Crisis Management using Mobile ad-hoc Wireless Networks

Bogdan Tatomir
Delft University of Technology, NL
B.Tatomir@ewi.tudelft.nl

Leon Rothkrantz
Delft University of Technology, NL
L.J.M.Rothkrantz@ewi.tudelft.nl

ABSTRACT

In this paper we describe a disaster management system. It is assumed that each individual in the field is equipped with a PDA (Personal Digital Assistant) and that can communicate with other PDAs in the vicinity. Together the PDAs form an ad-hoc network. Users can enter their own observations to the PDA, like the position of victims, or a description of the current situation at particular location (e.g. smoke, emergency exits, traffic congestion). This information is entered in a special iconic language. Reversibly, the PDAs inform the users on the overall current situation of the crisis. In order to come to a shared view of the world, the knowledge that is present in the network has to be shared and fused. The proposed way to communicate is via a shared blackboard. This approach facilitates communication in a time and place independent way.

Keywords

PDA, wireless communication, ad-hoc network, distributed blackboard, icons.

INTRODUCTION

A complex chaotic world is characterized by always changing environments and events caused by unexpected autonomous causes. To control such an environment and taking appropriate decisions is a far from trivial problem. One of the main reasons is the lack of reliable, complete up to date information, caused by poor communication. An extreme example of such a situation was the now famous terror attack on September 11 in New York, which created an environment of uncertainty.

At DECIS Lab Delft (Delft Cooperation on Intelligent Systems) there is a project running concerning Multi-agent based intelligent network decision support systems in a chaotic open world (COMBINED). A general overview of this project was presented in (Burghardt and Storms, 2004). In (Oomes, 2004) talks about organization awareness in crisis management.

GOAL

In this paper we will focus on solving the problems caused by the communication breakdown. Our approach to solve these problems, related to chaotic situations is smart communication. A digital assistant will play a key role in our research. We assume that our actors in the combined system communicate in different ways, using computer networks, GSM etc. To improve the communication and to solve the problems mentioned above, we add a new device, a handheld, connected by a wireless network. Key actors in the combined system will be connected and represented as agents in a virtual communication layer, based on an ad hoc wireless network. The actors and their digital representatives are clustered. We assume that the clusters are overlapping or there is a communication link between the clusters. Clusters have a virtual representative. This virtual representative is then connecting with other clusters, networks and computing devices. The next layer is composed of agents and services (with or without agent interface, see Figure 1). There are communication links intra/inter clouds and layers.

ARHITECTURE

We consider the architecture of a distributed system that is designed to handle non-deterministic environment of crisis management. The entire system is cooperation between layers of decision making, where each has its own specific issues to deal with. On the bottom level, the participants are leaves in the decision hierarchy: digital assistants connected together through a wireless network (see Figure 2).

A crucial behavior of an agent is that it communicates. So an agent will report about his observations, plans, actions and results. This information becomes available in the agent community via a virtual communication layer using the "blackboard technique". The blackboard will be implemented in our wireless, ad-hoc connected networks. So our handheld will be used for human computer interaction-services, local processing and storing activities and for network facilities.

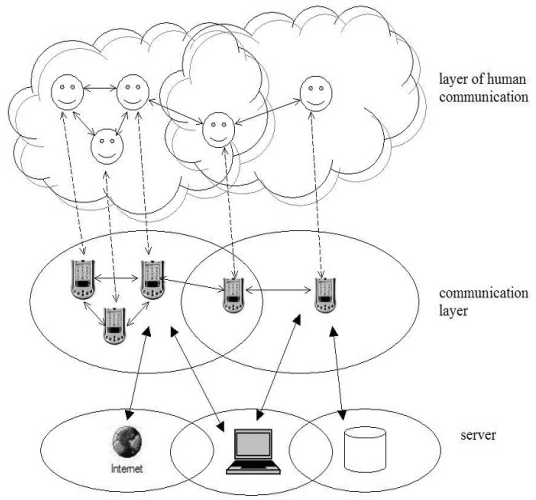

Figure 1. Overview of actors, agents and services

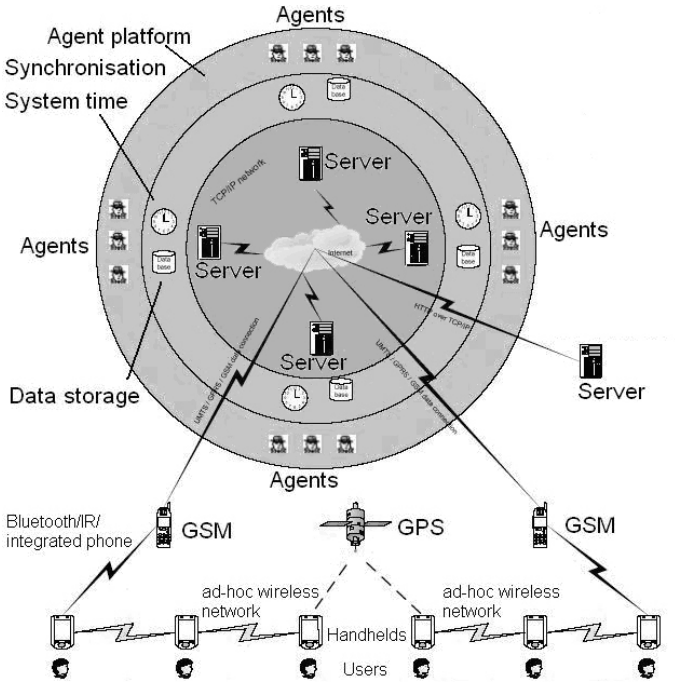

Figure 2. Architecture of the system

For MANETs the approach of blackboards seems to be difficult to implement, although the concept could facilitate easy communication between the different nodes. The difficulties are in how to provide the functions that the blackboard should offer the user, such as the possibility of adding, removing and updating data, but also in the management of the data (e.g. combining and resolving conflicts) on the blackboard. The difficulty arises from the fact that data is distributed over nodes that might not be able to reach each other from time to time. A challenge is to find out how to store and retrieve information in ad hoc, distributed, and loosely connected networks. On the one side it is impossible to copy all the information to every node and from the other side the information should be available, if some node is disconnected. The network should have a recovery mechanism. One way to realize that is to provide neighboring nodes with partial but redundant information. If some node with information is disconnected the other nodes start a copying process.

However, a blackboard facilitates accessing data independent of location and time. These two aspects make blackboards suitable for MANETs.

WORLD MODELING

Let's focus now on the information which will be provided to be shared on the blackboard. There is a great variation of modalities and modes in the communication between the actors in the combined system. Human agents are used to verbal or written communication. Cameras will send the recorded pictures and sensors a simple coded message. The communication layer and network in the Combined system should be robust and fast content of the messages should not ambiguous, compact and easy to process. To realize human friendly HCI and unambiguous communication a special crisis language was developed. This language is not based on usual text but on icons. The icons represent a concept, i.e. smoke, fire, explosion, car, and people. To use strings of icons a special syntax and grammar was developed.

Iconic communication

In a crisis situation, there is a big chance to have a noisy background, so that speech recognition is not a very good choice. The communication based on icons offers many advantages:

- The PDA's are not equipped with external keyboard, so icon selection by stylus is a useful alternative. They are easy to use and to transport, and can be placed anywhere in the field, and they facilitate enormously the transmission of information.

- The communication through the icons is a fast one. The meaning of an icon is being extracted immediately, as being basic concepts and it is a 100% visual method in sending the information. And usually, this visual way of communication, is the most developed one in the human being.
- A string of icons can be converted to text using any language and furthermore, using speech synthesis, it can be spoken aloud in any language. The motive is that icons are independent from any language, and they need no translation, because they are self-explaining.
- It is easy to learn, needing just the activation of our intuitive part; it is simple, modular based, has limited words and grammar rules, but rich enough to talk/report about a crisis.

Design

We designed the interface to be used for the transmission of information from a PDA. We have defined 108 icons and grouped them into fourteen icon categories, according to their meaning. The icons were chosen based on reflexion, logic, common sense, considering the situations some objects are important. Each one of the icon categories has a representative icon (e.g. Figures 3 and 4) that shows the main characteristics, being like a hint for the 'background' list.

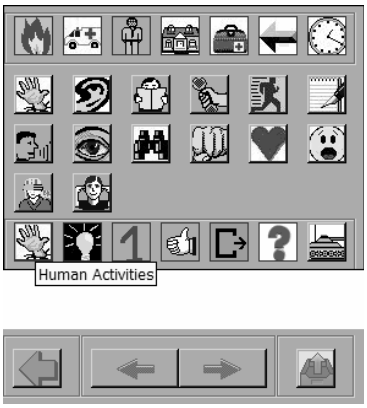

Figure 3. Categories of icons and the subcategory of human actions

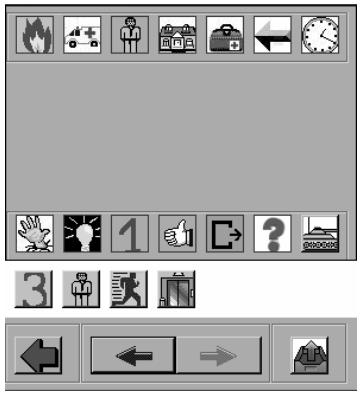

Figure 4. A sentence of icons: 3 men run towards the elevator

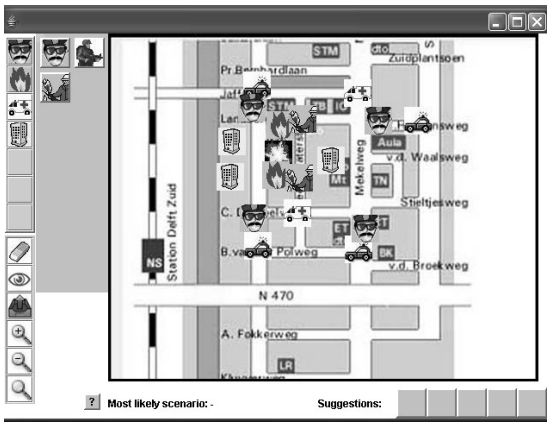

Figure 5. Icon map interface

Icon-map

The icons can be use just to report about the situation on the field. The observations provided in this way are subjective. They depend on time and place. A lot of ambiguity is introduced in this way. Just chatting with icons it's very hard to talk about locations. To solve this ambiguity we decided it could be useful to incorporate a map of the surroundings (Schooneman, 2005). In a communication system for emergency services it is important to indicate locations (see Figure 5).

The system should be used by the emergency services to keep each other up to date about what's going in a particular area, e.g. a city, by placing icons on the map and sending them to each other. We want a system that is intelligent, in the sense that it can deal with icons that are received multiple times, cope with icons that might be missing and icons that might be placed wrongly. If icons are received multiple times, the system should be able to handle this on its own, without human interference. In the other cases however it is very hard and dangerous to let the system delete, modify or add icons to its world model without human approval. Therefore the system should be able to ask for feedback to the users, if it detects an error might have occurred. Again these errors are based on our own beliefs about crisis situations, and might be different from reality.

REFERENCES

1. Burghardt, P. (2004) The COMBINED SYSTEMS point of view on Crisis Management, *Proceedings of the First International Workshop on Information Systems for Crisis Response and Management*, Brussels, 51-56.
2. Oomes, A. (2004) Organization Awareness in Crisis Management: dynamic organigrams for more effective disaster response, *Proceedings of the First International Workshop on Information Systems for Crisis Response and Management*, Brussels, 63-68.
3. Schooneman, P. (2005) ISME – Icon based System for Managing Emergencies, *Master Thesis*, Delft.
4. Storms, P. (2004) Combined systems - a system of systems Architecture, *Proceedings of the First International Workshop on Information Systems for Crisis Response and Management*, Brussels, 139-144.