Scaling-up Support for Emergency Response Organizations

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ABSTRACT

We present the design of an information system that supports the process of scaling-up of emergency response organizations. This process is vital for effective emergency response but tends to go awry in practice. Our proposed system consists of multiple distributed agents that are capable of exchanging organizational information. Each agent assists one part of the organization by visualizing the organization and allowing the user to update the information of its closest collaborators. When the agents communicate, they exchange and merge their organizational representations. The structure of other parts of the organization is updated indirectly through multiple interactions between different agents. We tailor our design to two specific procedures that are in common use today: the *Coordinated Regional Incident Response Procedure* (GRIP) that is applied in the Netherlands, and the *Incident Command System* (ICS) that is used in a number of areas in the United States of America.

Keywords

Emergency response, scaling-up procedures, situation awareness, organization awareness

INTRODUCTION

After a large incident like a major fire, an explosion, or an earthquake, it is crucial to build up an effective emergency response organization as quickly as possible. This process of scaling-up should result in an organization that has the appropriate size and structure, relative to the nature, size, and complexity of the incident. This ad-hoc organization should be capable of reaching the three general objectives of emergency response: to save lives, to stabilize the incident, and to conserve the surrounding property and infrastructure (Bigley and Roberts 2001).

The scaling-up phase in emergency response is a crucial one and highly determines the consequent ability to reach the organization's objectives. There are a number of reasons why this is such a complicated operation. First of all, emergency response is highly *time-critical* in that the sooner the organization is able to act the higher the chance of success. This usually means that the organization has to start acting even before it is completely formed. Preferably, it should be scaled-up in a way that makes it possible to act during growth. An example of unbalanced scaling-up is the response to the Volendam café fire in 2001 in the Netherlands. It took less than 30 minutes to get 40 ambulances near the disaster scene, but there was no local command structure in place to coordinate the flow of casualties and ambulances (Alders et al. 2001).

The second reason why scaling-up is such a complicated process is that an emergency response organization is *multi-disciplinary*. It involves the fire brigade, the emergency medical service, the police, and a variety of government agencies, including the appropriate authorities. These multiple parties usually have inadequate experience in collaborating on a large scale. That this might lead to problems is illustrated by the response to the 9/11 attacks on the World Trade Centers in NYC. Police men in the North Tower were informed by radio communication that the South Tower had collapsed and were ordered to evacuate immediately. During their descent they came across some firefighters who were resting. They communicated their orders and advised them to evacuate as well though "some of these firefighters essentially refused to take orders from cops" (9/11 Commission 2004). If the organization is structured as a "stove pipe", it is difficult to build trust across the different disciplines.

A third complication is related to the *multi-layered* nature of a large emergency response organization. A command and control structure needs to be set up with a splitting up of strategic, tactical, and operational responsibilities. Especially in the Netherlands, it is not always clear how many layers are in place and which decisions are taken by whom. During the response to the Enschede fireworks disaster in 2000 in Enschede, two crisis command centers were opened. The large scale of the disaster asked for command on a regional level (Hengelo) but the municipal center in Enschede was also opened and for a while the two centers were not aware of each other's existence. Finally, the Enschede center took charge, though according to the handbooks, it should have been the regional one in Hengelo (Oosting et al. 2001).

In short, scaling-up is difficult, but vital. We aim to improve the process by offering the design for an information system that supports the proper build-up of an emergency response organization. It should help increase situation awareness

(Endsley 2000) and *organization* awareness (Oomes 2004). We will first briefly discuss two specific scaling-up procedures that are in common use today: the *Coordinated Regional Incident Response Procedure* (GRIP) that is applied in the Netherlands, and the *Incident Command System* (ICS) that is used in a number of areas in the United States. Thereafter, we will present the design of a scaling-up support system, and will discuss how our approach can benefit both the GRIP and ICS procedures.

DUTCH GRIP PROCEDURE

In recent years, the Netherlands had its share of high impact disasters (Enschede fireworks disaster in 2000, Volendam café fire in 2001). This resulted in renewed scrutiny of the emergency response procedures. For example, there is now a national web-accessible *Handbook for Emergency Response* (Ministry of Interior 2004) that explains in some detail the *Coordinated Regional Incident Response Procedure* (GRIP by its Dutch acronym). The main feature of this procedure is the distinction of different levels of response. They are numbered GRIP-1 to GRIP-4, the former indicating a minor incident that only needs local coordination while the latter refers to a full blown regional or national disaster.

The *Handbook* warns against the problem of scaling-up too carefully and recommends the policy of "better safe than sorry". This entails that in case of doubt about the severity of the incident, it is recommended to scale up to GRIP-3. This level of response means that there is a command structure in place close to the disaster scene from which the local operations are managed. Furthermore, on a tactical scale, the regional crisis center is opened (the Netherlands is divided up into 25 emergency regions) and representatives of the different emergency services gather to decide upon the appropriate actions. Usually the fire brigade commander is in charge of this team. Finally, GRIP-3 prescribes that a strategic team is added that is chaired by the mayor of the municipality in which the incident has happened. (This is sometimes called the Dutch paradox: the strategic responsibility is in the hands of the local authority while operational command is on the regional level).

If the incident is more easily brought under control than was expected, the organization can be scaled down to GRIP-2 which means that the strategic layer is removed. If on the other hand it turns out to be more serious, the response level goes up to GRIP-4 which entails that the final responsibility goes to either the Queen's Commissioner for a regional disaster, or the Minister of Interior for a national disaster. As can be seen in the organizational chart in Figure 3, the leadership on the strategic level is advised by either a municipal or regional policy team. Overall, the Dutch structure of the emergency response organization, and the procedure to scale up the organization, are not straightforward, and are the result of a long political and administrative tradition. Recent disasters clearly show that this rather complicated structure easily leads to confusion. As mentioned in the introduction, it led to disagreement about responsibilities between the strategic and tactical layers during the Enschede fireworks disaster (Oosting et al. 2001).

AMERICAN INCIDENT COMMAND

After some massive wild land fires in California in the 1970s, the collaborating services came up with a new procedure for multidisciplinary emergency response (Bigley & Roberts 2001). This was later called the *Incident Command System* (ICS) and it formalized the management structure for command, control, and coordination during emergency response. The term "system" is used here in the sense of a comprehensive management structure and organizational design. The basic structure is really simple. There is one command section and four other components: the planning section, the operations section, the logistics section, and the finance and administration section. Whatever the scale and complexity of the incident, and the consequent size of the emergency response organization, this basic structure remains the same. The ICS organizational structure develops in a modular fashion based upon the kind and size of an incident. The organization expands in a modular fashion, only to fill the positions that are needed to effectively manage the emergency. As the need arises, the four basic functional sections can be added, each with enough units to control the incident. This modular and flexible approach to building an emergency response organization makes it suitable to meet the needs of any kind of incident.

An ICS divides an emergency response into five manageable functions essential for emergency response operations: Command, Operations, Planning, Logistics, and Finance and Administration. The command function manages the incident, which includes establishing the strategic objectives if the operation and ordering and releasing resources, and includes the Incident Commander and the Information Officer. The operations function instructs all tactical resources to achieve the strategic objectives developed by the command. The planning section develops the action plan to accomplish the objectives, and monitors the progress of the operation. The logistics section provides support to meet incident needs and provides all resources that are needed to support the incident. And finally, the finance and administration section monitors the costs related to the incident and provides administrative services.

The 9/11 commission made a comparison between the emergency response after the terrorist attack on the Twin Towers in NYC and the Pentagon in Washington DC. Although the calamity in New York was on a much grander scale, the commission judged the response at the Pentagon to be more efficient and effective since ICS was in use in the National Capital Region. About the response in New York they state that "(…) the Incident Command System did not function to

integrate awareness among agencies or to facilitate interagency response." (9/11 report p. 321). They recommend ICS to be adopted nation-wide and support the decision of the Department of Homeland Security to make their funding contingent upon the adoption of ICS.

DISTRIBUTED ORGANIZATIONAL AWARENESS

We present an outline for a *distributed* organizational awareness support system for an emergency response organization which is aimed at helping the organization shape itself into the most appropriate form at the right time. The main purpose of the system is to monitor the buildup of the organization in real-time so decisions on expanding, restructuring, or slimming down of the organization can be based on the most recent facts.

Every organizational unit (center, department) has the same organizational support system, an *organizational awareness agent* (see Figure 1) that consists of a database in which the organizational structure is stored, a central unit that processes and analyses the organizational information, an interaction layer that visualizes the organizational chart and allows the operator to make mutations, and a communication unit that allows it to exchange messages with other agents. The visualization is similar to a geographical information system in the sense that the appropriate scope and scale can be chosen; a central crisis center may want to have an overview of the entire organization with operational units as the smallest entities, while a unit commander may only want to see related units on the scale of the people involved.

One of the main characteristics of this approach is its distributed character. Every center, department, or unit has the same system that represents and visualizes the entire organization from a local perspective. Each unit is responsible for keeping the organizational information in their local support system up-to-date (who is enrolled in the units, what tasks are being performed, who commands who, and so forth.). This organizational status is disseminated within the organization whenever there is communication with other units. This implies that the more departments communicate, the more the organizational information within a unit is up to date. Also, because there is communication among multiple departments, the representation of the entire organization is updated indirectly, and known throughout the entire organization.
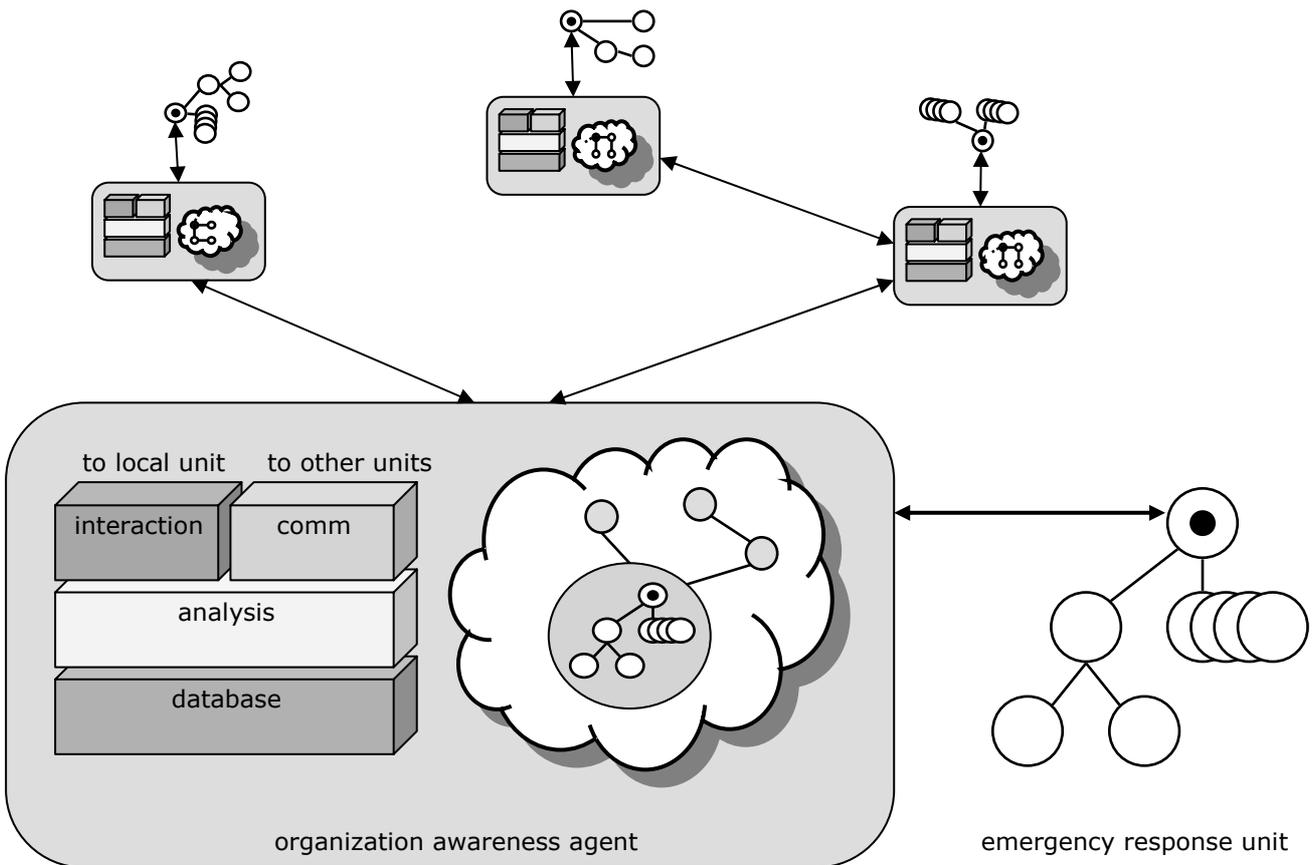
Figure 1. Organization awareness agents. Each unit has a support agent, which consists of four major components, and is responsible for maintaining the unit's view on itself and the entire organization.

For the communication about the organizational structure between different agents, an exchange protocol is needed. The structure will represent the members of the organization and the lines of authority. The principle of the protocol is that two agents exchange their organizational structure (or the mutations since the last communication) and merge them to form a new representation (see Figure 2). The merge is only done after the necessary consistency checks. For example, two agents might both have communicated with a third agent, and both would have included this third agent's representation. The agents discover this doubly represented organizational subpart and will only represent it once.
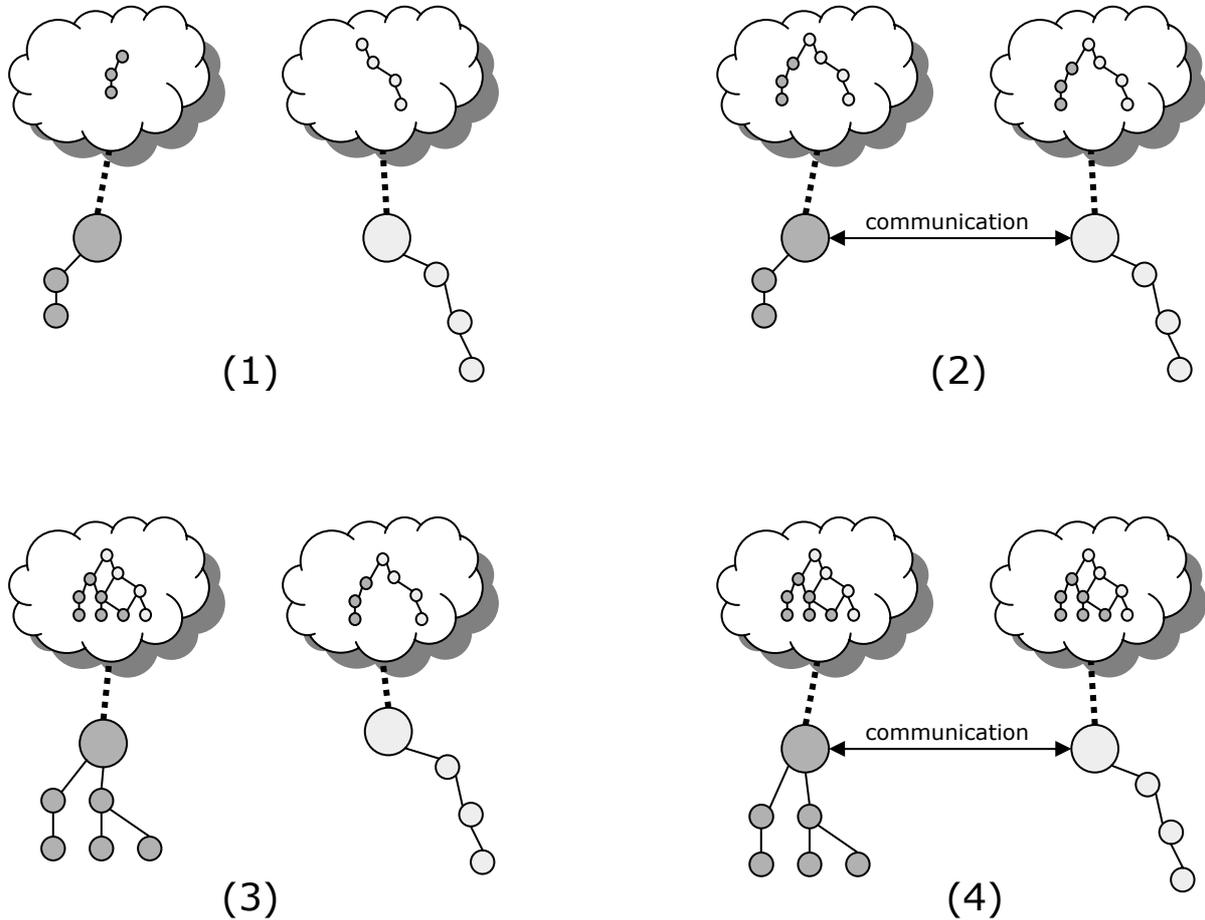
Figure 2. The organization awareness exchange principle. Each units maintains it's own view of the organization and updates this view during communication with other units.

The main advantage of this distributed method over a centrally stored organizational representation is that there is no single point of failure. If for example the central crisis center is taken out by an earthquake or terrorist attack, the information on the organizational structure is still available in multiple other agents. Another benefit over a centralized design is that the quality of the organizational information that one department has about another is proportional to the frequency of communications. Nevertheless, if two departments do not communicate at all, their organizational structure is communicated indirectly through other centers or departments ("mutual acquaintances").

SUPPORT OF SCALING-UP PROCEDURES

As briefly shown in the sections on GRIP and ICS, scaling-up procedures can vary wildly in different countries. However, whatever system is used to manage the scaling-up, proper scaling-up can only be achieved if sufficient 'organization awareness' (Oomes 2004) is achieved. This section extends on the distributed organization awareness concept as described in the previous section, and demonstrates how such a system could be used to support the actual scaling-up procedure. The system concept is conceived around the notion that it should be *generic* and *robust*. The system should be generic in the sense that it should support any type of organization, regardless whether it uses ICS or GRIP. It should be robust in the sense that it should have no single point of failure.

We assume that future emergency response organizations will make use of the aforementioned 'organizational awareness agent' system, and that all participants are registered in the organization via this system. This implies that every unit, center or department has an interface to their agents with which they can keep information on their own unit up to date and through communication can be made aware of the rest of the organization. One obvious display is an organizational chart, or organigraph (Mintzberg et al. 1999), that has an equally prominent place as the situation map of the area.

Figure 3 shows a dynamic organizational chart specifically designed to visualize the Dutch scaling-up procedure. Basically, the boxes that indicate the departments or units change from color whenever they have become operational. Such a chart would immediately make clear for decision makers which elemental units are not instantiated, and whether there are any inconsistencies in the organization. This scaling-up support system is expected to improve the organization awareness of all the key decision makers and will reduce confusion about the division of responsibility and authority. Extra features might include that clicking on one of the boxes reveals information on the specific people involved and their (mobile) phone numbers and email addresses. Furthermore, the system can detect omissions in the organization and gives advice on establishing links between disconnected members of the organization.
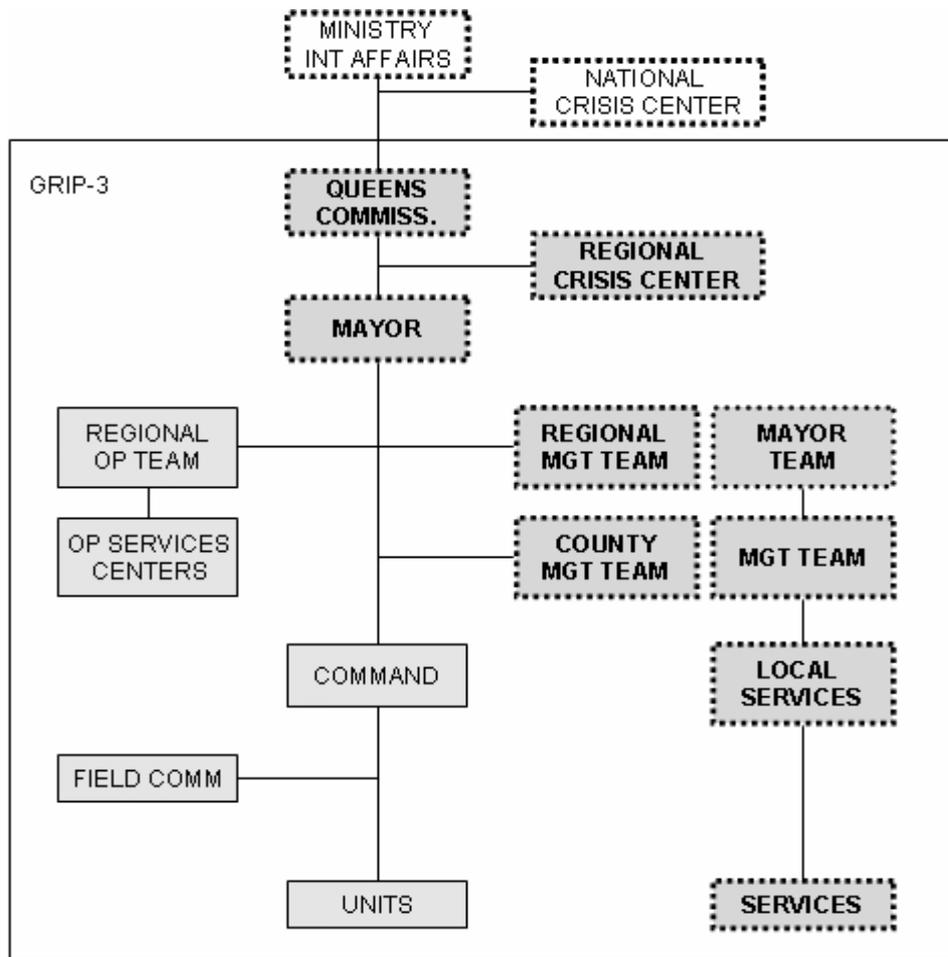
**Figure 3. Dynamic organizational chart representing the Dutch emergency response
organization at the GRIP-3 level. The dotted participants should be present under the
GRIP-3 definition, but are not (yet) instantiated or contacted.**

As for the ICS-based emergency response organizations, we need a different way of displaying the organizational status because of the fundamental difference in structure. One major problem in an ICS based organization is that specific functions might be over- or under-allocated. Such a problem might be spotted early on by using a relative sizing of the basic five components (see Figure 4). Also, in the same manner as in the GRIP case, color differences could designate which units, or rather functions, are not instantiated, but should be.
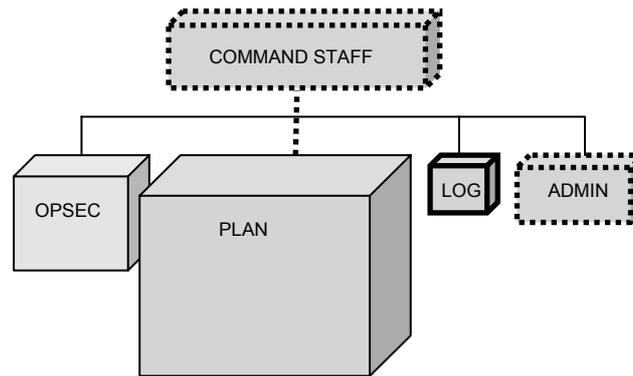
**Figure 4. Dynamic organizational chart representing an
emergency response using ICS. The size of the boxes is a
relative indication of how well a certain function is organized.
Dotted boxes could indicate that a certain function is absent.**

Aside from the visual differences between the GRIP and ICS support, the basic support system concept is identical. The key thrust of these types of support system is the distributed organization awareness agent concept that allows for many support functionality that can alleviate scaling-up problems.

CONCLUSION

This paper provides the design of a support system concept for aiding emergency response organizations with their scaling-up procedures. We identify several basic issues involved with scaling-up, and base their support concept around these issues. Two major requirements have been set for the support system: it needs to be *generic* en *robust*. To achieve these requirements, we propose an agent-based distributed organizational awareness system that provides important cues to decision makers as to manage their scaling-up process. To demonstrate the generic nature of the concept, the paper briefly explains the difference between scaling-up procedures in the Netherlands and in the USA, and demonstrates how support could be given under both protocols.

ACKNOWLEDGMENTS

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