Real-Time Organigraphs for Collaboration Awareness

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ABSTRACT

Collaboration awareness, as extension to organization awareness, is knowing how organizations do work and achieve their goals. This knowledge moves on a scale from stated prescribed ways of acting (such as procedures and protocols) to informal channels of communication, teamwork and decision-making. Based on available static and dynamic data, standardized insights can be given about collaboration in emergency situations in the form of organigraphs. We argue that for gaining practical collaboration awareness, both the formal structure of an organization as well as informal interactions should be inspected. Informal interaction includes informal communication channels, actual decision making on the spot and multi-disciplinary joint activities. We have implemented our system in the form of a web-based visualization tool. This tool would have been useful in the Hercules disaster, giving insights in informal information exchange, possibly preventing fatal decisions.

Keywords

Collaboration, Visualization, Coordination, Organization Awareness, Management, Disaster Response.

INTRODUCTION

In the Rotterdam (the Netherlands) disaster response control center that is operational when disasters exceed a certain severity, there is one person whose only job is to watch the other members of the team. He is checking for signs of extreme fatigue, making sure people regularly eat and drink, and notifying the commander when someone seems lost or isolated. The function of the person can be called "maintaining self-awareness" and it is possible because of the limitation in scope of only monitoring the people in the room. On a larger scale, a disaster response organization needs to monitor and evaluate its own performance, though due to the sudden onset of the operation and the severe time pressure this is usually not possible. There needs to be some check of whether different departments are actually communicating and coordinating with each other, whether information is actually correct, and whether coordination loops are closed in a later phase of the operation.

We attack this problem by firstly extending the idea of organization awareness (Oomes, 2004), which was mainly focused on the structure of the organization and the communication patterns, to "collaboration awareness". This concept encompasses everything that is useful knowledge for letting the synchronized joint actions run efficiently and effectively, not only monitoring the formal structure and procedures but also showing the informal communication and coordination patterns and allowing the individual members of the organization to adapt their view on the collaboration to their needs.

We combine and extend the notions of the different “images of” (Morgan, 1996) and “views on” (Mintzberg, 1993) an organization, and integrate them with the idea of “organigraphs” (Mintzberg and van der Heyden, 1999). Members of the disaster response organization all have their own perception of the relevant aspects of the organization that they are a part of: its formal authority structure, the informal gossip channels, the official protocols, and the ways to bend the rules and get things done more effectively.

Our system uses information from manuals to be able to show the formal backbone structure of the organization and the protocols that have been agreed upon in advance. Most importantly, though, it works with real-time data on the actual communications to establish the actual coordination processes. This information is translated into proper graphical models in a similar way that a geographical information system gives the user information on a certain area at the right scale and scope (van Aart et al, 2004). Organigraphs are presented that allow for insight into the machinery of the organization and answers questions such: “What is the formal organization?”, “Who is responsible

for what?", "How do people work together?", "Who is communicating?", "Who is teaming up?" , "How have decisions been made?", "Are people aware of each other's activities?" and "Who is solving what problem?".

Finally, we apply our system to the post-hoc analysis of the Hercules disaster at Eindhoven airport in 1996 in which the absence of a crucial piece of information resulted in more casualties than was strictly necessary given the scale of the accident.

COLLABORATION AWARENESS

The concept of explicit (graphical) models of aspects of communication and coordination supports "collaboration awareness" that consequently has a beneficial effect on the functioning of the organization – it not only depicts the entire organization but also parts or aspects depending on the perspective, scope, and function of the members of the organization that needs an explicit view for his/her work.

Every group activity raises two challenges: *division of work* and *coordination* (Mintzberg, 1993). Division of work is breaking down the main activity into various distinct tasks. Coordination is the ability to manage the relations between the distinct tasks to carry out the work (Malone, 1987). In stable environments, such as factories, or small accidents (such as a small car crash), it can be sufficient only knowing how the division of work is done. In a factory, for decision makers to know that machine operators are in the factory main hall can be enough information. At a small crash, knowing for a control room that a police car is present can also be enough. However, in less stable environments and more complex emergency situations more information is needed.

Collaboration awareness is knowing how organizations do work and achieve their goals. Any member of the organization needs a (partial) notion of collaboration awareness. To avoid information overload, only specific information can be shown using filtering. To apply the filtering we make a distinction between the members that actually perform the work, such as firemen, and those who make tactical and strategic decisions, such as fire brigade commanders. The members performing the actual work in the field have different information needs, e.g., knowing where their group members are, what the individual objectives are, what the group objectives are, etc. The members making tactical and strategic decisions in the field, crisis center and control room will need information about how work is performed, by whom and how.

Organigrams represent a theoretical view on a formal organization, assuming that the members of the organization will behave as such (Morgan, 1996). In pre-defined environments, such as factories, this can be the case. In complex environments, such emergency response, organizations will adapt (regroup, scale-up or scale-down) to cope with the situation. Oomes (2004) describes an organization awareness approach using dynamic organigrams that reflect state changes based on actual information.

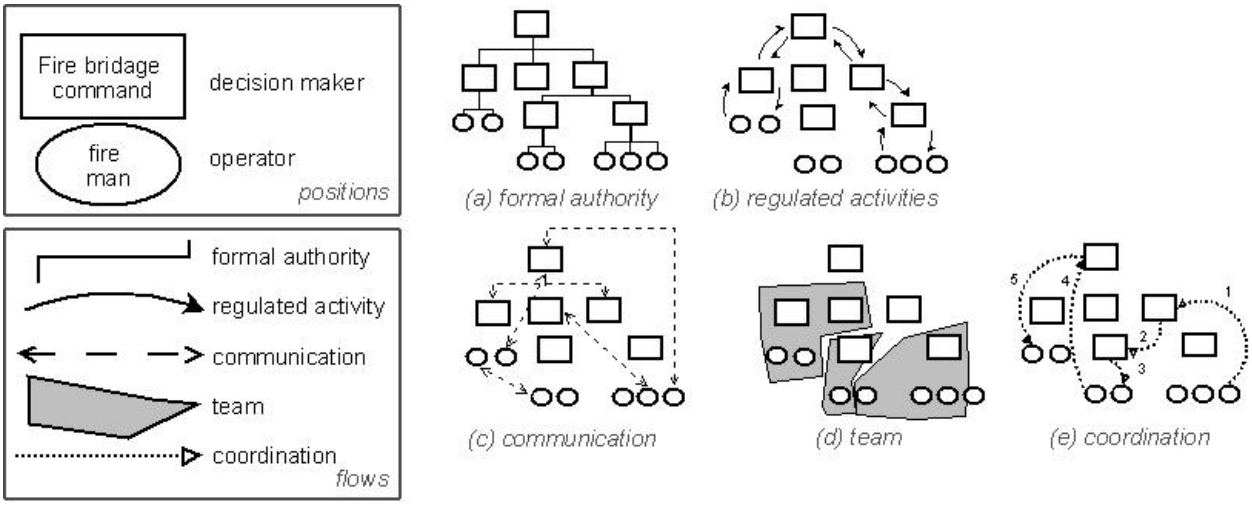

Figure 1: Five graphical flow-views on coordination

An organigram represents three pieces of information: (1) what positions exist, (2) how these are grouped and (3) how formal authority flows. The selection of positions reflects the division of work and responsibilities. Typical emergency response organizations are organized on basis of their skills, e.g., police, fire brigade and medical

support. The grouping of position (i.e., positions clustered in units, departments, divisions or regions) can be based on the geographical distribution. For example, the Dutch emergency organization is grouped into 25 distinct regions. Formal authority shows how coordination flows down from the top decision makers to the actual people who perform the work. An example of a typical organigram is illustrated in Figure 1-a, showing positions, their grouping and formal authority.

Next to (1) *formal authority* we propose to add four additional views on organizations following Minzberg (1993). These views are (2) *regulated activities*, (3) *communication*, (4) *team* and (5) *coordination*. The regulated activities view represents coordination as a network of prescribed procedures and protocols (see Figure 1-b). Next to formal authority, the content of instructions can be inspected. For example, a fire brigade commander gives the command (top-down) to two fire crews to engage a fire. The crews will report (bottom-up) the status of their activities.

The communication view shows who is actually communicating with whom (see Figure 1-c). Particularly in emergency response organizations, unofficial coordination exists based on informal communication channels. Although there are many formal procedures and regulations, to make the organization run a lot of unanticipated coordination based on informal communication will happen. Another view on this phenomenon is the team view, representing coordination as a set of people clustered into peer groups to get the work done (see Figure 1-d). An example is where firemen assist in medical activities. Finally, the coordination view represents how practical work decisions are coordinated. Next to communication and team view, critical decision have to be made. In critical situations, there can be no time to follow the formalities or the formalities do not cover specific situations.

Organizations are usually studied from the point of view of the researcher who tries to get an overview of the entire organization from the outside in and looks for patterns of interest (hubs that indicate highly connected people, clusters of people, isolated departments, etc.). The perspective of a person in the (disaster response) organization is quite different; that person needs to fulfill some tasks, take on a certain role, and in trying to achieve her individual goals, has to coordinate with other actors in the organization. In most cases, a view of the entire organization is not necessary at all (Klein et al, 2004). What is needed is a functional view on the organization that answers questions such as, “Who do I need to talk to find out if they have found victims already?”, “Where can I get coffee?”, “Who can get me a truck to transport a 10 ton beam?” and “How many ambulances are available?”. In Table 1, the five views are combined with their practical application, type of information presented and the source of information needed to construct the views.

View	Application	Type of information	Source of information
Formal authority	Understand who controls whom, division of work	What positions exists, the reporting structure and how these are clustered into units (departments, regions or divisions)	Organization Awareness, HRM department, public website or year reports
Regulated activity	Understand machine-like functioning of the operation	Prescribed procedures and protocols	Policies, process flows, handbooks, manuals
Communication	Understand information and data flows	Communication lines	Communication logs from mobile communication , telephone, email, webpages
Team	Understand culture of organization	Grouping, multi disciplinary joint activities	Situation Awareness, location of resources and people
Coordination	Understand task allocation and the coordination over these tasks	Locations and sequences of task allocation, delegation and work decisions	SitReps, Job lists, Planning reports, Orders

Table 1: The five views on organizations, the application, type of information presented and source of information.

Therefore the view on the organization should be centered at that particular person, and take the *perspective* of that person. The 112 call center operator will need to know which ambulance crew to contact and which emergency room to warn about the expected arrival of an ambulance carrying a victim. For the type of coordination he is conducting, it is not very relevant to know, for example, who the director of the hospital is, but he might want to know who supervises the ambulance crews he is talking to on a daily basis, in case there is an issue that involves coordination on that level.

This issue of *scope* is pervasive in organization awareness and it is usually implicitly assumed that the whole organization needs to be visualized. But for some people in the organization it is much more important to have a good view on people outside the organization itself, to know, for example, how government agencies are organized and who to contact there for some specific piece of information.

The analogy of maps can be fruitful, though should not be taken too far. The person that is using an organigraph should know their own "place" and have control over perspective and scope of the specific view on the organization. But while maps can lead you from A to B through an intricate maze of multiple streets and turns, navigation in the social world will in most cases not go much further than "a friend of a friend" (2 degrees of separation). What will be crucial is to have *functional* view on the organization: Who is coordinating what? Who do I contact to arrange this or that? Who knows what?

GENERATION OF REAL-TIME ORGANIGRAPHS

In order to generate collaboration awareness insights, we have constructed the Collaboration Awareness Tool, a web-based visualization software tool. The tool gathers formal knowledge from the manuals and protocols, and real-time data from the actual running organization that results in different "views" through organigraphs on (parts of) the organization. We use graphical software techniques to generate views in the form of organi*graphs*. An organigraph is a way of representing structural coordination information as diagrams of coordination flows. The organigraphs we propose are standardized representations of flows of interaction within organizations based on the five views. We note that both the views on organizations and the organigraphs theories are from Mintzberg (1999) and Mintzberg and van der Heyden (1999).

Assuming that data about the organization and situation are available, real-time and post hoc analysis can be performed. Formal organization information, such as organization structure (division of work) and prescribed procedures can be gathered from handbooks and digital knowledge bases, e.g., Emergency Escalation plan of Dutch Ministry of the Interior and Kingdom Relations (2006). For gathering dynamic data we refer to Oomes (2004) where monitored interactions between members of emergency response organizations can be stored in communication log using the discipline-wide Dutch communication system "C2000[1]". Other information can be gathered from control rooms and crisis centers.

The Collaboration Awareness Tool generates organigraphs based on dynamic *event archives*, i.e., databases that contain data gathered in real-time. To gather dynamic data, sensors (or probes) will be instrumented on communication lines and available information systems. These sensors will listen for events (such as decisions, communication acts, information updates, etc.) and store them into the event archives. In order not to demand too much resources (such as energy and computational power), sensors can be managed with a mechanism to activate and deactivate them on demand. An *event* is a piece of information annotated with a timestamp, unique name, source, type of data and the actual content of the event. Below is an example of an event.

```
Event {
       Id: event81323
       Time: 23/12/2007, 14:15:53
       Source: "Police station Nieuw Sloten Noord, Amsterdam"
       Destination: "Fire station, Weesperzijde, Amsterdam"
       Type: "Message"
       Content: "One car on Fire"
}
```

In order to generate organigraphs on demand, the tool is able to select information based on queries. This works as follows: Based on the type of view, for example the communication view, events of type "message" will be selected

[1] www.c2000.nl

based on a time interval, source, destination and content. For example, to inspect a conversation between the fire and police station, the messages exchanged are selected:

```
Selection [type="message", source="police station", destination="fire station"] {
       Event81323, 23/12/2007, 14:15:53, police station, "Green car on Fire, Keizersgracht 301"
       Event81356, 23/12/2007, 14:17:01, fire station, "Sending truck 431"
       Event81378, 23/12/2007, 14:31:41, fire station, "truck 431 on the scene"
       Event81411, 23/12/2007, 14:47:21, fire station, "fire extinguished"
}
```

Finally, based on this selection, the tool automatically generates organigraphs (see Figure 2). The boxes represent the two actors in the conversation, and the arrowed dashed lines represent the message exchanged. These kinds of representations are common to ICT developers, e.g., UML and flowcharts. Our experience is that these relatively abstracted graphical representations can be read intuitively. This claim is supported by the fact that people are able to react better on complex data represented graphically, because it provides models of the world that are schematized to convey only the relevant aspects of the present reality (Tversky, 2001). To generate the organigraphs on demand, we use the open source graph visualization tool Graphviz (Gansner, and North, 2000). Our tool is built with the web programming language PHP in combination with Javascript and the open source webserver Apache, The event archives are developed with MySQL and XML.

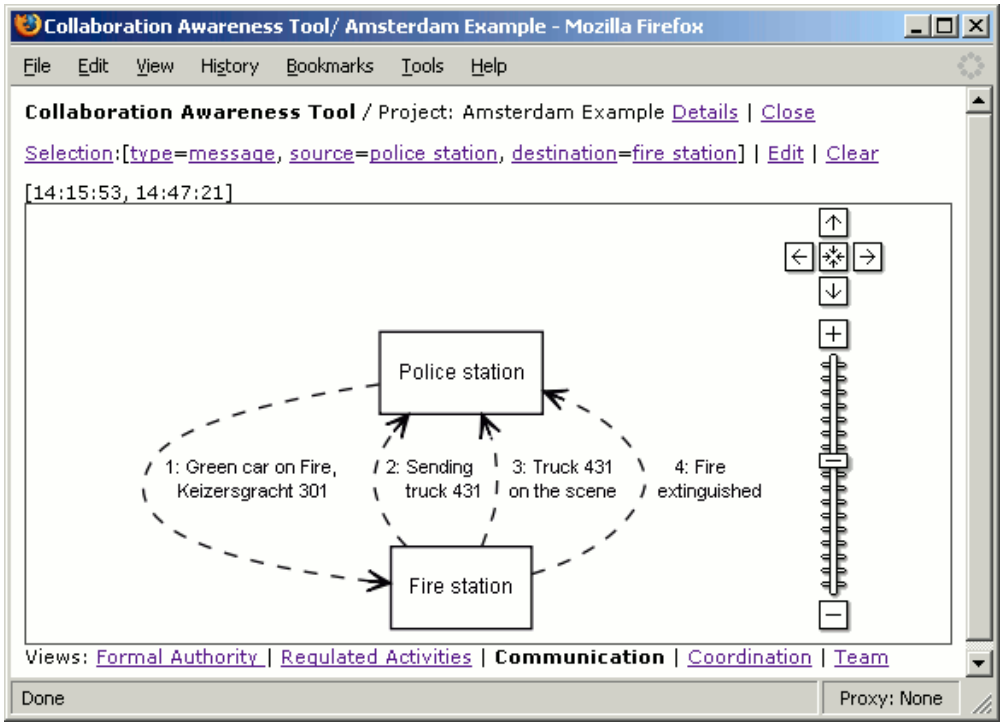

Figure 2: Screenshot of Collaboration Awareness Tool, showing a communication organigraph

The graphical representations can be used by all members of an organization. Based on the work they are performing they can be specifically informed about the working of the organization. This satisfies specific coordination information needs. To prevent information overload, selections are used to filter non-relevant information away, next to the specific views.

EXAMPLE: THE HERCULES DISASTER

On July 15th,1996, at 18:02, a Belgium Hercules-type military cargo aircraft crashed at the airport of Eindhoven, the Netherlands. The aircraft got into trouble during descent and was able to land on its belly 300 meters next to the landing strip. Air traffic control did not inform the fire brigade about the number of passengers on the aircraft. The fire brigade assumed that only a four person crew was on the aircraft. Therefore the fire brigade decided to start with extinguishing the main fires. The cargo area of the aircraft carried 37 members of the Royal Dutch Army brass band,

who were not injured during the initial crash. The main exit of the cargo area is the cargo door in the belly of the aircraft, which was blocked. A kerosene fire emerged during emergency response, claiming 34 deaths and 7 seriously wounded (Raad voor Transportveiligheid (the Dutch consul for transport safety), 2002).

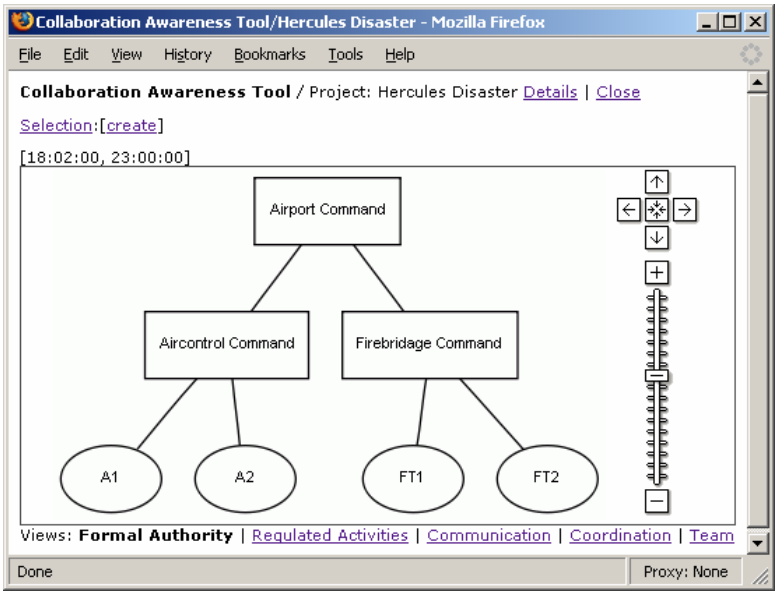

Figure 3: Abstracted formal authority organigraph of the Hercules Disaster

The Hercules disaster has been intensively studied (Bruinsma and de Hoog, 2006). Here we study only the error that air traffic control failed to inform the fire brigade about the number of passengers. An abstracted illustration of the formal organization is given in Figure 3 showing the decision making positions Airport Command, Fire brigade Command and Airport Command and the operators a1 (air traffic controller 1) and a2 (air traffic controller 2) and ft1 (fire truck 1) and ft2 (fire truck 2). Although the positions, grouping and reporting lines can be seen from this organigraph, the actual decision making process and outcome of decision making cannot be investigated.

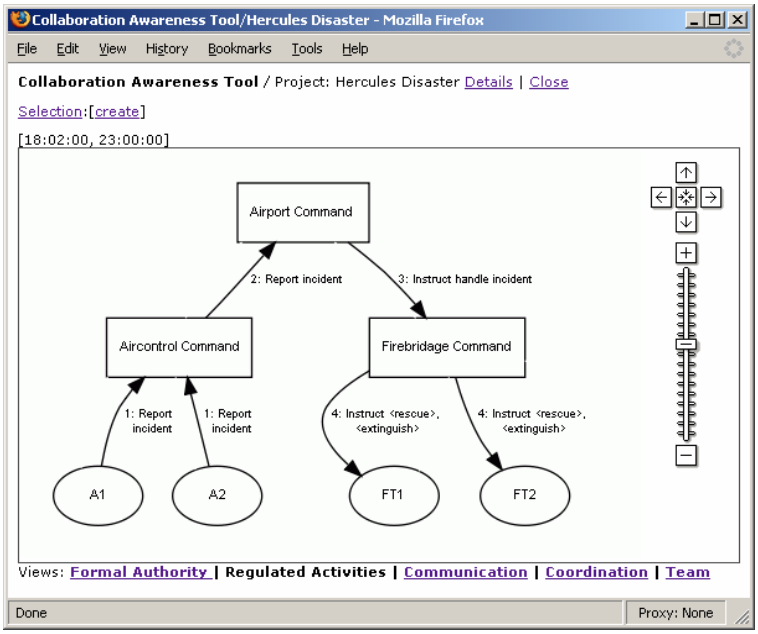

Figure 4: Abstracted Regulated Activities organigraph of the Hercules Disaster

Figure 4 shows an abstracted view on the regulated activities, following the formal procedures. In case of an airport crash, air traffic controllers have to report these incidents (see message 1) to Airport command, which will report (2) to Airport command (2). Airport command will instruct (3) fire brigade command to handle the incident. Fire brigade command has to make a decision[2] between (a) starting with extinguishing the fire and then rescuing personnel on board or (b) starting with rescuing personnel on board and then extinguishing the fire. The decision will be instructed (4) to the fire trucks. The prescribed emergency protocol can be inspected, but the outcome of decisions cannot be seen.

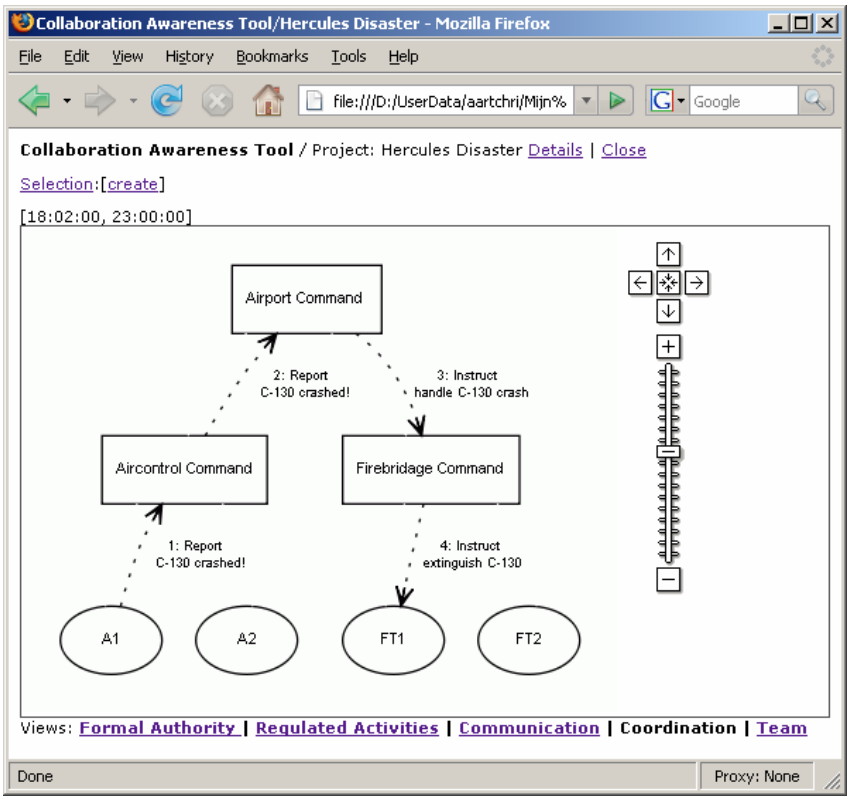

Figure 5: Abstracted Coordination organigraph of the Hercules Disaster

Figure 5 shows an abstracted view on what actually happened. We assume that relevant information has been monitored by sensors and already properly annotated with metadata, such as source, time, and content characterization helping proper selection and filtering. We constructed a event archive based on official reports (Dutch consul for transport safety, 2002). As can be seen, the sequences of decisions followed what the formal procedures prescribe: a1 reported the crash to Aircontrol command (1), who reported the C-130 crash to Airport command (2). Next, Airport command instructed Fire brigade command to handle the C-130 crash, who instructed ft1 to start with extinguishing the c-130 crash. This organigraph shows the actual decision making sequence following the formal procedures, based on assumptions and standardization. One of the assumptions is that a cargo aircraft only carries a crew of four. The reporting structure is based on standardized emergency protocols.

[2] The decision making of Fire brigade command has been abstracted.

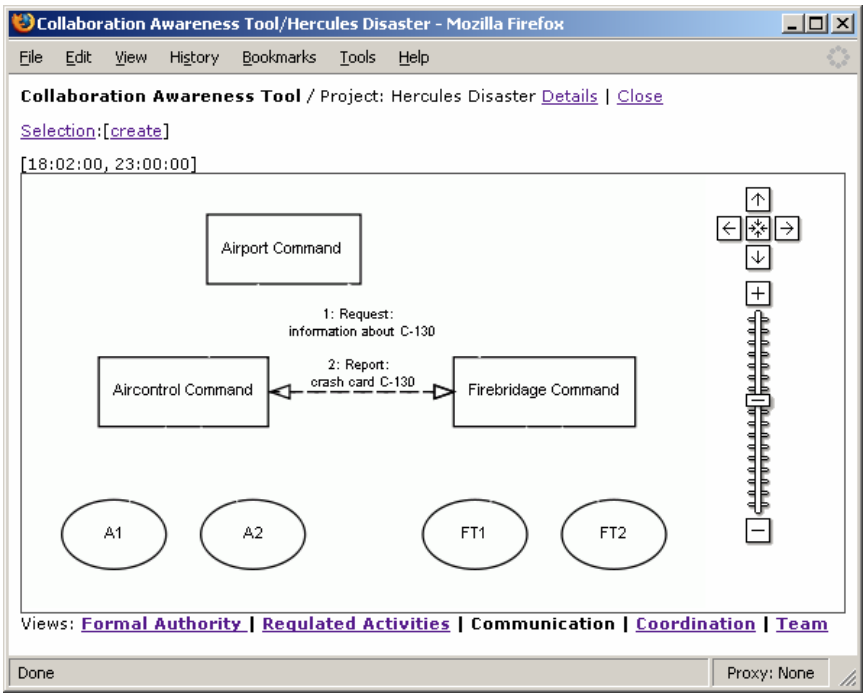

Figure 6: Abstracted Communication organigraph of the Hercules Disaster

To find the cause of the fatal decision, Figure 6 shows communication between Fire brigade command and Aircontrol command. In this communication Aircontrol command and Fire brigade command did not exchange information about the number of passengers. In every emergency situation, proper information management is essential. In this case, if the members of this organization could have had an explicit picture of the missing piece of information, Airport command could have intervened. In this intervention, the decision of starting with extinguishing the fire would have been changed into giving priority to rescuing the passengers.

CONCLUSION

In this paper, we have presented a method to inspect five different coordination aspects of organizations. Based on available static and dynamic data, insights can be given about coordination of emergency situations in the form of organigraphs. Two classes of organigraphs are described: formal and informal. The formal class contains the formal authority and regulated activity organigraphs showing the formal structure in the form of positions, units and reporting lines and prescribed activities based on formal procedures. With this class the (theoretical) division of work into joint activities and the management of the relations between these activities can be inspected. Many techniques exist to inspect this form of organization awareness. Data needed for this class of organigraphs can be gathered from organization awareness tools, the HRM department, public website, annual reports, policies, handbooks and manuals.

We have argued that for gaining practical collaboration awareness, informal interaction should also be inspected. Therefore, the informal class of organigraphs contains the communication, coordination and team showing informal communication channels, actual decision making on the spot and multi-disciplinary joint activities. Data needed for these views can be gathered from communication logs, situation awareness tools (e.g., Blandford and Wong (2004), location of resources and people, SitReps, job lists, planning reports and orders.

We have applied the Collaboration Awareness Tool to the Hercules disaster, because it is well documented and is seen as a typical (dramatic) example of lack of insights. We have shown that the use of the organigraphs show different viewpoints, which can be used for different purposes. The communication organigraph shows the omission of exchanging data about the number of passengers on the aircraft. If this view would have been used during the rescue operation, it could have prevented the fatal decision of starting with extinguishing the fire instead of starting with rescuing the passengers on the aircraft.

Although we made a very abstracted study of the Hercules disaster, we argue that next to the formal viewpoint, the informal viewpoints can give crucial collaboration insights. Especially when the situation and the emergency response change, there will be much data and types of data. Taking different viewpoints and therefore filtering data can be helpful. In its current form, the tool is not a killer application, but has the potential to provide different insights in rescue operations supporting decision making and operation.

Given the ability to graphically represent different views on organization, coordination and collaboration, the next step is to develop AI (artificial intelligence or knowledge-based) systems able to support members of crisis management organizations during decisions making. These AI systems could be able to detect patterns and automatically inform stakeholders. Scalability can be achieved by these systems taking into account different dimensions: quantity of information, quality of information and complexity of information. When the state-of-the art permits, decisions could be made automatically without any (fatal) delays.

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