza Katuk

College of Arts and Science

Universiti Utara Malaysia

06010 Sintok Kedah, Malaysia

Tel: 604-9284660 E-mail: k.norliza@uum.edu.my

Safaai Deris

Faculty of Computer Science and Information Science

Universiti Teknologi Malaysia

83130 Skudai Johor, Malaysia

Tel: 607-5532343 E-mail: safaai@utm.my

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Abstract

Failed management in emergency response effort due to inefficient and ineffective operation influences the adoption of information and communication technology specifically the Internet technology and World Wide Web. Timeliness, rapid response and efficient information dissemination are crucial in emergency management. This paper proposes a software design architecture taking advantage of the intelligent agent technology to facilitate autonomous notification and auto generates situation report. The adoption of agent technology has made it possible to produce scheduled report with standardized format that can reduce duplications and redundancies of information.

Keywords: Disaster management system, Intelligent agent, Emergency communication, Integrated reporting

1. Introduction

Emergency situations resulting from natural disasters such as flood, tsunami and earthquake represent complex and dynamic environments with high level of uncertainty. These are critical situations where human lives and properties are at stake. With the advancement of information and communication technology (ICT) especially widespread use of Internet and World Wide Web (WWW), improvement on the efficiency and effectiveness of the management of emergency is

possible. The emergency response operation can be enhanced through better coordination and communication among involved agencies by the adoption of ICT, in particular through the use of artificial intelligence which is suitable for dynamic, unpredictable and uncertain situations.

Emergency management in general consists of various phases such as preparation, mitigation, response, recovery and learning. In the preparation phase, a warning system is usually designed with mechanism for threat recognition, threat evaluation and alerting mechanism (Norwawi, 2004). However, there are reports on failure and inadequacy of warning systems which is self-defeating (Chan, 1997). Inefficient coordination among authorities and warnings which are issued on an ad-hoc basis are the main reasons for the warning failures (Chan, 1997).

Fedra (1999) developed a decision-support system (DSS) using high performance and networking technologies to improve the planning and operational decision-making process where the requirements are timeliness, accurate, directly understandable, usable and easily obtained. A similar network approach was also adopted by Bui and Sankaran (2001) taking advantage of the ICT specifically Internet, inter-platform connectivity software, group decision theoretical progress where large number of data can be processed, facilitating faster decision-making and high level of objectivity in decisions made. They proposed the concept of virtual information centre with a web centric management system.

Some examples of the application of the Internet technology specifically the WWW, is the South Asia Flood website which provides the platform in information sharing for the Hindu Kush Himalayan Region aimed at promoting regional cooperation (Shresta, 2002). Hospitals were also reported using web based disaster management system that is accessible from desktop, laptop and mobile computers located at place designated as the command and control centre (McGee, 2005).

Taking into consideration that stress and pressures could influence and deteriorate human decision-making capability, an interactive assisted technology could offer significant benefit through its ability to give guidelines and recommendations to emergency managers. Iba and Gervasio (1999) claimed that an assisted technology has better advantage than an automation technology. Human expert is still a very important element in the decision system being a part of a socio-technical system linking people, organization, machine and computers (Norwawi, 2004). This is made possible through the application of software agents which is a computational entity that can be implemented in complex system due to its special characteristics such as autonomous, proactive, reactive, adaptive and sociable. A society of autonomous agents or better known as multiagent system can be developed where the agents can organize themselves in achieving a common goal. Norwawi (2004) discussed the matching characteristics between emergency environment and multiagent system which includes the multi organization and level of jurisdiction. These similar characteristics enable the multiagent system to be a natural representation of the roles in an emergency management.

Multiagent environment consists of multiple software agents working together to accomplish specific objective. An agent can be described as a computer program that performs some information gathering and holds very well-defined objectives of its creation. In computer science, agent has a very significant role especially in performing complex tasks in an application. Agents must be aware of their own capabilities and of changes to other agents and their environment. To remain effective, agents must be able to adapt their structures and knowledge while they execute. In order to achieve some objectives, systems employ a set of agents that are autonomous, proactive, adaptive, and reactive (Guessoum & Briot, 1999; Wooldridge & Jennings, 1995). Each agent has its own competencies and knowledge, but it needs to interact with other agents to solve complex problems, avoid conflicts, acquire and share information, and so on (Guessoum, 2004). The intelligent characteristics own by the multiagent will ensure that the complex tasks in flood management can be implemented in the most efficient way. The multiagent plays a very important role especially in predicting flood and notifying related people in flood management. During the emergency, fast and immediate response are highly needed to assist and evacuate victims. It also interacts and communicates with each other so that the functions can be performed faster.

Due to the above discussion, this study has develop a web-based flood management system that integrates intelligent features such as autonomous notification and auto-generate situation report that can be scheduled accordingly by the emergency management authority. This work is possible by adopting an intelligent agent technology, a software agent that can decide when to notify, to integrate reports from various agencies, auto-generate the report and sending it to all parties involved. The main aim of this paper is to present the software architecture for the notification and situation reporting embedded in a web based flood management system.

2. Web based flood management architecture

This study has adopted a multi methodological approach integrating the design research methodology (Hevner et al., 2004) with knowledge engineering. The first major step in KE specifically the knowledge acquisition activity consists of four major steps: planning of the knowledge acquisition sessions, extraction of knowledge, analyze the knowledge acquired and knowledge verification with the domain experts (Liou, 1992).

The state of Kedah in Malaysia is taken as a case study since flood is the most common natural disaster and frequently occurs during the wet season. In Malaysia a flood management committee (FMC) is formed at the district, state and national level depending on the magnitude of the flood. In this study, interviews with the agencies involved such as the National Security Division (BKN) and Social Welfare Department, were conducted to get an overview of the flood management operation. Among the problems highlighted were the difficulties in managing and distributing reports from various agencies involved to those interested parties. The cause of this difficulties were the use of facsimile machine, non-standardized report formatting, delay, duplication and even inconsistencies in the reported items. The second problem highlighted was that information dissemination among public is not well distributed.

The analysis and design for the web-based flood management system have been accomplished by following standard notation for object-oriented graphical modeling. This research has produced use case diagrams, activity diagrams, collaboration diagrams, sequence diagrams and class diagrams. All diagrams which have been mentioned representing different behavioral and structural of the system. The web-based flood management system consists of six use cases and three actors. Figure 1 illustrates the general use case diagram for web-based flood management system which has been design using Rational Rose 2000 software. The flooding phases are represented by use cases as depicted in Table 1.

Multiagent concept has been utilized in during pre-flood phase whereby two agents have been used for the purpose of assessing potential flooding and notifying the flood committee members. An agent has also been used for flood report generation during flooding and report generation after the flooding. For the purpose of assessing the potential flooding, the agent was given a name as Situation Assessment Agent and Notification Agent for agent responsible in sending notification.

3. The multiagent architecture

In this study, three agents have been initiated. The agents are for situation assessment, notification and report generating. Figure 2 shows the architecture which includes the interaction and communication between agents in the three phases of flooding. The process is initiated by the situation assessment agent that retrieves the hydrological data from the Drainage and Irrigation Department (DID) database. The agent will use current water level for each river in certain district and compare with the corresponding normal water level. Based on the water level and rainfall measurement, the agent can predict potential flooding. The agent monitors the situation for 24 hours a day. If there is a potential flooding, then a signal will be sent to the notification agent.

Figure 3 illustrates the situation assessment activity diagram. Upon receiving the message from situation assessment agent, the notification agent will create a message containing details regarding the location of potential flood. The message will be sent in the form of SMS and email. The two agents work together in the pre-flood phase. When a message is received by the Notification Agent, it will obtain information of corresponding flood committee members from the database. The phone numbers and the emails of the involved district flood committee members are used to notify the potential flooding. The Notification Agent will compose message in the form of SMS and email which contain the area of potential flooding and the nearest river water level reading. Next, the notification agent will also activate the virtual emergency operation centre EOC in order to allow the flood management committee to utilize the online flood management system as shown in Figure 4.

The Report Generation Agent is created for report generation. This agent will gather data from database and compile the report according to specific subject as required by users. Reports are presented in the form of Microsoft Office Document which later can be saved in hard disk and also can be directly printed. During flooding, the report generator agent will begin its activity once EOC is activated. This agent will gather information regarding the current flood occurrence and generate report in a printer-friendly form. The types of report generated in this phase will depend on the users' request. The report generated in this phase will be stored in the database and will be used to generate the formal post-mortem report. Figure 5 illustrates the interaction between agents with messages that need to be sent for the Situation Assessment Agent, Notification Agent and Report Generator Agent in this flood management system.

The autonomous notification and situation reporting functions have been integrated in web-based Flood Management System that has been developed using Active Server Page technology on the Microsoft platform. Figure 6 shows the screen shot of the system's main page.

4. Conclusion

Agent technology has demonstrated to be useful in facilitating faster notification and generating situational report through its autonomous, reactive and proactive characteristics. It helps in improving the emergency management operation through better communication and coordination via the Internet technology specifically the WWW. It will provide an anytime anywhere technology capability for the emergency managers and the public providing better access to information for the purpose of decision-making, planning and operating procedures. The agents used in this study have efficiently decreased the time in manual processes for notifying the related agencies of flooding situation.

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Table 1. Flooding Phase and Use Case

Phase	Use Case
Pre-Flooding	Manage Administration, Manage Preparedness Operation, Authenticate User
During Flooding	Manage Response Operation, Authenticate User
Post-Flooding	Manage Recovery Operation, Generate Flood Response Operation Report, Authenticate User

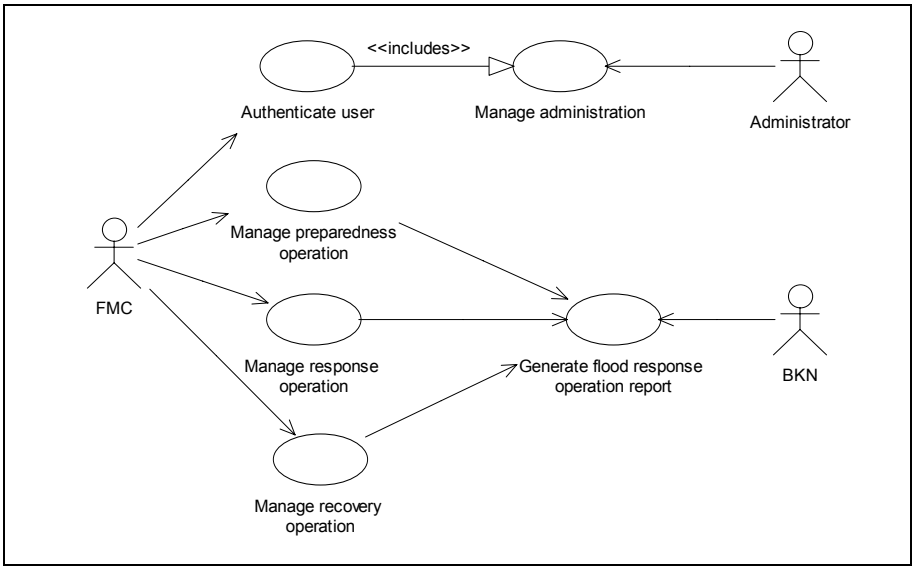

Figure 1. General Use Case Diagram for Web-based Flood Management System

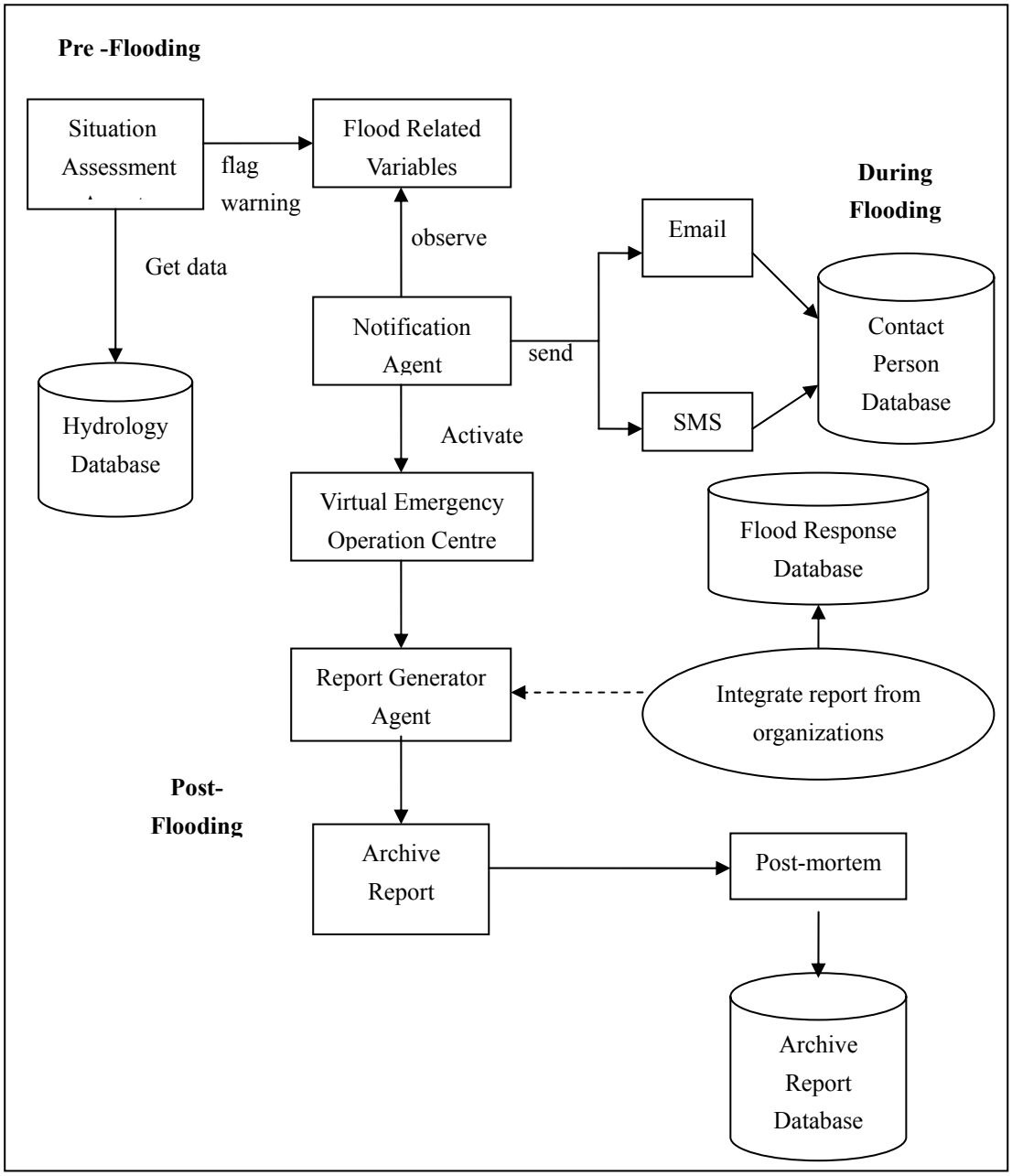

Figure 2. Multiagent Architecture for Flood Management System

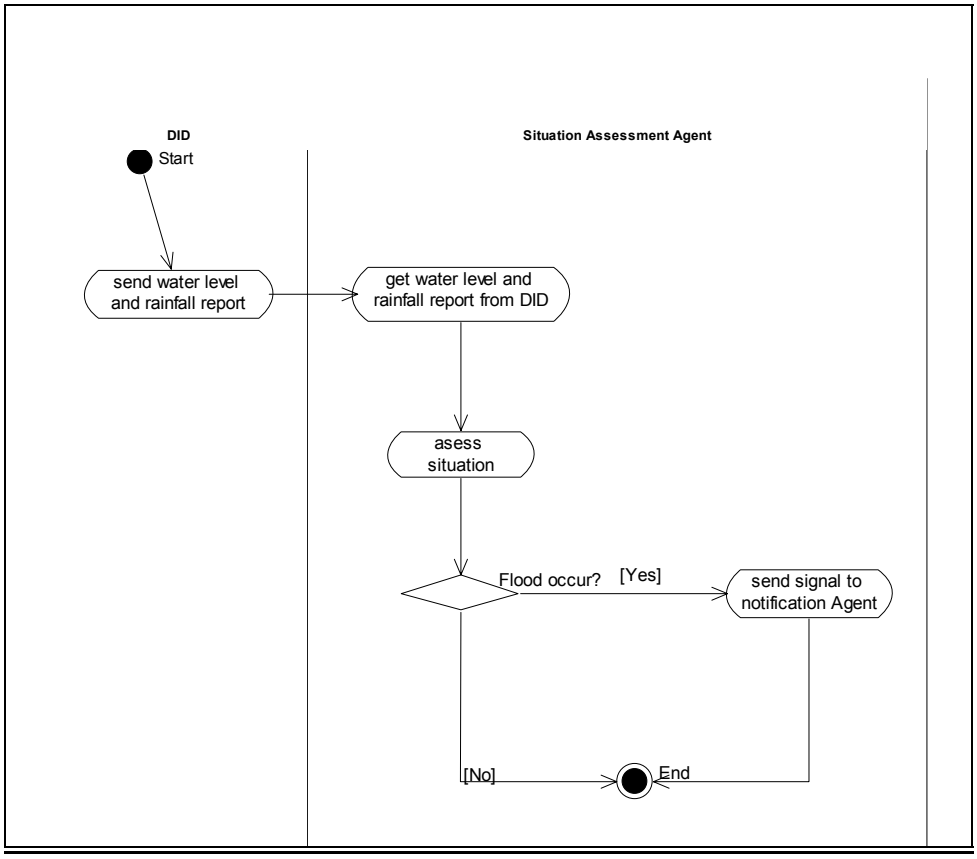

Figure 3. Activity Diagram for Situation Assessment Agent

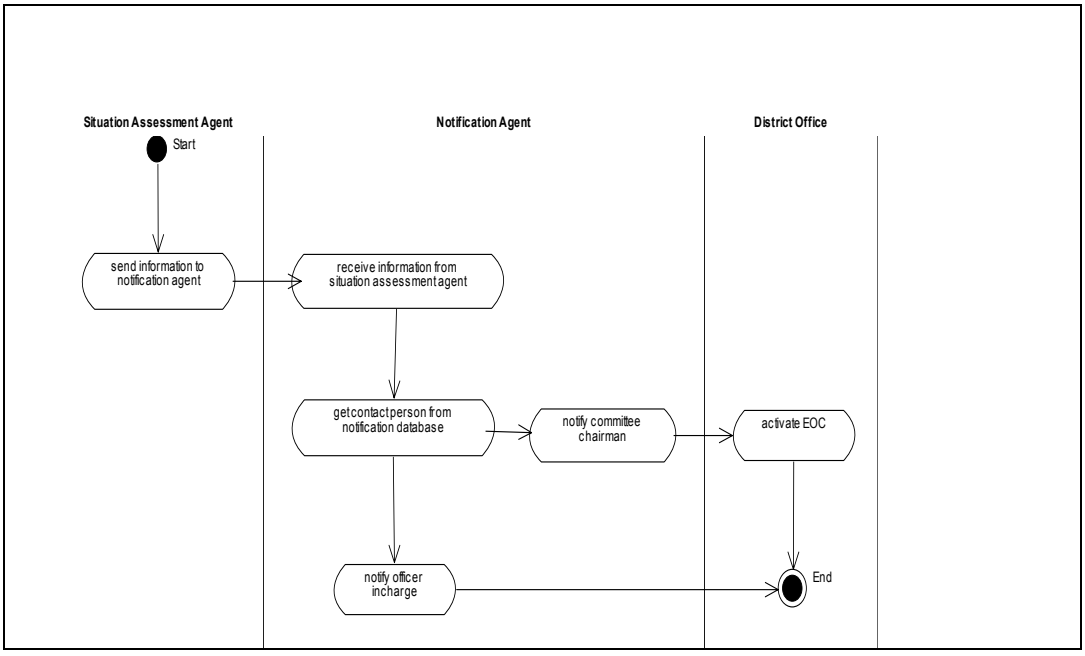

Figure 4. Activity Diagram for Notification Agent

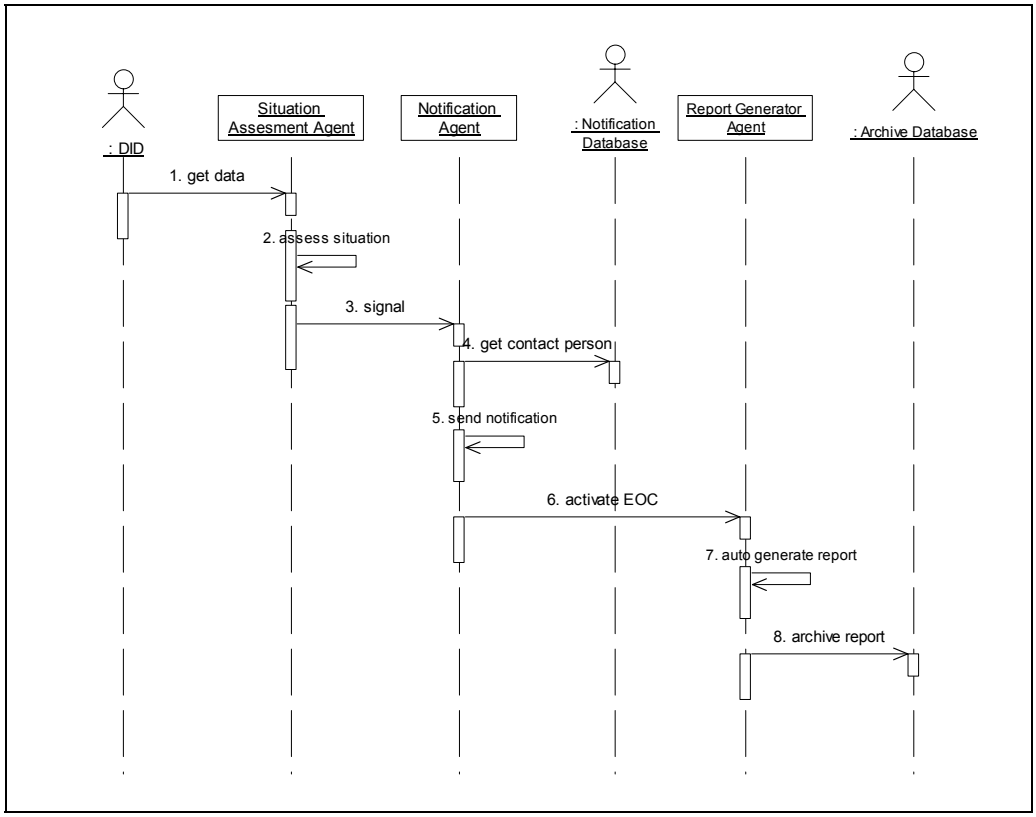

Figure 5. Sequence Diagram for Web-based Flood Management System

Figure 6. Screen shot for web-based flood response system