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Agent-Based Coalition Formation in Disaster Response Applications

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***Abstract*— We present an agent-based coalition formation approach for disaster response applications. We assume that agents are operating in a dynamic and dangerous environment, and they need to form convoys to traverse unsafe areas. We introduce a commitment-based convoy model, where the commitments are negotiated between the participant agents. We show that this leads to a complex multi-issue negotiation, with two spatial and two temporal components. We propose an approach for reducing the negotiation space through the creation of discrete offer points, and describe a possible negotiation flow. We validate the model in a scenario using the map of New Orleans flooded by hurricane Katrina.**

***Index Terms*— coalition formation, embodied agent, convoy formation, disaster management**

1. Introduction

Efficient disaster response requires participants to form teams and coordinate their actions. This process is complicated by a variety of factors:

Dynamic, unpredictable and dangerous environment. In the immediate aftermath of a disaster (such as the hurricane Katrina in New Orleans or the asian tsunami) previously safe areas might become dangerous or unaccessible. The environment might contain new sources of danger in the form of natural obstacles (damaged buildings) or even hostile agents (such as looters or stray dogs).

Dynamic tasks. In rescue missions, tasks appear unpredictably. The discovery of a wounded person at a dangerous location creates a new task with specific logistics, protection and medical aspects. In severe disasters, the number of tasks can greatly exceed the available resources. Occasionally, tasks need to be preempted for higher priority tasks.

Dynamic teams and collaboration patterns. Although some disaster management teams are pre-established, trained together and have a clear pattern of command and control, many teams are assembled on an ad hoc basis, as a response to emerging tasks. Teams are composed from heterogeneous groups of entities: persons, vehicles, service animals, and so on. Team members might not report to the same chain of command, might have communication problems and their interests might not be completely aligned. For instance, the state police and guerilla groups might cooperate in a rescue operation but resume hostilities after the emergency.

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Breakdown in communication lines. In many environments, we normally assume that there is a full connectivity of the mobile agents. Police units normally maintain connection to a central dispatcher over dedicated frequencies. Although it is desirable to maintain this organization in a disaster area as well, in practice, this centralized communication frequently breaks down. For instance, after hurricane Katrina, the policy could use their radios only as pair-to-pair walkie talkies. This prevents the collection global information and centralized command of operations.

Our research group at the Networking and Mobile Computing (NetMoc) laboratory at University of Central Florida is working on a negotiation based coalition formation approach which can be used to assemble ad hoc coalitions in an emergency management scenario. In this paper, we are concentrating on the negotiation regarding convoy formation for mobility in a dangerous environment.

Our assumption in this paper is that forming convoys is always advantageous. This assumption holds in many instances in disaster response applications; for instance many organizations instruct their workers not to go alone in dangerous area. There are, however, several worthwhile exceptions. For instance, a damaged bridge of limited bearing capability might only hold a small number of agents. In other situations it might be necessary to reduce the size of the convoy for achieving stealth or to prevent alarming or offending the local population. Thus, the utility of the convoy might not be superadditive (or even monotonically increasing) with the number of participants. For instance, the stealth of a convoy decreases with its size. These issues are subject of future research of our group.

The environment considered in this paper assumes a 2-dimensional geographic area, where we identify: *safe areas* which are traversable by any agent, *danger areas* which are traversable only by convoys and *unaccessible areas*. The model can be extended in a straightforward way to involve more than three area types which affect the movement of the vehicles in a variety of ways (such as slowing down, requiring higher energy consumption, and so on). In this environment, we consider the actions of a set of *embodied agents*, which have a well-defined physical location and movement capabilities. In practice, these agents can be "RAP" (Robots, Agents and/or Persons). The goal of every agent is to reach a destination location. Beyond disaster rescue, these types of scenarios arise in other applications as well, such as military operations in urban terrain.