PRINCIPLES OF WORKFLOW SUPPORT IN LIFE CRITICAL SITUATIONS

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Abstract

The prime objective is to investigate how technology and work organization can support the workflow in handling time critical emergency calls, having the prerequisites of giving the highest priority to saving human lives and minimizing the effects of emergency situations. The challenge is to maintain and improve the quality of service (QoS) during and after a proposed technology driven organizational change. This thesis is based on empirical work including extensive ethnographical studies of emergency call handling at Swedish Emergency Service Centres, SOS centres. Today the SOS centres are basically organized as independent centres. The proposed technology enabled organization concerns the contingency of handling emergency calls nationwide, in SOS clusters. One of the desired outcomes of this reorganization is that peaks and falls in the handling of emergency calls will be levelled out. It is assumed that any operator will be able to handle the call independent of the location of the emergency situation, opening up for a more efficient handling of incoming calls. In principle, introducing new information technologies enables this reorganization of SOS centres. However, the basic claim of our investigation is that a transition to the new organization has to take into account systemic requirements, to support a non-disruptive change.

The first of the three main results concerns essential aspects of technology based organizational changes. From the empirical work, we have concluded that the tasks constituting the workflows at SOS centers are conducted in parallel, and that the coordination of the tasks can be modeled using a risk-driven blackboard-based spiral model. We have also concluded that there is a rich face-to-face communication and body language situation within the centers supporting coordination of workflows. This coordination is context-dependent thus the means of creating awareness of the overall situation in the centre support the acquisition of important extra information in the specific case.

The second result concerns methods and models to increase the quality of the requirement specification process. The principal approach is to specify assessments and systemic requirements. Furthermore, issues such as how to validate empirically based workflow models, as well as how to measure groupware usability and how to support the information sensitive change are considered. Suggestions concerning methods and models that could provide means to that end are presented.

The third result concerns identification of relevant research and development challenges coupled with new insights about combining ethnographical approaches with system modeling. Identification and suggestion of suitable experimental platform design, enabling testing of service qualities, including a suggested role for agent technologies are presented.

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To be a part of and support your development is one of my missions and hopefully we will stay connected in all possible future. From the experience of being a mother and perform research studies I have developed skills and competences. Condition & endless love are extremely powerful, as well as curiosity, development and freedom of mind!

Principles of workflow support in life critical situations
Jenny Lundberg

1 Introduction

This thesis addresses issues related to preserving or improving the quality of workflows to handle emergency calls at emergency call centres. The analysis is based on studies of workplace behaviours at present emergency service centres. The challenges identified and studied are emerging from both organisational as well as technological changes. In the organisational change we witness a trend connecting the centres into a national net of emergency centres, i.e. a change from 'centre' to 'centre-to-centre' views are taking place. With the main motive of spreading the work on all the centres, thus reducing the time to answer calls, levelling out peaks and falls in the handling. Challenges as how to continue to carry out the mission of saving lives and minimizing the effects of accidents and catastrophes are in focus. To keep and even improve quality of service in a distributed setting requires taking local knowledge and ground-service connections seriously under consideration.

There are approximately 20 emergency service centers (SOS centers) in Sweden, with the main duty of handling emergency calls, i.e. "112" calls. A majority of the centers are responsible for dispatching ambulances, informing rescue service and police. The computer system currently in use, about to be changed is the CoordCom system, a DOS based system, with the basic structure of predefined fill-in forms, with different possibilities to view activities and possible actions connected to the case. As for example, the operators can select and display information such as the action plan, the dispatch able units, event plans, ongoing events and information concerning which operator that made what task. A computerized map, presenting the current geographical position of the vehicles available, and possibilities to position the caller, is also a part of the computerized system. Medical index, maps in paper, whiteboards are some other important tools that the operators use to perform their tasks.

Today the SOS centers handle the emergency calls in their geographical area of responsibility quite independently. Cooperation between centers takes place mainly when handling occasional overflow calls. Basically this means that in case of larger amounts of calls to one center, due to bigger emergencies or catastrophes, another center can take over the calls that the operators on the original center do not have time to answer. The center handling the overflow calls select the calls that could turn into cases, and returns them to be handled at the original center, or under special circumstances (catastrophe and secondary centre) handle the emergency themselves.

Sitting in the same centre, sharing the handling of emergency calls has several advantages. The rich face-to-face communication and body language is right at hand scope for coordination and problem solving. This coordination is very context dependent. And creating an awareness of the overall situation in the centre, obtaining

extra information in a case, and use subtle gestures getting the appropriate support are if not free of effort, essential for a work place such as the SOS centers.

As mentioned, today the SOS centres are organized as individual centres, handling their geographical area of response. With some cooperation between the centres, such as handling of occasional overflowing calls. The new organisation is basically about handling emergency calls nationwide instead of region wide. Introducing new information technologies enables this reorganisation of SOS centres.

For the organisational change of the SOS centres we can speak of connections between centres, i.e. centre-to-centre, time-critical handling of emergency calls and connected organisations, i.e. geographical distribution and exchange of services on a national level. If any operator could handle any incoming call independent of geography this could enable more available operators to answer incoming calls. Peaks and falls in the handling of emergency calls could be levelled out. The main focus is on what we can call 'nationwide computing', connecting operators sitting in different centres.

In this thesis a strong focus upon how to preserve the workflow is put. Ethnographical methods and ethnomethodological analysis is the base from were the assessment of current work practice at SOS – centres are made. But also inputs from participatory design methods such as future work shops. An attempt to derive requirements from the methods mentioned is made. A focus upon information is put by using information sciences derived from situation theory. A consideration of connecting the descriptive methods towards engineering methodologies is made with a distinct focus on the workflow perspective.

The basic idea behind call centers is to collect and centralize competence in a room were the personnel have ability to share competence and resources. Most of the commercial call centers handle costumer service, support and orders and some centers handle functions related to telephone switch functionality. The operators in the call centers systematically handle incoming and outgoing communication, often using some sort of information- or decision support system.

Specific for the SOS-centers today is the covering of a specific geographic area of responsibility. Responding to an emergency, the centre allocates resources i.e. the properly categorized case meets the most suitable resources. The operators working in the centre creates an overview of all emergencies and resources, monitoring the handling of the case, and initiating or assisting new resources into the case. The handling of the cases, and the knowledge about the resources are centralized, both the cases and the resources are decentralized.

The tasks performed at the SOS centers in Sweden are focused on saving lives and minimizing the effects of accidents and catastrophes. This means that the people working at those centers have very specialized skills and knowledge about the proper procedures from handling and identify incoming calls to allocating, dispatching and navigating rescue teams to the site of the accident. The tasks are time critical as well as focusing on handling sensitive information in a proper way.

If the operators working in the emergency service centres are to be connected to other centres, this most probably poses challenges on the organisation of the centres, but also on the related organisations. The operators will not be tied to the geographical area as such, they will use different kinds of tools to communicate and coordinate nationally. As they do today to cover their region of responsibility, but now the whole country is their area of response. Challenges such as how to categorise, and structure the information are of importance as also the challenge of how to communicate and coordinate actions. We can speak of distributed centres, perhaps to some extent we can start to think in terms of a partly virtual organisation, if this centre-to-centre suggestion gets implemented.

2 Research questions, challenges and methodology

There are three research questions with related challenges that are the focus of this thesis:

Research question 1 (RQ1)
In what way can the workflow model of single SOS centres be transformed to a workflow model of SOS clusters while maintaining or increasing the quality of service?

The second research question concerns ontological issues of suitable categorizations and is formulated as follows:

Research question 2 (RQ2)
In what way can the information type categorisation of single SOS centres be transformed to a workflow model of SOS clusters while maintaining or increasing the articulation of the work?

Research question 3 (RQ3)
Design of suitable experimental platform enabling testing of service qualities.

Related to the research questions are the following challenges:

Challenges

Methodological issues related to:

- Identifying normative and actual workflows in work practices at SOS emergency service centres.
- Identifying a suitable service oriented architecture supporting workflows.
- How can we identify and maintain critical qualities during technology enabled transition.

Figure 1 below illustrates the main concepts and ideas about our socio-technical systems.

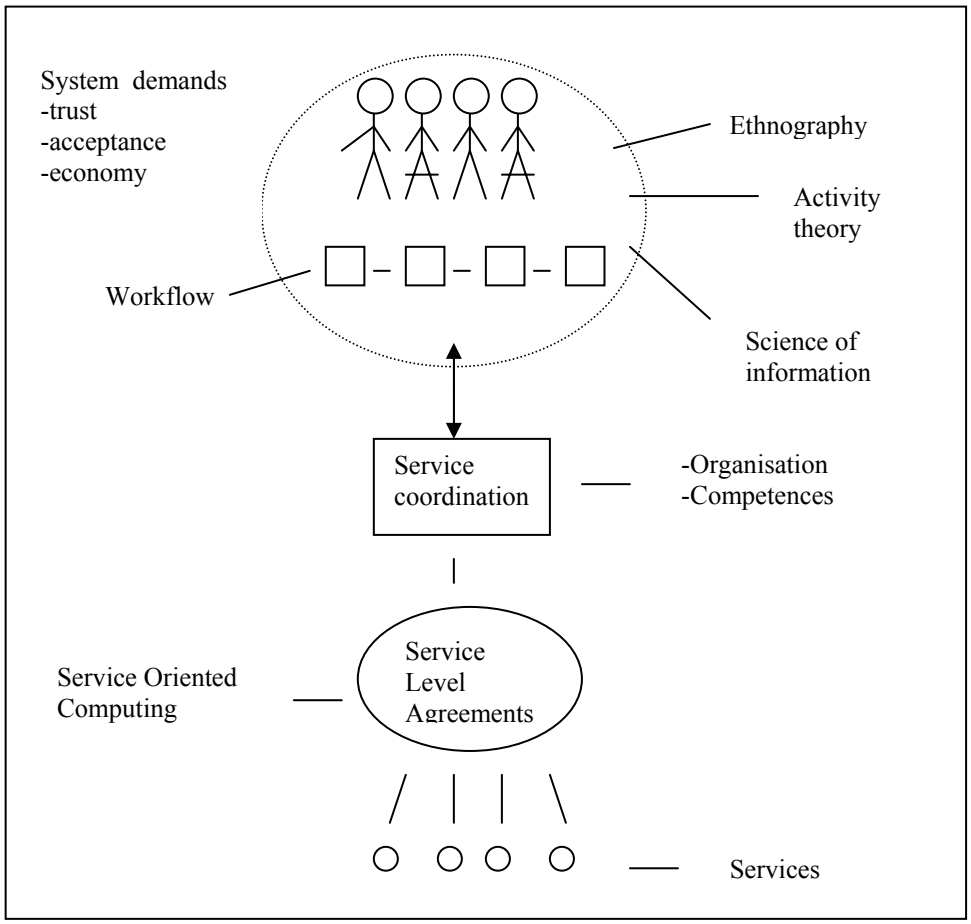

Figure 1. Socio-technical system with main components and technologies.

In this thesis the methodologies used has been selected mainly as a result of a configuration to the research questions. Ethnographical studies, ethnomethodological analysis and ethnomethodologically informed ethnography have been used. Furthermore, participatory design methods such as future work shops have been used, contributing to for example the assessment. Situation theory has been used as a modelling technique, for the functional demands. The CommonKADS methodology has been used, providing for example to implementation aspects as in the meta-model in figure 9. Requirements engineering has been of inspiration to the systemic requirements. With emphasis on the systemic, we consider a division of assessment into functional and non-functional demands harmful [50]. Furthermore, a validation perspective of the outcome of the studies has been made. An implementation perspective that builds upon the current systemic requirements with the object type categorizations has also been made. The Activity Theory has been used as an analytical tool, both in analysing the cases and as being a part of Developmental Work research, for the technology enables transition. Concerning implementation aspects, multi-agent-systems have been considered and are recommended according to figure 10 concerning the role for agent technologies.

The methodologies used in this thesis are mainly academic but are inspired from the abilities opened in the SOS domain. Ranging from taking an active part in being a participant in an operator education. The work is in its foundation qualitative, however with quantitative influences, as for example the validation of the cases within the second workflow principle in the chapter with making workflow transparent. In chapter 10 a more extensive description and discussion concerning the methodologies used are presented.

Concerning the cooperation with SOS Alarm, it started in 1999. Most field studies took part in 1999-2002. Field studies were conducted in five centers in different parts of Sweden, most of them situated in south of Sweden. In 2000 a first work shop with operators from one centre were conducted. During the year of 1999 approximately 20 visits to four of the centres were conducted, approximately 400 cases were observed. Field studies, interviews, discussions, videotaping, co-listening to real cases, computer logs, analyses of material were conducted. Developing suitable ways for how to get all available data in a case, which operators that handled the case, how long time it took, how the operators cooperated and more. Also shorter studies on ground service, as paramedics[1], rescue service[2] and police[3] have been made. Approximately four meetings with the headquarters in Stockholm were conducted. Technological responsible and project responsible, consultants, operators, managers of centres were participating in the meetings. In the last meeting Ericsson staff were participating. They were selected as responsible to engineer the new technological platform that was one aim with the NOVA 2005 project. In 2000 approximately 15 visits to the centres were conducted. One work shop with operators from three different centres was conducted. Focusing on the specific centre-to-centre or SOS cluster issue.

The cooperation with SOS Alarm was in the NOVA 2005 technology program, i.e. one of twelve action programs. NOVA 2005 was a future program developed in cooperation with clients and co-workers, established by the SOS Alarm board. Four reports were conducted within the SOS-BTH cooperation. These reports were used as a basis for seminars and the requirement specification that were a ground for the demands for the new technological platform. One dissertation and three licentiate thesis's (this included) has been produced as a result of this cooperation.

3 Own contributions

The thesis is based on the following six articles of which the first three have been published, and the following two submitted, and the last is ongoing work, to be submitted:

1. Lundberg, J., *Mobitex Technology in Use: Status and Priority.* Article in Proceedings of 25th IRIS conference, 2002 Bautahöj, Denmark [1]

[1] Ambulance ride, work shop, meetings and discussions.
[2] Meetings and discussions with firemen, information about rescue equipment.
[3] Presentation of and tried their information and decision support systems.

2. Ståhl, O., Wallberg, A., Humble, J., Fahlén, L.E., Bullock, A., Lundberg, J., *Information Exploration using The Pond.* Article in Proceedings of Collaborative Virtual Environments, CVE2002, Bonn, Germany, 2002 [2]

3. Lundberg, J., *Communities of emergency handling* Article in Proceedings of the 26th IRIS conference, 2003, Porvoo, Finland [3]

4. Gustavsson, R., Brandt, P., Lundberg, J., Rindebäck, C., Östlund, L., *Agent based workflow support in life critical situations*. Submitted to Journal of the Brazilian Computer Society, JBCS, 2007 [4]

5. Gustavsson, R., Lundberg, J., Rindebäck, C., Ådahl, K., *Functional verses non-functional requirements considered harmful*, Submitted to World Congress in Computer Science, Computer Engineering and Applied Computing, Las Vegas, USA, 2007 [50]

6. Gustavsson, R., Lundberg, J., Rindebäck, C., Ådahl, K., *Assured qualities of service-oriented systems*, Ongoing work, planned to be submitted to International working conference on evaluation of novel approaches to software engineering, ENASE, 2007 [65]

The own contributions in this thesis are threefold:

1. Essential aspects on technology based organisational changes
2. Methods and models to increase the quality of the requirement specification process
3. Identification of relevant research and development challenges coupled with some new insights on combining ethnographical approaches with system modelling.

The first contribution [1] of the listing above concerns *essential aspects on technology enabled organisational changes*. This contribution is domain specific with insights in the emergency handling. The insights are both case specific concerning the cases as such, but also from a structural point of view, such as the work flow principle. Insights in how the categorizations of emergency calls are made, and the relevance of structuring the cases in categories in concern to how the handling of the case proceeds is presented. Findings in relation to the article are presented in Chapter 5 *The anatomy of workflows in SOS centres*, Chapter 6 *Validating the workflow principles*, and Chapter 7 *Making workflows transparent - case specific domains*. Furthermore, a matrix with the extremes in SOS clusters and empowerment of the edge are presented. Made as one means to specify the extremes, and from the result consider suitable level and analyze potential risks. Findings in relation to this article are presented in Chapter 8 *Maintaining critical performance during reorganization*.

In the second contribution [2], *methods and models to increase the quality in the requirement specification process are presented*. Different approaches towards this contribution are described. The principal approach is to specify assessment into systemic requirements. These demands are then carefully analyzed and modelled. The functional requirements are analysed and implemented from an information analysis point of view, with emphasis on the semantics of the information. Concerning the

systemic requirements they are modelled and implemented building from the object type categorization that is the main structuring of the cases in the centres today. Another contribution concerns the relation of descriptive methodologies, such as ethnography towards computing and engineering methodologies. Validation contributions such as validation of principles, consideration and formulation of measurement criteria are presented.

In the third contribution [3], *identification of relevant research and development field*, parts of the focus of this thesis are related to this paper. In the fourth contribution [4] the identification of relevant research and development challenges are further elaborated. In this thesis parts of this work are presented in Chapter 9 *Requirements engineering and implementation of workflow support*. Basically this paper concerns the basis of the empirical studies where the ethnographical method used. It concerns the connection towards requirement and the requirements process with validation. This in connection with the model of information analysis makes it a relevant research and development field. The SOS cluster issue is an interesting application to use, and the research and development field could most probably benefit from other application areas. Concerning structuring and displaying of information, issues considering the second article [2], are further elaborated in chapter 9.7. Concerning the systemic requirements, it is further elaborated in the fifth article [50]. Further more, the workflow perspective addressing software intensive distributed socio-technical systems are proposed. An assured contribution in the same spirit as article five is presented in the sixth article [65].

Two additional comments concerning my own contribution are the following, *usability* contra *understand ability* and a methodological contribution concerning configuration of methods.

In the first additional own contribution, not included in the above six papers but in this thesis, is some insights concerning usability. There is a general agreement in usability contexts that we need to engineer user-friendly interfaces as a means to get usable computing products. There is a critical risk to consider about this perspective; the risk that it takes so much attention in the human-machine interaction discussion, perhaps not driving the issue forward as fast as it could. Instead of focusing so strong on usability, perspectives upon *understanding the system* could be more productive. A potential productive perspective to have on usability today is the perspective that *usability* concerns *understand ability*. This issue of understanding where in the process one are is most probably a productive perspective. Having such a perspective, issues concerning transparency and traceability appear naturally. In the second additional comment concerning my own contribution is the use of methodologies, that the selection of methods has been configured to follow the research question. Basically, from the research questions stated, the methodologies has selected as a means to reach answers to the research questions. In table 1 a matrix relating the articles and contributions from five essential perspectives point of view. The perspectives are those of ethnography, requirements, science of information, agent and services.

Article nr and reference	**Ethnography**	**Requirements**	**Science of information**	**Agents**	**Services**
Article 1 [1]	X				
Article 2 [2]	X	X	X		
Article 3 [3]	X	X			
Article 4 [4]	X	X	X	X	X
Article 5 [50]	X	X	X	X	X
Article 6 [65]		X			X

Table 1. Categorizing and relating the own articles from five essential perspectives point of view

The remaining part of this thesis are structured as follows:

In the next chapter, a comparison of related work is presented. In chapter 5, a general description of how cases are handled is presented. Two cases are presented, with a focus upon the anatomy of workflow, and workflow principles are established. The workflow principles derived from chapter 5 is used in chapter 6, where a validation by using two new cases is made. In chapter 7, making workflow transparent, the focus is put on how far it is possible to draw general structures from a specific case, using the four cases. In chapter 8, the focus is put on maintaining critical performance during reorganization. SOS clusters and empowerment of the edge are considered, as well as missions. In chapter 9, the focus is on implementing workflow support, where systemic requirements are presented. Following those, a suggestion of implementation of functional demands by using information analyze, and information structuring methodologies. The systemic requirements are partly implemented by using the current object type categorization, adding a SOS cluster focus. Chapter 10 is the methodological chapter, followed by a chapter concerning validation principles. In chapter 11, design suggestions for future service-oriented workflows are presented. In chapter 12, validation principles are presented, validating the design suggestion. In chapter 13 a conclusion is presented, capturing the main content in this thesis. Chapter 14 considers future work, presenting possible future departures, including a reference to a draft of an article. The last three chapters contain references, glossary and appendix.

4 Comparisons and related work

Related work on principles of workflow support in life critical situations with a science of information perspective, and with the perspective upon SOS clusters grounded in empirical ethnographical studies do not exist to our knowledge. Seen from a research field perspective, this research is related to the field of Computer Supported Cooperative Work (CSCW). CSCW is a multidisciplinary field where both social as well as technical aspects are taken in consideration. The focus is on taking a narrow perspective on work and human interplay in computing settings. Where a general contributing paper could include some sort of field studies, perhaps ethnographical in character. Followed by a computing solution, responding to some extent to the outcome of the field studies. This research is also related to a larger research field, that of Human Computer Interaction, (HCI), also a multidisciplinary field, but with its roots in psychology and cognition, as opposite to CSCW where the roots of the human perspective lays more in the field of social science. Parts of this thesis are related to Knowledge Engineering and Management and Requirement Engineering contexts. Concerning the automation aspects, there are relations to agent and multi agent communities.

The closest related work concerning the information and organisational aspects is the work of [5] where studies on the reorganisation of information handling from face-to-face meetings in pharmaceutics contexts are replaced by call-centre support. Distribution and outsourcing of parts of the tasks are considered, mainly from information and risk analysis point of view. There are some work on globalization and off shoring of software distribution and outsourcing of relevance [6] [66] [71]. Basically we have a common understanding of how to define the system. The system is socio-technical systems, with internal workflows including information and businesses processes within the system. Figure 1 presented in chapter 2, shows how the system is defined. Basically the agents, here depicted as humans, and the workflow below that is incorporated in the ecology of the system. The ethnographical method used is connected to the agents and workflows, as is the science of information, but with a specific focus upon information structuring and handling. Connected to the agents and workflows is the system demands, with issues concerning trust, acceptance and economy. Services are connected to the workflow and agents, as with a service structure, where organisation, coordination and systemic requirements are connected. As the service structure is put, service level agreements are stated. These agreements are then derived onto the workflows and service structure with the CommonKADS methodology, where functional requirements are put. As an example the organisational context in OM-1 structure in CommonKADS supports a service oriented structure, where such related information is put. Supporting the overall information ecological view that is put upon the system.

Concerning the organisational aspects, some parallels can be drawn to [5] [6] [66] [67] however, the SOS cluster organisational change differ since it concerns a reorganisation where the qualities of the old organisation has to be kept adding the qualities in the new organisation. Concerning the virtual networks aspects; there are inspirational aspects on virtual organisations [7]. Initiatives with a focus upon sustainable information societies are also related on a general level [9]. Concerning time-criticality in SOS clusters the work of [10] where measurements on distributed information handling, with focus upon the time it takes for information calculations in such context. With one conclusion that such delays in distributed systems could in the extreme prolong or make the process of shared awareness harder. The defence and warfare are those that are considered to hold a leading position in applying networked handling. There are some relevance and similarities concerning clusters in research and development of information systems for defence and warfare [11]. The reach and richness focus upon information, and especially the Network-Centric-Warfare[4] initiative are of relevance for this work. Concerning application and use of automation and agent based solutions; the related work on trust is a critical issue, where a trust model is of inspiration [12]. Concerning the requirements aspects, discussions of relation to [68] are made. Also, this work is related to [13] [69] where a similar focus upon the same work-practice domain and ethnographical methods are taken; however what differs is the requirement and information structuring perspective.

[4] Network Enabled Capabilities, there are different names dependent upon national belonging of the word.

5 The anatomy of workflows in SOS centres

5.1 Handling emergency calls

In this section we focus on the first two challenges presented in chapter two.

Methodological issues related to:

- Identifying normative and actual workflows in work practices at SOS emergency service centres.
- Identifying a suitable service oriented architecture supporting workflows.

Described in more detail in [3] [14] the general handling of an emergency call is as follows:

The handling of emergency calls, and how the computer support is used in the centres[5] are operator individual and case specific. However patterns of how the operators' behave handling the calls, and characteristics of the calls can be revealed. To capture both the generality and the specifics of how cases are handled, both general and case specific descriptions of emergency calls handling are presented. Starting with a general handling of a call, it is divided into the answering and categorizing of the call, the responding and division of labour, and finally the monitoring and updating of the call.

The answering and categorizing of the call: The emergency call has come into the centre, the beep, indicating that it is an emergency call is heard from the CoordCom system and the visual representation appears on the screen. The operator selects and highlights the call in the queue, pushes the answering button and answers the call.

- SOS one, one, two, what is your emergency?

The operator types the emergency event and does a request for the address, checks the address with the caller, id-number, and categorizes the call into an event code. In this dynamic ongoing discussion with the caller, the operator uses the computerized forms to structure the typed in text. Along with the medical index in paper as a support for categorizing the event, the phone number for the search in the address database, and the event code system in the computer support for the event code. The other operators present in the room or other staff reachable through the system are also used as a support for the decision-making and categorization made by the operator.

The operators turn to the responding and the division of labour: For the resources to be sent, the dispatching operator uses the categorizations made and searches for the most suitable units for the case. Suiting both to the priority of the case, the action plan and to the geographical state of the dispatch able units. The operators use the paper maps, the computerized map and different forms in the computer, such as the available units form. If there are several different vehicles to dispatch there often are

[5] The centres have different version of the system, and the systems functionality differs between the centres, such as the receiving of Mobitex statuses.

different operators working with the case. In for example the basic form for the case it is visible which operators that are working in the case.

As the units are assigned for the case, the operators take the role of monitoring and updating the case. They receive statuses from the vehicles and answers calls made from the units. The calls often concern geographical or coordinative issues. If the resources in the case are sufficient, meeting the case needs and are not re-dispatched for another case, the case is closed as the dispatched units signs off the case after completing their assignments.

The following Figure 2 depicts this normative flow described at the SOS centre.

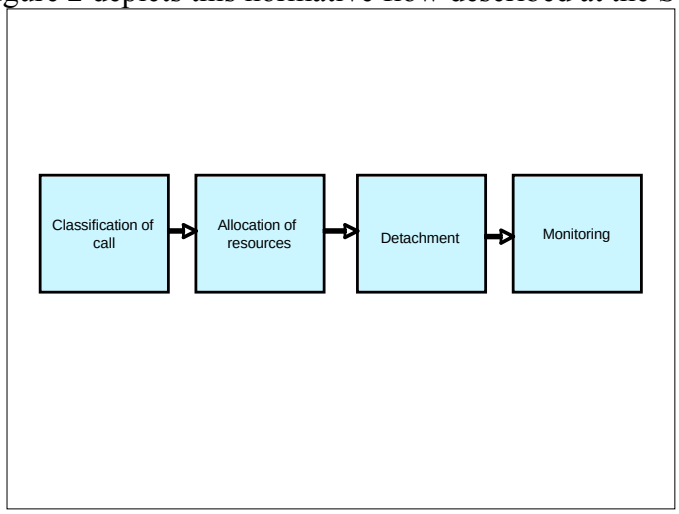

Figure 2. Normative workflow at SOS centres

However, in order to understand the factual workflow and its support we have conducted a set of ethnographical studies at SOS centers to reveal the cultural embedding of the normative workflow, Figure 2.

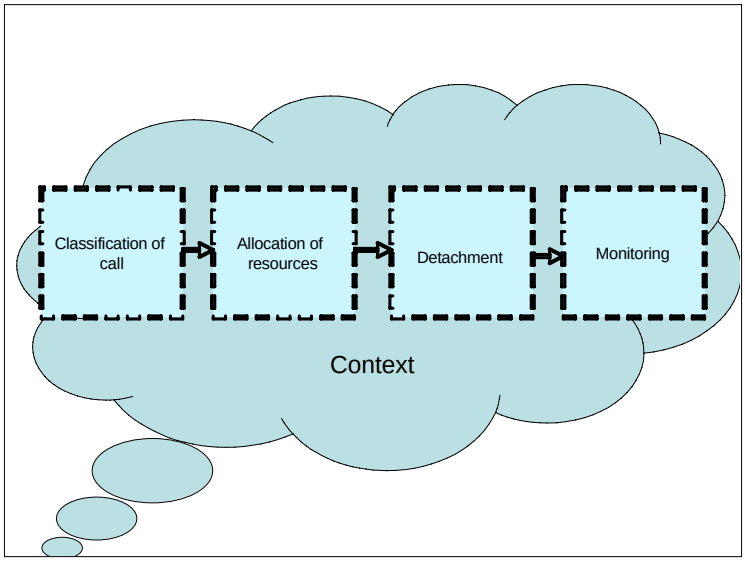

Figure 3. Workflow embedded in a context

The following dialogues related to the normative workflow of figure 2 reveals the underlying coordination mechanisms of the workflow.

5.2 The Heart-lung-rescue case

This is an example of how a case is handled (described in further detail in [3] and appendix):

This case, the Heart-Lung-Rescue case **(HLR)** is about an old man that probably has got a heart attack and is in need of an ambulance for treatment in hospital. The incoming call is answered by receiving operator (RO); she does the first conversation with the caller. The caller, HS, is the son of the unconscious 83-year-old man.

1[6] RO SOS 112
2 HS Yes hello, my name is Lars Persson[7]
3 RO Hello
4 HS I could need an ambulance
5 RO Yes, what is your emergency?
6 HS It is my father, he has fallen (HS exhale)
7 RO He has fallen, yes.
8 HS (not audible) he, went to the basement, yes I heard a bump you know…
9 RO Have he fallen from the cellar stairs?
10 HS No, probably he has got a heart attack or something like that
11 RO Aha, is he awake?
12 HS No, he is unconscious.

In this first section of conversation RO are trying to state what is the *caller's emergency* (c.f., Figure 1). As this is going on, RO *simultaneously* categorizes the case, typing in the event type for the event code, The M is for an event with a person involved, the 1 is the priority for the case, the highest priority, meaning acute case, and event type 23 means unconscious. RO sends the position to the address over to the computerized map system, and the exact location of the house X, Y coordinate position is visualized on the computerized map system. *Meanwhile, the dispatching operator* (DO) (physically located sitting next to RO) starts to work with the case, opening the event plan[8] for the case, searches for the most available ambulance and dispatches the ambulance X967, marking with an x in the event plan that this is made. DO put time surveillance on the ambulance to make sure that the paramedics respond to the case. If not, the system will remind her that they haven't answered. Meanwhile RO continues the conversation, making sure that the old man are breathing and enters his name. Checks the phone number and address (visible from the address database) and gets a narrow road description of how to get to the house.

RO asks for which road is the best road to take according to the son, since there are at least two different ways for the paramedics to get to the house. The close road descriptions are of vital importance since this address is situated on the country, with small roads and houses that can be hard to find. The son says that his father doesn't breathe and RO starts to prepare the son for a mouth-to-mouth rescue. She types the comments, fallen, doesn't breathe, HLR in the system and DO sends a mobitex[9] message to the paramedics. As ambulance X967 has acknowledged the case, DO

[6] Translation of conversation, the original conversation was in Swedish
[7] All personal identifiable information is changed, such as name and address
[8] Event plan, is the plan based on the event code that the is presented in the CoordCom system
[9] Mobitex, data sent to the paramedics via Mobitex system, case relevant information is sent such as the position of the person in need of help

dispatches the second ambulance for the case, X992 marking the dispatch in the event plan. At this time RO is initiating a HLR for the old man.

As this short case illustrates, the factual embedded workflow of tasks in Figure 3 are actually addressed *in parallel*, see figure 4!

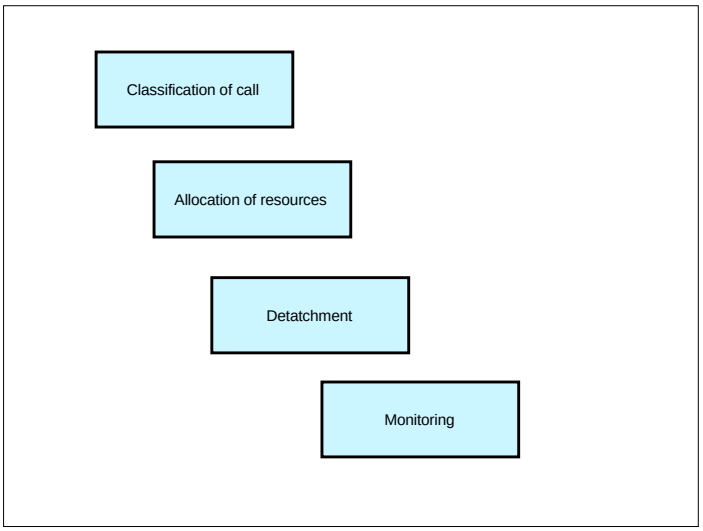

Figure 4. The factual parallel execution of workflow tasks at SOS centers

Our ethnographical studies thus reveals that the factual execution of workflow tasks are in parallel and that the coordination mechanism is *blackboard based.* As the operators perform the activities in parallel, they save time, which is crucial in the handling of the calls. Minimizing loss of information, instantiating an economy of information. This is possible since the dialogues are most often prepared and context dependant i.e. the operator knows that when ambulance x is calling it is most probably to get extra road descriptions since this specific ambulance just was dispatched. To see if there are further examples of parallel execution of workflow tasks, i.e. "The coordination of the tasks can be modeled as a risk driven blackboard based spiral model" in a time critical handling, we will present another case, the Diabetes case (D).

5.3 The Diabetes case

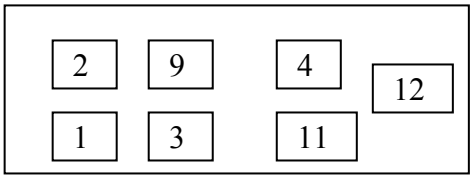

Figure 5. The operators' physical location of terminals in the SOS centre.

This case concerns a 112 call and is answered by the operator at terminal 3 see figure 5, requesting listening-in from ambulance dispatcher on table 11.

1 Answering operator (AO): SOS one one two, what's your emergency?
2 Man calling (M): Yes we have a diabetic here that we cannot contact (AO turns, the DO to be looks
3at her screen)
4 AO: You are not at all able to wake him up?
5 M: No, it gets no contact with him. (AO sends listening-in)
6 AO: He… for how long time has you not been able to get (DO answering listening-in and turns
7towards her screen) **contact with him?**[10]
8 M: **We don't know, we just got home from work, and found him in the bathroom now.**
9 AO: **Ok, but is he breathing?**
10 M: **Yes.**
11 AO: **He is. Ehh, what kind of number are you calling from?**
12 M: **It is a mobile.**
13 AO: **A mobile number**
14 M: **070**
15 AO: **070**
16 M: **111**
17 AO: **111**
18 M: **222**
19: AO: **222**
20: M: **333**
21: AO: **333 and what is the address?**
22: M: **It is Kings Corner 99**
23: AO: **Kings Corner** 99 in Royal town.
24(DO pushes on numbers on her keyboard, points at the screen
25 to the computerized map. AO looks down and then on
26the computerized map) ok and what is his name?
27: M: His name is Ingmar Vastman (spells)
28And it says Vastman on the door also.
29AO: Yes. How old is he?
30M: He is a bit over 70.
31AO: A bit over 70… ehh, but he is laying on the floor now or?
32M: He sits on the toilet, leaning over the bathtub.
33AO: He sits on the toilet, leaning over the bathtub.
34M: I've tried to push him up, but it didn't work well.
35AO: It would be good if you laid him in semi prone position.
36M: Yes
37AO: That you lay him half on his tummy
38M: Yes, he is laying a bit like that.
39AO: He is laying a bit like that, because the most important thing now is that he has space to breathe
40, so that he can breath for himself, so that… if he is breathing good as he sits, then you could leave
41him there, just keep an eye on him.

DO call the Royal town ambulance up.
Paramedic (P): Yes it is 967 it is Staffan.
DO: Hi Staffan, it is Pernilla here.
P: Helloo Pernilla.
DO: You will get an emergency ride to Kings Corner 99.
P: Send it.
DO: Yes it is a patient having diabetes that most probably cannot be made conscious. He talks to them right now (turns to RO) so I don't know anything more, but it is diabetes.
P: Send out.
DO: Yes I'll do so, bye.
P: Bye.

5.3.1Comments on the Diabetes case

Also in this case, the parallel activities are seen. AO sends listening-in to DO *simultaneously* as AO talks with the caller and types information concerning the case in the basic form. The dispatcher alerts the ambulance for the dispatch, after the listening-in is closed, *simultaneously* as AO is talking to the caller and not yet has typed in all information concerning the case in the form. According to the log the ambulance are alerted straight after the man calling has stated the address (row 23). An interpretation of that is that she waits to send the Mobitex to get as much information as possible, and to save time. As DO says to the paramedic "*Yes it is a*

[10] Fat letters to illustrate the listening-in

patient having diabetes that most probably cannot be made conscious. He talks to them right now (turns to RO) so I don't know anything more, but it is diabetes." she turns towards AO and looks at him. Then DO sends the information via Mobitex. Of interest also is that DO inform the paramedics that the patient is having diabetes. This information is not heard via the listening-in, but visible in the basic form as she answered the listening-in.

5.4 Parallel activities in cases

Both the cases support our reflection that using the ethnographical material covering cases, the activities are done in parallel and not in a normative manner as in the general descriptions. What the ethnographical studies have done is to make transparent the case specifics with the parallel activities. This cannot be seen in the more high-level normative description of the case. From this knowledge about parallel activities, we conclude a workflow principle:

Workflow principle

The workflow at present day single SOS centres is characterised by a parallel execution of workflow tasks. The coordination of the tasks can be modelled as a risk driven blackboard based spiral model.

Concerning the risk driven and spiral model approach, see the CommonKADS methodology [37]. Concerning the black-board based origins, article [55] can be of further reference. In the next chapter we will validate the workflow principle, and will specifically return to the second part of the workflow principle in section 8.2.

6 Validating the workflow principles

Having the ethnographical studies and the two specific cases presented, we have thus derived at a workflow principle. The principle presented, that the workflow is characterized by a parallel execution of workflow tasks. However, what if this principle just holds true for these two specific cases. We will find and present two new cases, the **Little town** case **(LT)** and the **Giving birth** case **(GB)**, validating if the principle still holds true.

6.1 Little town case

This Little Town case is about a traffic accident outside a grill kiosk in Little town. Two private cars are involved in the accident. We have chosen this case since two calls are coming into the centre concerning the same case with five second between. The first answering operator AO1 are sitting at table 2, see figure 4. The other call are answered by operator two AO2 sitting at table 3. Two cases are made, but the operators only perform activities (such as the dispatch of ambulances and rescue service) in only one of them. The case is also interesting since several operators are involved in working with the case. Except for the two answering operators, two more operators are involved the ambulance dispatcher at table 11, and the operator at table 9.

We present the transcription from the call answered at table 3, which is the second call concerning the same case. We used two video cameras to capture the case, one with close focus upon operator at table 3 and one with an overview of the centre.

(AO1 takes the first call concerning the Little town case)
1 AO2: SOS112, what is your emergency? (looks down at the keyboard, starts typing)
2Woman with foreign accent (W): Hello, I am calling from Little town, it is a car accident that has 3occurred.
4AO2. A traffic accident you said?
5W: Yes, a traffic accident.
6AO2: Have two cars collided, or?
7W: Yes two cars have collided. (AO2 looks down at his keyboard, types as if adding some
8more text)
9AO2: Two cars have collided… does it seem to be any injuries?
10W: It seems so, because I work in a kiosk huh, and I can see some outside, I think it is two girls 11and a bit older man,
12AO2: Are they still sitting inside the car, or?
13W: This guy is sitting there.
14AO2: The guy is sitting in the car.
15W: Yes, wait I'll check through the window.
16AO2: What is the address?
17W: It is Snack bar, Safire street 1.
18AO2: Safire street 1, outside Snack bar (looks down as he says Snack bar, keyboard key sounds are 19heard as he says outside, operator sitting at table 9 (O9) rises and says, -In Little town or? and nods 20her head towards AO1 sitting on the opposite side of herself. O9 sits down after about two seconds.
21W: Yes
22AO2: (Looks at his screen)
23W: Little town.
24AO2: In Little town
25W: Yes
26AO2: Yes… all right. My colleague are sending every already, but it is two private cars? (pushes the 27keyboard hard, leans forward, looks at the screen. O9 says aloud: -Traffic accident in Little town it 28is. AO2 turns and nods towards her. O9 starts to work with her keyboard)
29W: Yes it is this estate car.
30AO2: Yes, can you check a bit closer; my colleague has already dispatched rescue service here.
31W: Yes wait.
32AO2: Yes I'll wait in the phone. (Operator at table 11 says: - AO2 has got the case. O9 says: AO2's 33case. (AO2 turns towards O9)
34O9: You take the station there or (talks towards AO1)
35AO1: No I couldn't reach them. (AO2 looks at O9, and then it is heard that DO is dispatching 36ambulance H971)
37W: Ok, wait (conversation is heard in the background, "Hey you is it good with those people, I am 38calling the ambulance here, is it good with them (I don't know) Are they hurt?)
39Yes it is a man that is hurt, he has a bubble on his head, or, it seems so.
40AO2: Ok, it is a man that has got a knock on his head.
41W: Yes
42AO2: But he is not stuck is he?
43W: No, they are not, everyone is in the car, no one goes out.
44AO2: Ok, but they are alarmed here, so they will come as soon as possible.
45W: Ok (AO2 looks at his keyboard)
46AO2: Ok, thanks, bye. (The call is finished)
47AO2: You have taken care of the rescue service, or shall I? (AO2 turns his head towards O9, O9 48turns her head towards AO2 and says, -I have not been able to reach them until now.) (DO 49dispatches ambulance 951)

6.1.1Comments on Little town case

O9 says on row 27-28, -Traffic accident in Little town it is. This sounds as verification, as if to tell AO1 that it is a call concerning a traffic accident. That the operators has answered two different calls concerning the same accident almost at the *same time* is commented on row 32 - AO2 has got the case. A third operator does this at the *same time* as two conversations with two different callers concerning the same case.

During the ethnographical studies it is sometimes seen that two or more cases are created *in parallel*, concerning the same accident, and that the operators agree on which case they will continue to work in. In the list with ongoing events in the computerized system it is possible to see all cases as soon as they have been created. In the list it is also possible to see the address for the accident, in this case: "Snack bar, Little town".

The dispatch of ambulances is visible from row 35-36, *simultaneously* as AO2 is continuing the conversation with the caller. As the ambulance dispatcher has assigned the ambulances to the case, it is visible in the performance form for the case. In this case AO2 has a computerized map, where it is seen that the mobitex is answered by the dispatched units and the units geographical position. The operator can mediate this information to the person making the emergency call.

6.2 Giving birth case

This case has been answered at one of the bigger centers. A pregnant woman, going two weeks over are about to give birth, her husband makes an emergency call since blood lumps are coming out. The answering operator (AO) categorizes the case as a A1.14.06, ambulance case priority one, delivery after week 20 in pregnancy, major bleeding. In this sequence, the husband wants the operator to talk to the woman giving birth (GB), most probably in an attempt to calm her. *Simultaneously* filling in the case form in the CoordCom system.

1 Giving Birth: Yes, hello
2 Answering Operator: Yes hi. You shouldn't be upset. (An operator responsible for coordinating
3dispatches looks at AO and at the operator DO that most probably
4 will get the dispatch)
5 GB: Big blood lumps are coming out…
6 AO: Is it coming big blood lumps? Yes, I'll send an ambulance immediately here…
7 so they will come to you.
8 GB: sobs
9 AO: … so, calm down a bit (simultaneously, AO sends listening-in to the
10 dispatching operator.)
11 DO: I am in
12 AO: Yes… but the baby is supposed to come out now (continues the conversation)
13 GB: (sobs) Yes
14 AO: Yes, and the ambulance will come to you
15 GB: Yes
16 AO: Mmm

On row 2 an example of overhearing, of the operator responsible for coordinating dispatches in the case, (CO) overhears the conversation that AO has with the woman giving birth. The fact that she looks at AO and then on DO is an interesting issue. She is either predicting what will happen, or, if AO sees how she looks, coordinating activities, or at least indicating how it could be coordinated.

On row 12, *simultaneously* as AO is calming the woman giving birth she is also acknowledging, by saying yes, that the dispatching operator has received the listening-in. As the AO finishes the call with the woman giving birth, DO and AO starts a conversation were they are to coordinate the activities in the case.

1 DO: Should they go and get a midwife or something?

2 AO: Ehh, well, she didn't say anything about that the baby was on its way out, but she is bleeding…
3 DO: Yes… you, I'll take emergency car and ambulance.
4 AO: Yes

The ambulance is to go straight to the woman giving birth, and the reason for dispatching an emergency car is because they need a nurse anaesthetic. The vehicles position and status is presented on the computerized map, and which vehicles that are selected are connected to the case. This is visible for any operator logged into the system viewing cases and vehicles.

In the continuing handling of the case, DO and CO *cooperates* in solving the case. At one occasion CO walks up to DO and discusses how they can solve the case. In a conversation with the emergency car where the nurse anaesthetic has asked for a midwife, DO agree to get a midwife from hospital A. They now need a midwife, but are short of ambulances. They solve it by asking the police for assistance, the police agrees, but the emergency car calls again to inform that they have to choose a midwife from hospital B. This since the woman giving birth is treated at hospital B. The case is solved, and it went well, as the case was closed the woman giving birth was at hospital, in labour.

6.3 Comments on the Giving birth case

This case is rich of coordination, both between operators, but also between operators and ground service. The operator looks at each other, walks up to each other, coordinate some activities by using intern communication. It is also possible to see that the operators are simultaneously working on handling different tasks in a case. As on row 12 as the AO acknowledges that the DO has received the listening-in, and are ready to dispatch in the case. As a general comment, there can be occasions when the operator has received the listening-in, but cannot dispatch in the case. The operator sending the listening-in can choose to direct it towards several operators, where most available operator takes the dispatch.

6.4 Analysis of Parallel activities in the cases

In the **Heart lung rescue** case and the **Diabetes** case we have previously seen that the tasks are handled in parallel. We have now validated the parallel activities by two new cases, the **Little town** case and the **Giving birth** case. The validation is performed, and in both the new cases it is visible that the operators perform activities in parallel. The workflow principle is thus correct, the handling of the emergency calls *is characterised by a parallel execution of workflow tasks.* This leads us to redefine the definition of workflow, see **Glossary** workflow reconsidered**.** In all the cases, parallel activities are seen. An argument towards this validation of the workflow principle is that four cases are a small amount of cases to draw conclusions from. However considering the observation of approximately 400 cases that has been made, these selected cases are normal concerning the parallel handling.

As we have stated this, we return to the cases to search for further similarities between them. In next section we will perform comparisons between the cases, searching for similarities in how the cases are handled.

7 Making workflow transparent - case specific domains

If considering workflow from an application perspective, where the work practice of a domain is of interest, studies of the domain can be an important tool. One method to use when taking studies of the workplace serious is the ethnographical method. The basic of the ethnographical method is to participate in the domain, to find out as much as possible concerning the work practice. Using ethnography, taking the studies and description of the current workflows serious is an interesting attempt to create a solid ground for a workflow perspective. **For further methodological considerations, an extensive discussion is made in chapter ten, considering ethnography from the perspective of connection to models of computation.**

From the ethnographical studies, hitherto presented in cases, we have seen and validated that the tasks are performed in parallel. However, returning to the cases, and the case specific performance, what can we derive from the cases on a general level? Are there patterns of handling the cases, and on which granularity is it possible to make comparisons between cases? When does the handling of a case become to case specific? For this purpose, we need to return to the cases again, trying to find the right granularity.

We will return to the cases, comparing them to see in which parts of the handling they match. The classification of the call is made by a conversation with the caller. Considering the **Heart lung rescue (HLR)** case. Starting out with the operator asking the question: SOS 112 What is your emergency? In the **Diabetes (D)** case, this also holds true, as in the **Little town (LT)** case, and in the **Giving birth (GB)** case, see appendix. But lets go back and see what the answers are. In the **HLR** case, the caller respond by saying his name, in the **D** case, the caller answer by telling what the emergency is. In the **LT** case, the caller responds by telling where she is calling from, and what the emergency is. In the **GB** case, see appendix, the respond is a request for an ambulance. Basically no answer was the same, there were similarities as in the **D** and the **LT** case, as they said what the emergency was, however at this granularity we clearly can see differences in the answer. Thus we have come to deep and become to case specific. We turn back to the similarities in the answer of the operator, and on the higher level, the *conversation with the caller.* However when looking at the conversation with the caller, we can find some patterns of information that the operators search for when classifying a call, such as checking the address, and how many persons there are involved in the accident, and how they will prioritize the case. But how they do it and in which order are case specific. If we take the **D** case, the general handling that is found in all the four cases are marked in yellow, and the specific handling of the case, i.e. the case specific handling is marked in white. We have now added the general and specifics for the **D** case, see figure 6.

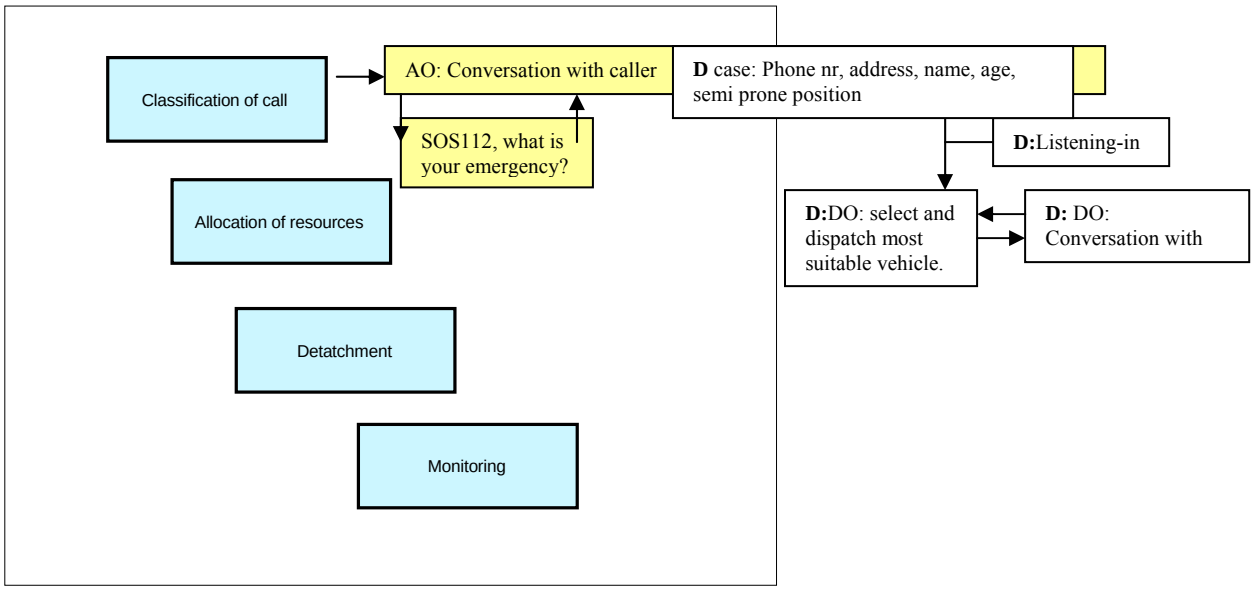

Figure 6. Parallel executions of workflow tasks, with general and specific handling.

We have thus shown a systematical way of going through the ethnographical data, by making comparison between the cases, down to the granularity when the comparisons differ and become to case specific. The workflow and the generalities between cases are made transparent by this systematical way of considering multiple cases. The specific cases are considered, but the result of the consideration is on a general level.

7.1 Categorization

From this systematic way of going through the ethnographical data, we can see that some parts in the handling of the cases are similar, as for example in how they answer the cases. The operators have a specific way of structuring the similarities between cases. They categorize the cases from a pre-structured list of *Object Types,* see further in appendix chapter 17. These *Object Types* are in a prioritized list, with highest priority first. The use of categories [1] is an important part in the structuring of cases and establishment of proper response. Categories can by definition not fill an exact match to all the cases. But are used by the operators, as in the way Kant described; a structural frame that our sense have to use to build up knowledge about the world. The categories of the cases play an important part in the handling, this since the *Event Plan* for what actions to take concerning the case is sprung from the categories. The event plan is a predefined plan generated from the categorization of the case. The operators follow the event plan, marking which tasks they have made, and which tasks that are to be performed. The structure of the categories is a six-character code, for example H1.11.23[11], labeled as object type. In H1.11.23 were H1 means human involved, first priority, 11 animal bite/insect bite and 23 means unconscious.

H = Human
B = Building
P = Production
T = Traffic/Road
O = Other
A = Automatic alarm

[11] See appendix for more information

1 stands for highest priority; there are four priorities at the SOS centers. The first is of highest priority, acute case. The second priority is critical, and the third priority is more or less just a drive to hospital. The fourth are of lowest priority and can also be considered as a drive, but could be made by a taxi or similar vehicle. There is a corresponding list for H second priority, and a list for building priority 1 and 2, and for production 1 and 2, and the same structure for traffic, other and automatic alarm. In the example below, the beginning of the list of categories in *human priority one cases*.

1. Allergy
2. Difficulties to breathe
3. Children, toxicities, 0-8 years
4. Child- decease
5. Transport to/from health institution
6. Bleeding, no trauma
7. Burn, electrical injury
8. Breast pain, heart
9. Abdomen, urine
10. Diabetes
11. Animal bite, insect bite
12. Drowning accident
13. Dive accident
14. Extremity, small wounds
15. Fever
16. Poisoning, overdose
17. Delivery
18. Gynecological, pregnancies
19. Headache
20. Hypo- hypothermia
21. Chemicals, gas
22. Cramp attack
23. Unconsciousness
24. Indistinct problems
25. …

The beginning of the list for **priority one, building**, rescue service begins as follows:

1. Extensive fire
2. Fire, smoke
3. Attic fire
4. Basement fire
5. Smoke scent, investigation
6. Explosion, risk

From these lists it is visible that a categorization and prioritization perspective is put upon the cases. In next section a validation of the cases upon this list are put.

7.1.2 Validating the cases from the categorization

To validate if the four cases presented fits into the *Object type* categorization, we will return to the cases. The **heart-lung-rescue case (HLR)** would fit into the H as in human, priority 1, 23 as in unconscious and 27 as for stroke[12]. So the Event Type would be M1.23.27. The **Diabetes case (D),** fits into the structure, of human, priority 1, diabetes, unconscious, M1.10.23. The last two cases used for validation of the parallel activities do also fit into the structure. The **Little town case (LTC)** would

[12] See appendix

begin with T1.04. The **Birth-Giving-Woman case (BGW)** would then be structured as M1.06.17 according to the appendix, however this case were handled at a centre with another categorization system, where A as in ambulance were used instead.

From this validation we have found that the cases fit into the *Object type* categorization. Furthermore we have also found that the *Object types* differ between the centers. This differentiation is an important issue to consider in the functional demand discussions considered in chapter 9. From this information about the categorizations in the *Object types* and how they are used, we could consider a research question, including the needs for a distribution.

7.2 Coordination of tasks

Returning to the workflow principle, the second part, stating:

The coordination of the tasks can be modeled as a risk driven blackboard based spiral model.

Considering the coordination of the tasks, from the ethnographical studies it is observable that the operators coordinate the activities in a *blackboard* based way. The *blackboard* metaphor is derived from submarine and military contexts. Just as in the *blackboard* metaphor, the operators' activities are published on the blackboard. And the continuing activities are structured from that basis, i.e. to some extent the operators perform their activities with the knowledge of what the other operators have performed. The Pond application [2] is another example of a blackboard application. Together with additional information such as which operator performed which task and when are documented in the system. This information is visible from the different views such as the ongoing cases and the dispatched units. From such information, operators can to some extent predict which operator it is possible to send listening-in to. As the operator has typed in information into the basic form, it has become a case, the information concerning the case are available for all authorized operators. Which cases are being handled, and which operator that has been and currently is working with the cases is also visible. This *blackboard-based* structure is a quite indirect way of coordinating the activities; the information is *broadcasted* to the viewers. As opposite to a dialogue-based way of coordinating activities, this coordination are made by the articulation of the tasks. Thus complemented with for example the listening-in function, a direct request to another operator that is asked to be supportive, and by the rich articulation work in the physical room.

Considering the cases, a validation of the second part of the workflow principle against the cases presented, see table 2 below. The names of the cases are presented in abbreviations. In the risk-driven column, it is concerned how the coordination in the dispatch are made. All cases are black-board based, and in the spiral column, the spiral coordination with parts of the dialogue presented.

Case	Risk driven	Black-board (Yes, Y or No N)	Spiral
HLR	Possible overhearing dispatcher sitting next to	Y	Y: does 67 know where to go?
LT	Y, two calls, not involved in the case assign the most suitable operator	Y	Y. You have taken care of the rescue service or shall I?
D	Y, sitting close but back against back	Y	Y, indirect by gazes
BG	Y, but with oral acknowledgement	Y	Y, many rounds also including coordinative operator

Table 2. Validating second part of workflow principal against the cases.

There is a clear division of control in the listening-in situation giving the sender the control. However the receiver can reject the listening-in, this makes the coordination *risk driven*. In the Little town case row 47-49, sometimes checkups are made concerning if a dispatch is made or not. As the listening-in is accepted, the ongoing handling of the case is audible in real-time. What makes the coordination of the task spiral based is that the operator initiating the coordination needs to be aware of that the tasks delegated has been made. One example of this spiral coordination is in the Giving birth case, where they choose to redirect the ambulance to another hospital due to the new information from the paramedics on the scene. Another example of spiral coordination is in the Little town case, where the second answering operator returns to the dispatching operator to ask if he is to do the dispatch himself or if the dispatching operator has made the delegated task of dispatching.

8 Maintaining critical performance during reorganization

In this chapter we focus on the third challenge presented in chapter 2:

- *How can we identify and maintain critical qualities during technology enabled transition.*

We focus on maintaining critical performance during reorganization, as described in introduction, a possible change from one centre to several centers are a challenge for a time critical organization as SOS Alarm. Within the centre the emergency call handling with the operators working almost shoulder to shoulder, gives rich possibilities for cooperation and learning. There is a minimal cost in asking for help and opportunities to give a helping hand are occasionally presented. A serious consideration towards how to support for cooperation between operators sitting geographically distributed is inevitable.

In this chapter a discussion of findings from workshops, and a consideration of the issue of partly virtual organization are made. Empowerment of SOS cluster extremes are presented and considered.

8.1 Findings from workshops and field studies

In one of the workshops[13] with emergency service personnel, mainly operators and directors were conducted. The operators were from three different centers, the main question asked were: if it is possible to share nationwide calls. Findings that confirmed much of the work practice findings presented were made. However also new issues were presented, war stories were told, and a selection of cases proper to new ways of working was presented. Concerning local knowledge, the example that every operator in same centre knows were the park is situated, however it is not probable that operators from other centre know about it, since it isn't present on the maps or anywhere in the system. Also abbreviations were mentioned. Does an abbreviation have the same definition in different centers?

Another interesting input came from a field visit in a specific centre. In the current organisation, a version of emergency call handling with similarities to centre-to-centre handling can be found. In the "moved-out-step" in X, an emergency service operator has been moved out from one of the biggest emergency services. This "moved-out-step" consists of an emergency operator previously working in the Y centre, but has been moved out to a rescue service centre, but still is connected to the Y centre via handling dispatch of rescue vehicles. At a field study in the "moved-out-step", a conversation with the moved-out operator was performed, and in the conversation an interesting comment arouse from him. He commented on the centre-to-centre issue in this direction:

> "I wouldn't be useful if I didn't know were the other operators *sat*, *likes*, and *reflected about things*."
> (One operator sitting in a rescue service station, cooperating with operators sitting in a SOS-centre commented on the issue of nationwide cooperation.)

This comment can be interesting to reflect upon since it considers a person that is close to working in a centre-to-centre constellation. Whether his comment would be true or not is not the most important to consider, but what is the content of the statement. This comment is further worked on in chapter 9 in systemic requirements.

From another workshop with paramedics, one of the hot topics that were discussed was the issue of choosing roads to get to the person in need of help. Sometimes the paramedics chose the road that the operator selected instead of a road that the paramedics new would take them quicker to the address. However, the reasons for the operator giving the specific road description could be that the person calling in knew if the other road was blocked or similar. However during such cases one could easily reflect about empowerment of the edge. This issue is elaborated further on in this chapter. Either connecting the caller to the ground service, which sometimes are done, or giving the ground service the opportunity to select road and be in charge of that during the ride.

[13] Description of project outline is presented in appendix.

8.2 Towards partly virtual organisation

Seeing the emergency service centers from a virtual perspective is an interesting challenge. To some extent the organization is already virtual due to the issue that the centers are geographically not in the same place as the ground service. They have to meet in a virtual connection by the sending and receiving of information by different channels and media. However it is not the full definition of virtual organization, only existing in the cyberspace, with no cooperation in the physical room that is in focus here. It is a partly virtual organization, consisting of both physical located teams coordinating actions, and teams that coordinates and interacts virtually.

The area of ICT enabling geographical distribution is quite mature. Many companies are working distributed and the research community has found some interesting challenges. In a journal article by [15] Hinds et Al consisting of research of 43 teams, 21 collocated and 22 distributed, they proposed that conflict was unproductive and saw the lack of conflicts in a team as a productive one. Even though conflicts cannot be seen only as unproductive, some interesting results came from the research. If the team had a strong identity, the effect of geographical distribution on conflict was mitigated. And the results showed that in the absence of a strong shared identity, the team members were likely to evaluate other team members behaviours negatively, assuming competition rather than cooperation when problems or miscommunications aroused. The authors also presented results from research showing that distributed teams, especially those that rely heavily on mediating technologies are often less cohesive, and their members are less satisfied with their interaction and like each other less than members of face-to-face teams. The conclusion of the article was that:

> " … spontaneous communication contributes to a shared identity, facilitates the creation of shared context, and aids distributed teams in identifying and resolving conflicts before they escalate, ... "
>
> (Hinds et Al, 2005, p 302)

This conclusion indicates that spontaneous communication is of importance for identifying and resolving conflicts in a distributed team before it escalates. One important issue to rise from the findings of this article is how to support spontaneous communication, since spontaneous communication often can be related to geography. This issue of spontaneous communication has been raised by for example the CSCW community, building "spontaneous communication" support applications.

Findings from work with networked and virtual organizations are also interesting, as for example hastily formed networks [8]. The geography is of importance in the emergency service context. Having a "virtual problem" i.e. a problem that do not need any ground service, may be a problem of getting advices, or getting connected to organizations giving specific information.

8.3 SOS-cluster extremes

In finding a proper level of SOS-clusters and empowerment of the edge, mapping out the extremes is one way to proceed. The first sort of centralization extreme could be total centralization, one centre in Sweden wherefrom all emergency calls were handled. The opposite extreme could be total decentralization, many small centers perhaps close to the stations of the paramedics, police or rescue personnel.

Concerning the first extreme, total centralisation of centres, where every emergency call was to be handled in the same centre, opportunities for the operators to cooperate with each other in-room would be possible. Also, having the equipment in the same location has advantages in maintenance and support. However, the operator would need to have access to how every city or municipality handles its emergencies, having documents and information grounded in knowledge about the ground service personnel, equipment etc. The physical connection to the stations of ground service would probably become minimal in all but the area of the centre.

The second extreme concerns the total decentralization of centres. The operators working close to local ground service personnel. Maintenance and support of many centres could become expensive. Also the in centre cooperation are likely to decrease when being geographically separated. In such a decentralized organisation, it could become difficult to keep an overview of the situation at hand, to coordinate vehicles, and keep an overview of accidents.

8.4 Empowerment of the edge extremes

The two extremes would be, total or no empowerment of the ground service. In the first extreme, the total empowerment of the edge would be that every paramedic, police and rescue personnel were answering any incoming emergency call searching for suitable response. However, coordination in handling the time-critical emergency calls could become complicated. As an example, if every time a paramedic would answer an emergency call not suitable, he or she would have to do the work of searching, calling and dispatching the most proper ambulance, police or rescue service. Coordination problems could become an issue. Also, every ground service would need to have some decision support or information support system to handle the cases, maintenance and updating issues included. Advantages such as if the paramedics got a case in close geography, driving to the case could perhaps become even faster. However if other resources were to be dispatched in a case, driving to the scene, simultaneously calling and coordinating other recourses could probably get complicated.

In the second extreme, were the ground service just follows orders from the operators, the ground service would have to call the operators in every decision, and severe time would be put on communication issues. In this extreme, conversations like, the paramedic calling the operator about which decision to take, and the operator needing ground service information to take the right decision would most probably be some of the consequences. The preparation of the operator becoming decision able with current technology would probably become time consuming.

In the following, table 2, a matrix of centralization and decentralization verses SOS-clusters and empowerment of the edge is presented.

	Centralization	Decentralization
SOS-clusters	Closer to local knowledge. Less information, just regional cases. Cooperation in centre.	Much information, handling any call in the nation. Coordination and dispatch could become an issue.
Empowerment of the edge	The operators act in close cooperation with ground service. Enabling centralized coordination between cases.	Decisions on place. Coordination between cases could become an issue.

Table 3. Description of the extremes, centralization and decentralization verses SOS-clusters and empowerment of the edge.

8.5 Engagement

Finding a proper level of engagement in the SOS clusters could be of interest. In keeping the advantages of any operator at any centre answering any emergency call, a nationwide answering and categorization of calls could be interesting. Turning to the dispatch part of the case, there can be advantages in handling all the dispatches in a case in same centre, preferably in the local centre. If the local centre is busy, other centers could take over. The benefits of both quick answers and coordination of handling the dispatch in the same could be of interest, preserving local connections to the ground service. However if the operators were divided into answering–dispatching division-of-labor, there could be a division also in the information. Important in this category is to structure the information avoiding information overload for the user of the system.

Finding a proper level of engagement in empowerment of the edge could also be of interest. A proper level could be that the operators dispatch and coordinate, but also leave most of the decisions to the ground service. If the ground service has to communicate grounded decisions taken to the operator, then the coordinative quality of the operator could be preserved. This issue is further elaborated in the next chapter.

8.6 Missions

Returning to empowerment of the edge, a well-known application area of this idea is related to future network-enabled warfare. The U.S. terminology is Network-Centric Warfare, in Sweden we have Network-Based Defence (NBD), and in the U.K. the term Network Enabled Capabilities is used. There are, of course, differences but the main idea is to support flexible setting up and deployment of task specific operations or *Missions*. Effect Based Operations (EBO) that defines the purposes of the Mission as well as measurable qualities of the results defines the missions. The challenges involves finding and setting up purposeful missions from available capabilities[14], fielding, monitoring, and supporting the mission in operation. Of specific importance are abortion of missions that could fail in an unwanted manner and assessments of operations after mission completions. Obviously, we can think of Emergency Call Handling as a mission of future SOS clusters.

In warfare, network centric methods have been developed aiming at support for quality of service in military operations [16]. Missions are to be seen as actions

[14] Personnel and equipment.

fulfilling the ‘organisational goal’. Fulfilling the organisational goal is to use the competences that the agents, i.e. humans and software contribute with.

Using network centric warfare and its findings in a networking of emergency service centres with an awareness of the differences of the focus in the different domains can be interesting. The focus of the emergency service centres are to minimize the effect of catastrophes, accidents and similar, but the focus of warfare include to create destruction for the enemies. However there are similarities such as finding and dispatching resources to an event, and take proper actions when having found the event. Coordinating resources and extracting information from different information channels have also similarities in the domains.

Taking the perspective of missions, in [17] quality of service in network-centric warfare, *event detection*, *situation assessment*, and *proactive response* are the corn stones. In the *event detection*, the initial prerequisite of a network-centric system are described. Allotting each available agent a specific role and physical location. A team of agents can identify crucial information sources and trigger on certain types of events. Data collection and information fusion can be used to detect crucial events. Team breakdowns are to be included as a possible critical event at this stage. In *situation assessment*, a continuous flow of interpreted data is provided to team of agents, involving dialogue between the cognitive entities. In *proactive response*, the team of situation assessment agents has identified a target in accordance with their mission. They make a selection of suitable responsive actions, an example in emergency handling context would be to identify and apply suitable vehicles to meet the specific accident. Which operator that is responsible for the mission, which operators that is responsible for the dispatches and so on. Missions are one of several interesting lessons from the Network Enabled Capabilities initiative to be learned.

9 Requirement engineering and implementation of work flow support

In this section we will provide answers to the three research questions presented in chapter 2. Assessment of the current SOS centers is presented, following that, the first and second research questions. The third research question ends this chapter. From the first research question, functional demands are presented, and from the second systemic requirements are presented. The third concerns design of suitable experimental platform enabling testing of service qualities.

Basically the focus is upon requirements and on implementation of such.

Research question 1
In what way can the workflow model of single SOS centres be transformed to a workflow model of SOS clusters while maintaining or increasing the quality of service?

To answer this question, we need to consider specific issues of concern. One such issue is the *sharing* of information. If analyzing the overall categorization and organisation of the information, the structure is to large extent case oriented. Since the work of the operators is to handle cases, most often time-critical cases, a categorization made from the cases seem suitable. However, a pronounced focus on

the operators and their "knowledge-foundation" i.e. the foundation that they use when handling the cases, their experiences of prior cases, difficult cases to dispatch, cases that were handled good, emotionally difficult cases and so on could perhaps be useful. If the operators were to save cases that they find interesting, this could open up for a focus on the operators' skills. Today sometimes cases are selected in the centres, but most often from a critical perspective were the operators have to show if the case were correct handled, often with legal characteristics. A development of this issue of information sharing is further elaborated under the information sub section in the design section in this chapter.

Another important issue to consider is performance aspects. Performance in emergency service centers revolves around time criticality. The emergency calls needs to be handled fast and accurate, two demands that not necessarily go hand in hand. If just time was the issue, computer systems could solely do the work of dispatching resources, if only accuracy was the question, operators could sit for hours discussing the best way of handling the emergency calls, how to calm the person, getting vital details concerning the case.

In performance aspects in a centre-to-centre cooperation, a specific focus on local artifacts and behavior should be taken, such as the paper maps. The coordination and cooperation of work using the maps, the local use of computerized maps, local words, and local names on places used by the inhabitants but not presented on the maps.
In the centre, the operators are observed doing connection between calls concerning the same event even before the calls are documented in the system. Sitting separated communicating more via text messages would probably pose a challenge in this respect.

The listening-in functionality, letting the dispatcher listen-into the conversation of the caller and the answering operator saves time. How this functionality could be preserved and developed in a new organization are of importance. Today the operators in the centre can determine if another operator are busy or not based on if they are working in a case in the system or are talking with a caller or perhaps are having a discussion other operator concerning the cases. However not sitting in the same centre as the person that is to dispatch in the case can become an issue. What if the operator in the other centre cannot take the dispatch? Probably the case would loose time if being transferred between operators in the dispatch.

In the work practice studies, the operators have on several occasions used the big paper maps as a tool for coordination in the cases. This issue has both been observed and confirmed in interviews with operators. Furthermore this issue has been highlighted in [69]. In some centers the operators doing remarks on paper maps and on the computerized maps. These comments seem to be of importance in finding a spot more easily or similar.

9.1 Assessment of current work practice at SOS – centres

This section starts with assessment of current work practice at SOS-centres.

Handling persons in stress – The operators often deals with persons in stress. Extracting important information in shortest possible time, simultaneously calming the person or instructing the caller in giving life saving treatment are potential

stressful tasks. The operators' deals with these tasks in the first stage of handling the emergency call.

Categorization – Categories are fundamental in the handling of emergency calls. As the operator obtain the most suitable category to the case, the decision support system creates an event plan based on the category, describing which events to be taken. This event plans constitute a checklist in the continuing handling of the case.

Time criticality - The operators has to handle the time critical emergency calls not only as quick as possible but also as accurate as possible. An awareness of time criticality is almost always present in the room. As an example is the noise alarm sounding every time emergency calls hasn't been handled before the 10th second limit. Another example is the time saving of the *listening-in* functionality that the answering operator sends to the dispatching operator.

The time criticality poses challenges upon the handling of the emergency calls, and impacts the structure of how the calls are handled. As mentioned in previous chapter, it is visible that predefined words or abbreviations were commonly used, both in text and in conversations. The use of abbreviations is a strong and interesting mechanism to support a fast handling of the emergency calls. Both operators and ground service personnel use abbreviations. Some of the abbreviations were the same for the operators as for the ground service personnel; some were the same but had different meaning dependent upon which one that interpreted it. And third, there were different abbreviations for the same phenomena, but shed from the different perspectives. In the spontaneous debriefings, the abbreviations was sometimes used, but complemented if they didn't capture the story. In creating a smooth workflow, the abbreviations were an important part. If they were correct the workflow went smooth, if not, the abbreviations consumed attention. However in the work shop concerning centre-to-centre cooperation, with operators from different centers, a strong concern about local abbreviations or local words for geographical places that perhaps not could be interpreted by operators from other geographical areas was raised. As mentioned, in case of risks for misunderstanding, the operators used the phone to get additional info.

Ground service connection – In dispatching vehicles, or connecting cases to suitable resources, the operators have knowledge about available resources. Monitoring, coordinating and updating information related to ground service are general categories of the operators relation to the ground service. Keeping an overview of the resources available, social knowledge about the ground service personnel, monitor ongoing cases, receiving status report are more case detailed categories about the operators work in relation to the ground service.

Local knowledge – the issue of local knowledge are both on centre level, on ground service level and emergency call level. On the centre level, knowledge about the centers, the operators, division of labor, local words and places are included. Part of this centre-to-centre local knowledge is the issue of local cooperation, such as cooperation between operators in the same room, local issues such as known addresses or sharing of recourses or sharing cases, about calls from the same area, sharing of physical tools, decision support system. On the ground service level, knowledge about stations, vehicles, and staff like paramedics are included. On the

emergency call level, local information about the geographical area, local language and to some extent also knowledge about the caller.

9.2.1 Systemic requirements: design considerations

Making design considerations out of the functional demands are a complex issue. In this section we will focus on some specific issues that has appeared.

Taking the empowerment of the edge perspective one effect could be that, if we take the example that the paramedics would have more abilities to make decisions, they would have to do more of the communication themselves. To reflect about in such circumstances, is the different medium to establish contact and communication. If a paramedic established contact with another ambulance via audio channels, if there were just one paramedic in the ambulance, it could be quite difficult, driving fast and communicating simultaneously. Even more, if they were to communicate by sending text messages, writing long lines of text, prior findings in the area showed that the driver had difficulties in keeping its concentration on the driving. Due to the risk of lack of concentration on the driving, buttons with predefined messages were preferred.

Another issue to consider is the listening-in functionality. If dispatches in a priority one case are rejected, this could have negative effects on the performance. Rejections of listening-in can be handled in different ways, either a special centre or part of centre could handle only dispatches, or operators could in inform/display when they are available, or subscribe to a list of available dispatch operators. In a scenario were any operator handle any call, and the calls are to be sent back to the centre in the geographical area of the case, the operator sending the case back to the geographical area of the case need to be aware of how busy this receiving centre are. Operators putting themselves in a mode available for dispatch could decrease the risk of cases to dispatch being transferred around. Perhaps also the operators could choose being in dispatch or answering mode, using different profiles.

Concerning the issue of maps. The paper maps in the traffic room has to be treated with extra care. Those of importance could be scanned, however if having local maps in the centres, two dispatching operators working with different local maps could become an issue. A design issue could be to have similar maps in the computer as printed in the room, this way both advantages are kept, on-line and in-room. However local maps could be of interest, an awareness of that the maps are centre specific are of importance. The issue that the operators' makes specific remarks on the maps could become an issue. An awareness of and perhaps distribution of the written local remarks could probably resolve this issue.

A focus on the issue of re dispatching vehicles due to new cases with higher priority can be interesting. Being at the scene, or having latest contact with the scene can give the ground service personnel advantages and knowledge to make judgments about actions. However, updating the operators is of importance since they have an overview of all ongoing cases. Also explicit division-of-labor between operator and ground service is important.

If the operators were to collect some cases in their own "portfolio" each operator owning all read and write access, building a good portfolio for their own developmental sake. Perhaps interesting for purposes of knowledge sharing, knowledge building, debriefing etc. The acquisition and dissemination of information could be done in a peer-to-peer technology style. Integrity issues concerning p-t-p sharing could then be considered which persons the owner of the portfolio would like to share his or hers knowledge with. In working centre-to-centre, this type of information sharing, based on actual documents can perhaps be of interest. This, since much of the conversations in the centres, from were the operators learn from each other are based on discussions about cases. Documenting the cases in a centre independent way, giving every operator the ability to share any document and case with any operator nationwide. This could perhaps to some extent support the operator's needs for skills in handling several cases in parallel.

9.3 Assessment of information flows in SOS centres

Research question 2
In what way can the information type categorisation of single SOS centres be transformed to a workflow model of SOS clusters while maintaining or increasing the articulation of the work?

In this specific context, the implementation of the functional demands is to be properly considered. Traditionally in systems design, it would be a matter of 'non-situation, non-context based' functions. However for this specific domain, context awareness is of importance. Also a serious perspective towards information is relevant, both since the amount of information to be handled increases, as will most probably the skills for interpreting the information. With this background, potentially suitable would be the logical structure of information that Devlin has provided [18] [19]. This structure could be a base towards implementation of support for cooperation in SOS clusters. Structuring constraints, situations and types for the semantics of the message across the information system to the operators.

Devlin has provided a logical frame in the structuring of information. An interesting approach since the meaning of information in computational contexts has been rather syntax centric. This logical frame has been influenced by the work of [20] at Stanford in the 1980's. Barwise and Perry developed their theories in order to understand human languages as communication of meaning, semantics and pragmatics. Suitable adaptations of the theories will provide us with models and techniques to address types of situations. Barwise-Perry and their followers including Devlin has developed formal theories that are addressing situation dependant semantics of language expressions as well as models of dialogues to convey semantic content. For further references see: [18], [19], [20]

Assessing context for semantic information exchange is about identifying *types of situations* in that context. For example: We observe dark clouds and bring the umbrella with us when we leave our house. In Barwise-Perry terminology, we have *deduced* (using experiences or knowledge) that from the specific situation "s" where we observe dark clouds we deduce a type T " it might be rain". Notation s: T, or s is of type T. Following that we have recognized a situation of type T, we know from our experience or knowledge that we might deduce that we might later encounter a new

situation type S "raining". That is we might have a "situation r" of type Raining, i.e., r: S. Informally, we have used our knowledge of the *type inference* T! S to deduce that a situation of type T might lead to a situation of type S. Having identified an eventual instance of type S we take appropriate measures ("bring the umbrella"). In Barwise-Perry notation, our knowledge or experiences and support for reasoning and deduction can be denoted as a constraint relation ("!") between types. In our example: T ! S. We thus have that useful characteristic of contexts that can be expressed by identification of appropriate situations and their types. In short, we describe our contexts as a set of disjoint types, T_j , j J with associated situations; $s_{ij} : T_j$, where i ! I.

Reasoning (based on experiences and knowledge) connects types and are expressed in the following notation:

- S ® T, an identified situation of type S leads to an instance of a situation of type T under the constraint C.

Information flows are described as chains connecting types, i.e., as:

- The chain; S ! T ! R indicates that we deduce that a situation s: S (might) lead to a situation r: R.

The *Information* "I" that is used in reasoning about situations "s" is described using the notation:

1. Information = representation + C(s, capability (receiver)), where C denotes the decoding/encoding constraints related to the receiver's capability to decode the representation of the Information.

A *representation* of an information item could be a written text, a symbol, a natural phenomena (clouds), a signal, or a program. The interpretation by a user (that is, the semantics of the information) depends on the capabilities of the user as well as the situation at hand. There is a clear context dependence between the representation of the Information and the capabilities of the receiver to interpret the representation. To determine the *semantics* of the Information in a given situation we have the following notation:

- s |= << I am sitting >>, or the equivalent notation s |= I, relates Information, represented as a <<sentence>> in English, with a semantics that determines if the information expressed by the representation is true or false in the situation s. Compare with the Tarski semantics of ordinary logics (with truth of logic expressions related to a fixed model).

The Barwise-Perry semantics is situation dependant. If the user got the situation type wrong then the semantics of the representation would be wrong. Similarly, if the user is not able to interpret the representation to get the associated Information, s/he will misunderstand the message and either become confused or judge the situation to be of a false type. In short, the *decoupling* of Information and representation in equation (1) allows us to study in depth issues such as common awareness.

Of specific interest to us are the connections between types and information flow and conversation schemas identifying focal situations for a dialogue. Models of establishment of a common ground (common set of situation types) to avoid misunderstandings are also relevant in our settings. In computer mediated information

services, the representation of the information is limited to *machine process able* formats (c.f., semantic web [21]). In short, computer based information processing can only relate input-output *representations* of information in the meaning of Barwise-Perry (equation (1)).

9.3.1 Language science and common ground

Devlin also provides insights such as info sense and common ground. One basic finding with info sense is the fact that information and representation of information are two different things. A book is a *representation* of information. The readers of the book interpret the words in the book and make information, from the reading and the interpretation information. This is an important issue to keep in mind in SOS-clusters. The idea that if we just provide them with information it will work out is not good enough shed from an info sense perspective. Another interesting point Devlin presents is the common ground. He presents different models to highlight certain issues concerning information. In one of the models he structures a two-person conversation.

Based on Devlin's model about two-person conversation is as in figure 7.

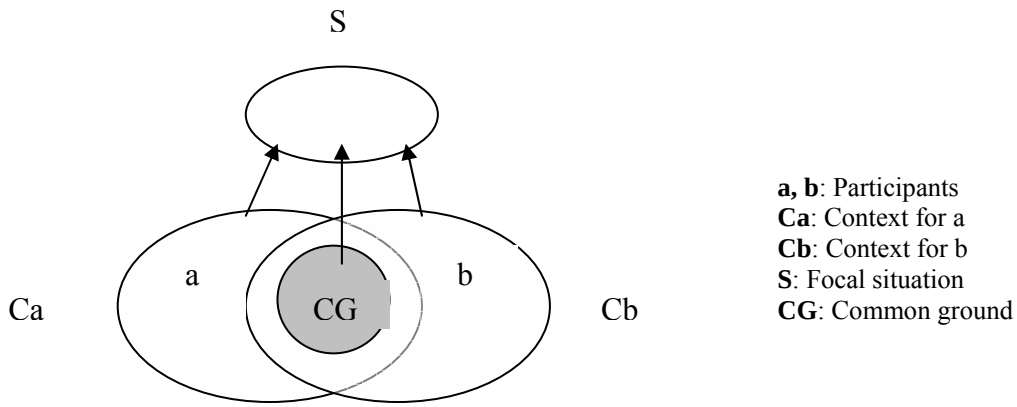

Figure 7. Common ground.

The representation of an item, remember not the information can be a written text, a symbol, a program or natural phenomena like clouds. X denotes the decoding/encoding constraints related to the receivers capability to decode the representation. The CG represents common ground, that is relevant since the decoding/encoding are closely related to what context that is shared and potentially can be easier to encode. And to know what context that is not shared, and interpret the data from that situation. Basically, the common ground is, if there is more than one participant, in this example we can take three participants. Participant A, B and D. The participants have their own context, **C**, that is A**C**, B**C** and D**C**. There is a focal situation, F, and a common-ground, **CG**. However, the complexity increases when adding more than two persons, illustrating the common-ground phenomenon.

In this model person **a** and person **b** are having a conversation. The **S** is the focal situation, and the grey area is the common ground, involving common knowledge. Applying this model in the emergency service centre example would then concern two operators, answering operator **ao**, and dispatching operator do having a conversation through telephone sitting in different centres.

Interesting in using this model is to define the focal situation, the context for **ao** and **do**, and the common ground, but also the area relating **ao** and **do** that is not the common ground. Devlin defines the common ground as:

"*One important feature of the common ground is that it involves common knowledge. That is to say, the two participants have joint knowledge of the common ground. As in the case of action, joint knowledge involves more than just the two individuals having the same knowledge. Not only do the two participants in a conversation have the same knowledge in the common ground, in addition they both know that they have this knowledge*. " [9]

And the areas relating **ao** and **do** as:

"…this will include information that each has but where it is not common knowledge to them that they have that information." [9]

What is interesting with these areas are the boarder in between the common ground and the related areas, but also the separated areas of the different operators. How do one operator know what the other operator know? One way is to have knowledge about what information the other operator has. Tracing which documents that was used, like "the operator that handled this case successfully did use this information to do so." Of course this doesn't capture the whole knowledge base of the operator, but hopefully it can give some sort of support.

9.3.2 Situations, types and information flow at SOS centers

We can now specify the information flow at SOS centers in terms of the Barwise-Perry situation theory. We identify the following three types of situations corresponding to handling incoming calls, determination of proper actions and allocation of resources in dialogues, and guiding the chosen rescue teams to the location of the accident:

- Situations c_{im},, i ! I of type C_m, m ! M (type C as in calls).
- Situations d_{jn}, j ! J of type D_n, n ! N (type D as in dialogues).
- Situations g_{kp}, k !K of type G_p, p ! P (type G as in guidance).

The information flows at SOS centers is given by:

1.Within the main type categories: for instance C_1! C_3, or D_4 ! D_2.

2. Between the main type categories: for instance C_m ! D_n ! G_p instantiated by situation chains (im, jn, kp) connecting c_{im} ! C_m, d_{jn} ! D_n, and g_{kp} ! G_p. Of particular interest are the handover situations between the different types C_m ! D_n and D_n !G_p.

To simplify our reasoning we restrict it to hand-over situations between types. In fact we argue that the first generation of support of workflows should focus on managing these transitions between types. An incoming call is described as the following situation:

- c_1 = <m, ch, t, ?sender, !reciever, env>, where m denotes the representation of the information item I (equation 1) transferred by the sender at time t using channel ch to the reciever. The signs "?" and "!" denotes that the sender is unknown whence the receiver is known in situation c_1. The "env" denotes the remaining part of the situation at hand.

The first task of the receiver is to identify the proper call type C. A next step is to verify the call and create an internal call_event to be the basic work item in the centre. In effect the receiver has developed a hand-over situation c = <m´, t´, ?sender, !receiver, call_event> of type $C_{hand\text{-}over}$. The message representation m´ is the internal representation of the original message m ! c_1: C_1. The work practice at the SOS centre in handling the call_event in the next step can be formulated as a workflow between types of C to types of D.

For example: $C_{hand\text{-}over}$! D_{input}.

The handling of the situation of type has as main activities to identify the ramifications of the accident. For instance, which people are involved, identities and known medical records, the geographical situation, available resources, and so on. Eventually we reach a new hand-over situation from D types to G types this time.

The new hand-over situation is d = <m´´, t´´, confirmed_call, call_event´>

of type $D_{hand\text{-}over}$, where m´´ is the internal representation of the incoming call at this stage and call_event´ is the updated SOS centre relevant context for that call. Again there is a work practice for the hand over process that can be formulated as the work flow: $D_{hand\text{-}over}$! G_{input}.

9.4 Information Ecologies

Furthermore to get a sustainable perspective where socio-technical aspects are considered, influences from the information ecology perspective [28] could be productive. In the case with the dysfunctional ecology concerning privacy issues at a teaching hospital, an experimental monitoring system, allowing a neurophysiologist to monitor several operations at once was implemented. By seeing and hearing the discussions from the operating room, the neurophysiologist could see if the surgery reached a critical stage and needed his or hers physical presence. There were positive comments concerning for example the audio. However, dysfunctions concerning privacy in the ecology appeared. The monitoring technology was understood as a privacy intruder. Comments such as the remote broadcast changed the nature of the communication inside the operating room in significant ways was stated. As one example concerning this issue was that relaxed talk and joking in the operating room often relieved the boredom and tensions. Such jokes concerning personnel not present in the room, could not be made now since an 'outsider' was watching them. Also concerning the teaching situation, an outsider could misinterpret a rebuke, and the fragile teacher-student relation could become under even more pressure. There were also other relevant issues concerning the dysfunctional ecology. The conclusion was that information changes shape and function dramatically when its broadcast boundaries are altered. So what can we learn from this concerning the ecology in the emergency service centers? One could argue that the operators handle life critical emergency calls, and that the operators have to cope with having trespasses in their privacy. However, what is lost with the comfort of the operator?

In the Nardi and O'Day discussions, the problems they highlighted with a sharp and excellence; however, there are no requirements indications, such as systemic requirements, as made in this chapter. Neither do they present methods for implementation or validation. A comment to give concerning the privacy issue, concerning the persons being recorded, could be a solution opening up for communication with the viewer. For example giving the viewer the possibility to identify his or her focus, as for example via an indication of a dot on which monitor he or she is currently observing. A conclusion concerning the Nardi and O'Day discussions is to be aware of the broadcast boundaries and consider new ways of communication if considering remote broadcast in Nardi and O'Day style.

9.5 Supporting articulation work

In this section we will return to the second research question presented in chapter two. The research question was stated:

Research question 2

In what way can the information type categorisation of single SOS centres be transformed to a workflow model of SOS clusters while maintaining or increasing the articulation of the work?

First we need to define articulation work, and consider how the articulation work is made in the centres today. Following that, we need to consider how the *object type categorization* can be transformed into a workflow model as stated in the research question. Thereafter we present issues that could be categorized as systemic requirements.

In [22], articulation work is described as 'required for the orderly accomplishment of cooperative work'. Furthermore from a cooperative work point of view, articulation work are defined in terms of distributed, individual and yet interdependent activities that must be coordinated, scheduled, aligned, meshed, integrated etc. In [23] articulation work is described in relation to coordinated work. *Articulation work* is the work devoted to activity coordination, and *coordinated work* is the work devoted to their articulated execution in the target domain. Furthermore, the distinction between articulated work and coordinated work provides two non-hierarchical perspectives on cooperative work. Or as in [22] were the relation between *coordination* and *articulation work* is recursive, i.e. an established arrangement of articulating a cooperative effort may itself be subject to a cooperative effort of re-arrangement which in turn also may need to be articulated and so on.

From this information concerning articulation work, we have learned that it can be an important tool in the orderly creation of cooperative work. Also, that articulation work and coordination work are closely related. Another important issue concerning articulation work, is the fact that articulation work solely can lead to cooperative work, without having to take the step via coordination work. This is an important issue to add, since, such articulated handling without explicit coordination could potentially be less time consuming than articulation work requiring a proper focus on coordination of the activities.

The operators have some support for articulation work in the CoordCom system via acronyms, ongoing events and more. An example of tools supporting articulation work is post-it notes, paper maps and similar which the operator can use to articulate what work they are currently doing. Getting proper support and coordinate activities through the mere use of the tool. Articulation work can also be made by head positions such as looking at a direction for specific information, pointing in some direction, and other bodily gestures.

In this research question we return to the object type categorisation presented in chapter 7, making work flow transparent. The object type categorization is a strong indication of how the case will be handled. The current object type categorisation is used in an in-centre handling. As in the blackboard way of handling the emergency calls, the operators can see what each operator has performed, and what is yet to be performed. However, this articulation work, built into the computerized support is of another character than the articulation in the physical room. To some extent they can see the articulation of the work, as when typing in new information, and when listening-in to, or overhearing a conversation.

A possible way to consider the current articulation work, and the support for articulation in the computerized support is to use the object type categorization and extend it towards SOS clusters. One way of supporting the articulation work is for the operators to put themselves in a status, where they consider themselves to be busy or available, and if available, for which task. In the current object categorisation, the **quality**, the **praxis**, and the **debriefing** in the handling of calls are missing. These are 'in the walls' and could easily be forgotten if not considered in a SOS cluster constellation. Considering the **quality** in handling a call. As it is today, the operator most often do not know how it went in the case, as the operator dispatches a vehicle, the vehicle can reprioritize the case as they reaches the scene. As for example making a new categorization to a lower category could indicate to the operator that the first categorisation was wrong, or perhaps life critical treatments from the paramedics was the reason for the decrease in priority. The operator would not know this without making an extra effort in contacting the paramedics. However such active quality checks are requiring energy from the operator. The **praxis** in how the calls are handled could then become a hinder for the operators to maintain or increase the quality in the handling. Considering the **debriefing** of the case, which are an important issue in maintaining the quality of the handling. As of today the operators debrief by the coffee, however such coffee debriefing could be hard to support in a distributed environment. Concerning the **debriefing** with the ground service, this is just occasionally done, with a specific case in mind. However, supporting such debriefing could be an important way to even increase the quality in the handling. Also, the articulation work of the cases is not present, and there are no indications of how many operators that probably are to be involved in handling the case. Furthermore, occasionally the ground service makes visits to the centres for different reasons, including strengthening the relation and insights in the work of the operators.

Concerning how many operators that probably has to be involved in handling the case, such an estimation could be stated in the object type categorization, such as 2 for example after the three level categorization of the case. Concerning the quality in the handling of the case, this could also be stated in the object type categorization. The quality could consist of evaluation made by the parties involved. As an example, if the

operators involved in the handling considered the case went well, they can categorize the case in a number from 1-5 were 5 is excellent. And if the ground service considered the case to be good handled, they could follow the same categorization system. Concerning the debriefing part, the operator could collect the case in a map as in 'extra hard case', and share it with other operators. They could comment on the handling in 'online community style, and add information as in Amazon style either debriefing comments or as a comment on the case as such. In figure 8 below, we present an example of how a case that has been handled in a SOS cluster could look like.

M1.11.23.2.OP4.OP5.O?.P?.X

Text 1. Object-type categorization reconsidered. An example of how a future centre-to-centre object-type categorization could look like. The case that has been handled is a first priority case, involving humans, where M1.11.23 in how the object type categorization are made today. Added are the 2, meaning that this case most probably will need 2 operators, OP4, OP5 means that they are good candidates for the case, based on their status. O? is where the operators can evaluate how the case was handled, and P? is how the paramedics involved evaluate the case, and X, that further information concerning the case is published under file X.

A first priority case, involving humans, where M1.11.23 is how the cases are handled today, 2 means that this case most probably will need two operators. OP3 OP5 means that those two operators are suitable and are chosen. If they were just suggested a question mark would have been displayed after the letters. O? means that the operators involved can comment on the case as in a good case or not in 1-5 scale, the P? is the paramedic's opinion of the case, and X, that further information concerning the case was published under file X. An analytical conclusion to draw from this suggestion of new features in this object type categorization is a change from articulation work within the centre to articulation via the information in the computer system.

9.6 Architectural considerations related to the workflow principle

The work with connecting operators and computers in a transparent, open and scalable way in the future of the nationwide-networked centres is an important issue. The centres could be loosely coupled into SOS clusters. Fast and reliable performance in the homogenous collections of computers most probably rules out a grid cluster solution. However concerning the related organisations, grid solutions could be an alternative. The standard protocols that can connect the distributed systems and applications could be a web service solution. Agent based solutions could perhaps be an alternative. The agents need to support the parallel handling, and there could be advantages in keeping the blackboard-based structure. Important to consider is the control mechanisms, and to consider if distributed blackboard systems could be a possible solution. There are basically two main parts in the emergency call handling that need to be specifically considered towards agent-based solutions. It is the *hand-over* between the operators, and the *selection of suitable vehicle*.

For the *hand-over* situation the agent based solutions would basically suggest which operator that is suitable for dispatch. This suggestion demands some sort of measurements of how busy the operator are, as a basis for considerations of which operator that is suitable for the dispatch. This since this handover situation is *risk driven;* as mentioned in the work flow principles in chapter five, the answering

operator could potentially send the listening-in to operators that aren't available, thus prolonging the handling of the tasks. As the operators are sitting in the same centre, they can to some extent predict which operator that is least busy and available for a listening-in. To create a solution suitable in distributed settings, one way is to measure the operators work considering which cases the operator are involved in, and which part of the handling. But such measurement criteria are potentially difficult to find, and there will most probably be some manual way of blocking for listening-ins. This since making an agent based support measuring the cognitive load of the operator's demand special consideration and a proper focus on its own. As mentioned, a potentially suitable agent based solution is a suggestion of possible operators to send dispatch to. This *hand-over support* could help the operators in finding a support in the hand-over of the dispatches that are to be made. Additionally to the agent based solution of the *hand-over,* routines for handling this *risk driven* part would be suitable. If there is no operator available to answer the listening-in, or as in the **Little town** case, several calls concerning the same accident are made.

Turning to the *selection of suitable vehicles*, which is the other main part in the emergency handling that needs to be specifically considered. An agent-based solution can be suitable in this part of the handling too. Basically the agent would calculate which vehicle with suitable status and equipment that is closest to the accident. However and of specific concern, local circumstances such as how many vehicles there are to dispatch, and the organization of hospitals need to be taken into consideration. This *dispatch support* would also need to be supported by some routines; such as if there is no ambulance available, perhaps the police or rescue vehicle has to be contacted.

In the connection with the ground service, the information that the operators send are to be semantically correct, thus having different representations. Dependent on if it is the rescue service personnel, paramedics, police or other that is to receive the information. And the local issues needs to be taken seriously. Such as the local abbreviations and special local names of geographical places. A solution with an ontological base would most probably be suitable.

9.7 Inspirations from the Pond and the SHINE application

Concerning user interface and solutions of how to structure the information in an intelligible way, some issues of concern is presented in this section. First a description of the Pond application and a short description of inspiration to SOS clusters, furthermore a presentation of the SHINE application and relevance to the SOS cluster handling are made.

Basically the Pond displays and structure information about media such as CD's with Madonna and structured beside each other in a group of objects. These structuring of objects has similarities to fishes swimming in groups in a Pond. The group of objects that the user last interacted with are displayed largest, while the other objects sink down to the bottom of the Pond. The Pond is displayed on a horizontal touch screen, where multiple users can interact with the Pond, standing on the side of the display.

The Pond applications design objective is [2]:

"*Multimedia user interface where users with no prior knowledge or acquired competence should be able to easily handle both single as well as groups of objects in an affordable and easy way*".

From the description of the Pond application, a presentation of inspiration for SOS – clusters could be of interest. Concerning the multiple cases, the relation between cases could be displayed in a similar fashion, with the cases that are related, for example originating from the same geographical area, or cases where ambulances has been dispatched. Concerning prioritization of cases, the most prioritized case could be displayed a bit bigger than the other cases. Concerning the single and multi user discussions, in this fashion where users standing around the Pond, trying to interact with it, multi user support can be considered. However, concerning multi user and touch screen parallel activities and tracking would probably need more research and development to be suitable in an emergency-handling context.

In the Shine application, [53] [54] the main motive is to support the desire from elderly people to continue live in their home, under surveillance instead of living in elder centres. This application enables the elderly to continue to live at home, while sending some health information on demand to persons Two views are presented, the organisational with the team perspective upon the organisation, where different participants can see the houses of the elderly persons, and a potential vehicle approaching. But also use mobile devices with different authorization abilities and views upon the information. Possibilities to persons in elderly care contexts. The second view concerns the elderly and the values upon him or her from measurement tools. Concerning multiple cases, support for multiple cases with mobile device is possible. The personnel adding this information via the mobile device make prioritization of cases. The team handling are supported on different levels, both in the organisational view, as in where personnel are, in the mobile device, which person is handling what case, and in the house view, where the authorized persons can access the status from the measurement tools. Seeing also which other persons having this information.

For SOS clusters there are most probably organizational perspective and conclusions to draw. One such is the team support, where the presentation on different views upon the case, but also to use mobile devices in case handling with prioritization and authorization.

9.8 Systemic requirements

Specifying systemic requirements is a process in itself [50], in this section a presentation of such is made:

- Nationwide access to categories, plans, maps, and vehicles. Basically, the information in the centers today should be available from the different centers.
    - Support for operators to share the information.
    - Duplication of information should be handled, as if several calls concerning the same event.
    - Local words, abbreviations etc. are to be handled.
    - Possibilities for one operator to hold several cases

- The smooth cooperation in handling the time-critical emergency calls is probably essentially due to the fact that the operators sitting in the same centres with eye-contact and having knowledge about each other's skills and limitations.

- Operators have developed a sense about when other operator are having difficulties and needs support with without explicitly having asked for it.

- Knowledge of earlier handled cases, familiarity with individuals ("just needing someone to talk with") or similar cases.

- Social knowledge about operators, ground service, caller etc.

- Exercise – Serious adaptation of new technology and new ways of working includes specific focus on exercise. New routines such as knowledge about the dispatch handling, the geography etc.

- Evaluation & debriefing – This point has to some extent already been implemented in the object type categorization as in the ability for the operators and paramedics to evaluate the case as in the 1-5 evaluation in the object type categorization. And a basis for debriefing are made in the object type categorization, concerning the pointing to the file were the case is saved.

- Trust – this issue will be further elaborated in this chapter, and can be included in both the exercise and evaluation & debriefing points, however in this article a special focus on the trust issue is presented. Trust in relation to the computer supporting the operators in an intelligent way, as in expert systems, agent systems or the like.

- Integrity –When sharing the emergency calls, there could be issues suitable under an integrity category. As the operators handles the cases today, there is no documentation process making connections between cases. This integrity issue will also be further elaborated in this chapter.

There are several issues that need to be considered that not easily is interpreted into functional requirements. Here we look further upon integrity and trust. Considerations from an operator working in a moved-out step, cooperating with operators sitting in a SOS-centre commented on the cooperation with the SOS operators are presented. Other systemic requirements such as exercise and social knowledge are presented. But it also concerns the skills that the operators have developed a sense about when other operator are having difficulties and needs support without explicitly having asked for it. Local knowledge of ground service and geography, knowledge of earlier handled cases, familiarity with individuals ("just needing someone to talk with") or similar cases.

9.8.1.1 Integrity

It is of importance that the operators handle the incoming calls in an objective manner. However doing connections between both calls and callers are sometimes of

importance. If the operators were to handle emergency calls not from their own area, it could be of importance to know if the caller has called several times before, during that day, during that week or month and so on. Perhaps the operator cannot draw any conclusions from the callers' behaviour, but being aware of the caller's behaviour can potentially be of importance. Perhaps the police may need to be contacted or similar. This knowledge could potentially be useful also in the establishment if there are one or two collisions on the highway and if the caller is making a second call and a vehicle has already been dispatched. Today the cases are documented and stored for some purposes. The conversation/interview with the help seeker are recorded in audio format, and important issues are typed and stored for a period of time in the system. The operators can get the callers address, to get a ground for the location of the event based on the number called. Also information about which operators involved in the handling of the case is available. However the information about the cases are as earlier mentioned used in evaluation purposes. In a new organisation of handling the calls, perhaps some considerations concerning integrity issues should be made. The local in centre knowledge about callers will perhaps to some degrees disappear. If so, it could be interesting to use some of the information about the callers making connection to other callers or to the phone number or personal number? However, having the abstract connections between the calls or callers documented into the system poses special challenges on the documentation and handling. There are laws to preserve the integrity of the caller, and the information cannot be stored and distributed without regulations. A strong motivation to the use of information is important. Relating the textual documentation of the caller in the CoordCom system to the Storm system that is in use at the Police Force, little text and information concerning the person is documented. Neither are relations to calls from an individual point of view made.

9.8.1.2 Trust

In time-critical emergency call handling context, it is vital for the users to trust the system. Such requirement has been presented in articles and books about agent system in emergency settings, and detailed work place descriptions of emergency settings have been written. [24][25][26]. However, the closest in combining agent similar automation and detailed work descriptions in the research of emergency call handling is done via expert systems. In this specific chapter written about expert systems in emergency call handling setting, in the American equivalence, 9-1-1, the problem of trust is in focus. This expert system was "designed to reduce the sophistication of demands on dispatchers, and thus to decrease the likelihood of human error" [24]. The expert systems new functionality was that:

"The system would now use algorithms, structured by the predetermined (i.e. programmed into the system) ranking of each fire station's response area with respect to every address in Central Lane's data base, to determine what available units was the closest to an incident."

A recommendation list of units in terms of their priority, based on the location of their home station, regardless of their current availability was presented. When the expert system was in use, the users blamed the increased number of errors (even though there had not been a dramatic increase in error rate) on the system.

""The system, it was often said, had recommended the wrong unit(s)." ""I don't trust it," was a frequently heard refrain." [24]

This can both set an example of a real world case in applying expert systems in dispatching vehicles in emergency settings, focusing on dispatching vehicles, and that trust can be an issue in this specific context.

9.8.1.3 Moved out step

Returning to the moved out step statement, presented in chapter eight, and the operators comment that he wouldn't be useful if he didn't know were the other operators *sat*, *likes*, and *reflected about things*. The operator had prior worked with the other operator in the SOS-centre. Supporting systemic requirements such as social knowledge can be difficult. Connecting to the operator statement, you could think of functional requirements in forms of maps over the centre with the operators' positions in respect. Support formal and informal meetings, on-line discussion forums, personal presentations on-line etc.

This comment is potentially interesting to learn from for a SOS cluster perspective due to the similarities in the "moved-out step" and the centre-to-centre organisation. The main similarities are that the work is geographically distributed and it is emergency handling operators that are cooperating. The main difference is that the operator is sitting with rescue service personnel and not operators. This comment that came from a person working distributed within the SOS organisation, can be an important ground to make further analysis from. How the operators *sat* indicate that the physical location in the room is of importance. From the physical location it is close to consider the other operators location. Which persons the operators were to communicate and debrief with, how to coordinate the work etc. The second and third issues that he focused on were *likes* and *reflected about things.* Likes and reflected about things indicates some sort of personal features, from these features there can be issues connected to how the individual operator get along with other operators, how they connect and communicate with ground service and similar. The issue of '*reflected about things'* could indicate issues how to predict and follow another operator's way of thinking, and from this it is close to draw connections to how the coordination and communication of activities are structured and performed.

The operator had prior worked with the other operator sin the SOS-centre. Supporting requirements such as social knowledge can be difficult. Connecting to the operator statement, you could think of functional requirements in forms of maps over the centre with the operators' positions in respect. Support formal and informal meetings, on-line discussion forums, personal presentations on-line etc.

9.8.1.4 Implementation aspects upon systemic requirements

Presenting implementation aspects upon systemic requirements is interesting for different reasons. There could be transitions from what was once considered not a functional requirement, into a function and vice versa. We are serious in the view of systemic requirements, and the process of transitions and building of systemic requirements.

Concerning integrity aspects, one issue could be in the example of having "portfolios" with cases, having the personal identification such as address and personal number. However, if all information related to the caller and the person/s in focus of the call

are being “unidentified”, then the cases could be stored and handled more easily in integrity respects. Continuing the design of integrity discussion in relation to the caller. As mentioned in the assessment and requirements discussions, local knowledge about cases and caller between the operators covering if a person has called before, i.e. some history of the callers. Documentation puts higher demands on the way and which sort of information that are used. However a decision of excluding important information because it is difficult to transform from oral words to text has to be taken into consideration. Having a best before date on integrity related information could be one example of design suggestion of solving the integrity issues.

Concerning trust issues, a decision support system could make suggestions about which vehicle suitable to dispatch in the case. However, just getting a suggestion from the system can be hard to trust, however if it was possible to find out which parameters the decision were based on, then the user would probably feel that the system was more trustable, due to that the user him or herself could calculate if it was a good suggestion that the system made. However, just presenting the result and all parameters that the calculation was based on could be a possibility, however to be weighed against the risk of information overload.

9.9 A validation

Returning back to the work shops conducted, the input in these work shops can be seen from a validation perspective. Issues presented at the work shop and in field studies and similar such as feedback of information is important. Some operators have commented that they didn’t know in every case how the case went. This could become an issue. If the operators wish to know how the case went they call the ground service and get the knowledge. Prior to the sending and receiving of information were made by phone or radio and the feedback were given in every case. An interesting perspective concerning this issue could be that the operators working in the centres today probably has got a picture of how the case went since they have handled similar cases before were they got feedback. However for new inexperienced operators this issue could in some circumstances become critical. Perhaps new ways of extracting the information in pictures could be of interest.

9.10 Implementing workflow support

Research question 3
Design of suitable experimental platform enabling testing of service qualities.

The following two pictures capture the main ideas of workflow implementation:

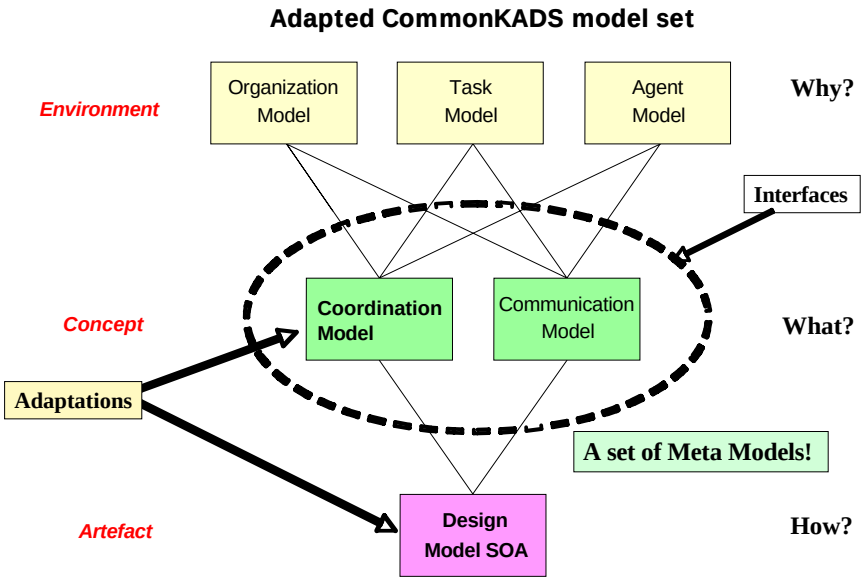

Figure 8. Meta models based on the CommonKADS methodology supporting service-oriented architectures.

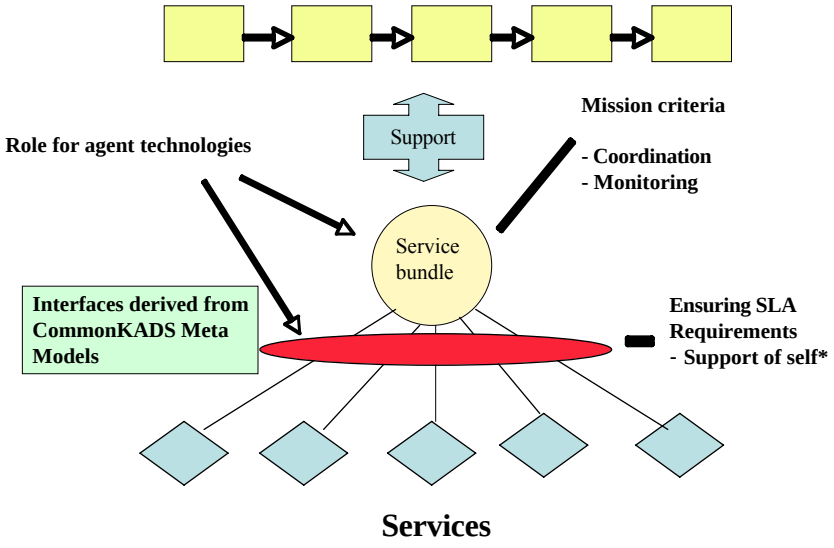

Figure 9. Design model of experimental platform enabling testing of service qualities.

In figure 8, the meta models in the CommonKADS methodology are reconsidered supporting a service-oriented architecture. Basically the reconsideration made concerns an exchange from the knowledge model to a coordination model Furthermore, the design model is specifically directed towards Service-Oriented-Architectures. In figure 9, a design model of experimental platform enabling testing of service qualities are presented. Roles for agent technologies are presented. This concerns both the coordination and monitoring aspects in the service bundle, but also on a service level upon the services as such.

In the next chapter a further consideration on the methodological part of this thesis are presented.

10 Methodologies

This chapter is related to the discussions in chapter 2, where a description of methodologies was made. However in this chapter a further analytical consideration towards methodologies and use of such are made. The identified research questions consider configurable methodologies for analysis and design of socio-technical systems. We focus on Ethnography, Ethnomethodology, Activity Theory, Participatory Design and CommonKADS furthermore we have discussed science of information in chapter 9.

In this chapter methodologies are in focus. The different methodologies considered are analyzed, ending with methodologies used in this thesis. Consequently, there are methodologies described in this chapter that not have been used in the scope of this thesis, as for example Evolutionary Prototyping, and some of the methodologies have been used only partly as for example the CommonKADS methodology.

This chapter begins with a definition of ethnography, including brief history and strategies to take. A description of ethnomethodological informed ethnography is made in the third section, followed by an ethnomethodological section. In section five, six and seven a computing perspective is taken, through for example requirements engineering and mathematical structures. In this section a specific perspective on computing is put, with most focus on the initial part of what could be categorized as requirements elicitation and modeling. Also some directions towards a mathematical description connecting back to the functional requirements and the use of situation theory back in *chapter* 9. In section eight a description of engineering and management methodologies are in focus, and in section nine, the methodologies used in this thesis are further described and somewhat analyzed.

Combining descriptive methodologies and engineering methodologies are of interest for a variety of reasons. In this chapter the perspective of ethnography's role in models of computation is in focus.

One reason for using and presenting methodologies are that other doing research can choose to use the same methodologies based on for example the result. However, as this old traditional view upon methodologies is perhaps a bit hard to apply in this work, since it is partly built upon descriptive methodologies, and of user participation. However on a more general level it is perhaps possible to draw conclusions and learn from the methodologies and the results as such.

10.1 Ethnography

Concerning the categorization and definition of ethnography. Ethnographical methods are to be categorized in the fields of qualitative and empirical methods [29?]. Without getting into the rich history of ethnography, ethnography emerged as a broad approach to social inquiry from anthropology in the early 1920s [39]. One definition of ethnography is that of participation in people's daily lives, for an extended period of

time, overtly and overtly [44] collecting data, as much data as possible, or as some ethnographer's state, as much data as possible that are in the focus of the research. There are ongoing debates about the focus of ethnography and how "objective" the ethnographer actually can be in relation to the domain. Following this line of objectivity leads us to the dilemma of *reflexivity.* This dilemma is something that basically all social researchers have to deal with, i.e. the fact that we as researchers are human beings, observing human behaviour. The basic question following the dilemma of reflexivity then is if we ever could tell anything objective about human behaviour? Perhaps the results of the research is just a mirror of the researcher him or herself? Having presented ethnography, a bit about the history, and critical issues that are handled in the ethnography debate, the focus is turned towards different strategies in using ethnography.

Different strategies of how to use ethnography in design processes have been developed. The one that has gained most attention is the '*Quick and Dirty*' strategy. This strategy is suitable when there are short of time and in large-scale settings. The studies are made within, from an ethnographer's point of view, very short time, and provide a broad understanding of the activities in the work domain. [45] Another strategy is the *Concurrent Ethnography* strategy, it:

"*is a parallel process in which investigation of work and systems design proceed at the same time.*" [29]

In this strategy the designers could ask questions that have implications to what the ethnographer will focus on when returning to the field. This strategy is flexible with as much iteration as are required. *Evaluative Ethnography* is a variant on the '*Quick and Dirty*' strategy. It is a strategy with short ethnographic studies, after initial outline of design or specification. Debriefing meetings with abilities to return to the field, and iterations between the meetings before returning to the fields are possible. There are other strategies, but these three has perhaps gained most attention.

Of importance in this context is to describe what the ethnographer tries to capture by his or her studies. Most often, the ethnographers try to capture the work practice of the domain of research. In Crabtree's description of work practice one can see important words such as 'flow of the work', 'artifacts', 'working division of labor, 'instances' and 'articulation'.

"*Work practice may be observed through ethnographic study, where the analyst develops first-hand knowledge of the work in question through immersion of the work. The analyst's task here is to explore the work and inspect it closely through the gathering of materials from within the flow of the work and assembly of those materials into instances of workaday activities being done. Instances may be constructed from the conversations that occur over the course of the work, from the documents worked on, the artifacts used, from videos, etc. Instances constitute the unit of analysis and, like the discrete activities they elaborate, they latch together to articulate the working division of labor and the discrete assemblages of work practices whereby articulation gets done*." [39]

Such words are most often of importance when analyzing the ethnographic data from the field. Actually if these words have strong influences on the analysis of the data

collected, they can be labeled as strategies. There are for example workflow strategies. Continuing this track of ethnographic data, a turn towards how to use the data collected in design solutions is made.

10.2 Ethnomethodological informed ethnography

The ethnomethodological informed ethnography is an attempt to bring ethnography closer to design. As Crabtree defines ethnomethodologically informed ethnography:

"*a means of analyzing work, but also to articulate ways in which such ethnographic studies might be related to design*." [39]

In this definition it is visible that ethnomethodology and ethnography is quite close connected, and that there is a focus of relating it to design. The purpose of such a connection differ, but one reason might be that:

"*The purpose of ethnomethodologically-informed ethnography as we have envisages and practiced it is primarily as an informational input into design, informing the designer of actual practices which may not normally be captured by other methods."* [40]

It is clear that ethnomethodologically-informed ethnography has a connection to design, however it is not clear what makes the trick of ethnography when including ethnomethodology. A definition and consideration of ethnography are presented in the next section.

10.3 Ethnomethodology

The perhaps most important point of views in ethnomethodology is the analytical view trying to capture the 'insiders perspective'. Warfield Rawls sentence [43]:

"*ethnomethodology means the study of members' methods for producing recognizable social order*"

This sentence capture an interesting part of ethnomethodology, showing the importance of analytical understanding from the persons being observed point of view. Of importance, is the fact that ethnomethodology is not itself a method, as one could easily believe since it includes methodology in the term itself. Rather ethnomethodology is more of [43]:

"*an attempt to preserve the "incourseness" of social phenomena. It is a study of members' methods based on the theory that a careful attentiveness to the details of social phenomena will reveal social order.*"

Were the method sheds light on the discovery of the things that persons in particular situations do, the methods *they* use. Ethnomethodology deals with accountable phenomena, which are observable and reportable, i.e. available to members to see for them selves and to talk about [42]. Ethnomethodology as other practical social reasoning deals with indexical expressions. Basically what a certain word means in the specific context. Ethnomethnodology sees the activities in the domain as organized following social schedules. The definition of ethnomethodology in Garfinkel's own words: [42]

"*I use the term "ethnomethodology" to refer to the investigation of the rational properties of indexical expressions and other practical actions as contingent ongoing accomplishments of organized artful practices of everyday life.* "

In suggestions for definitions of ethnomethodology, it is quite clear that the organisation and structure of human behaviour is of importance. From these definitions of ethnomethodology it is evident that making a clear line between ethnography and ethnomethodology is hard, and for what purpose. However, seeing ethnography as a descriptive tool and ethnomethodology as an analytical tool is close to a general understanding of such separation. That there are a separation between them is clear, ethnomethodology does not require ethnography and vice versa.

The reason for making a small investigation about ethnomethodology is to understand what makes the trick of design when including it to ethnography. To this question we have not got an answer, more than that ethnomethodology provides an analytical point of view. However what has been found in this search is that there are other approaches similar to that of ethnomethodological informed ethnography. One approach is that of technomethodology Button and Dourish [38] asks how ethnomethodology can be applied to the design of new technologies, and their answer is technomethodology:

'*technological support for socially-organized activity which have come from an ethnomethodological perspective'.*

In these definitions it is quite clear that ethnomethodology and technology has a strong connection. One could assume that the difference between ethnomethodological informed ethnography and technomethodology would be the lack of ethnography in the latter. However no such evidence is found. From this quote of the paradox of technomethodology it is not clear if ethnography is excluded or not:

"The paradox of technomethodology lies in the attempt to design novel technological solutions based on an analytical perspective with a specific orientation towards the existing detail of practical action. [38]

It is not clear what the '*existing detail of practical action'* is. However from these investigations we could tell that there are similarities between the ethnomethodological-informed ethnography and the technomethodology. But perhaps, what it says is that this issue of connection is of importance and several attempts has been made to provide solutions. One perspective to take in connecting description and engineering perspectives is to be close to the requirements process. In the next section a closer look upon this requirements process is taken.

10.4 Ethnography and models of computation

In this section the issue of connecting ethnography to models of computation via the requirements problem is presented.

"*Efforts to incorporate ethnography into the design process were initially motivated by the requirements problem. Simply put, the requirements problem is a practical problem preoccupied by the question: what is to be built? Ethnography was*

constructed as method that may help systems developers analyse the work of the design space and produce an answer to the question by formulating specific design solutions." [40]

In the following quote the kernel of the motivation of relating ethnography to models of computation, but also the ethnography's role presented.

"*Numerous computing projects have failed because although the resultant program did precisely what it was specified to do, it was the specification that was itself in error because it over-simplified the work activity in classic computing reductionism style, thereby ignoring crucial aspects of the activity that should not be abstracted away. It is the hope that ethnography will help in serving to warn about what should not be ignored while not insisting that everything is important."* [40]

This quote gives one perspective to the ethnography - requirements engineering issue. The requirement perspective could probably be a good candidate to integrate ethnography in its agenda. This since it is in the early stages of the development of computing systems. Requirements engineering communities are aware of ethnography and comments it as:

"*A fundamental problem with ethnography as far as requirements engineering is concerned is that, as a technique, it is intended to be non-judgmental. Ethnography was developed as a technique for understanding complex societies and not as a technique for making judgments about how ways of working could be improved or supported by computer systems. Therefore, ethnography needs to be used to support other approaches to requirements elicitation rather than as a stand-alone requirements elicitation technique*." [46]

The requirements engineering community clearly has difficulties in adapting ethnography in their methodological agenda. Due to the main reason as shown in this quote, that ethnography is non-judgmental. Computer systems on the opposite are judgmental, in the sense that selections have to be made. But as seen in next quote, the requirements engineering community has hope that ethnography matures enough to fit into a requirements context.

"*However, the use of ethnography is still immature and it is not easy to incorporate this into a systematic requirements engineering approach".* [46]

Basically there are some issues to be solved before the ethnography and requirements engineering issues are connected in a satisfying way. This leads to another interesting issue, the systematization of requirements, to begin with, the waterfall model.

"*One answer to the question of systematization (i.e. how may the requirements problem be handled routinely, time after time?) is provided by the Waterfall Model.* [40]

In the industrialization, the first development structure for organizing large projects with large staff within the constraints of budget and time was made by the Waterfall Model:

"*Although the approach to analysis advocated by the Waterfall Model is hugely problematic today, the models impact on design has been profound, shaping ways of thinking about and doing systems development in general.*" [40]

One basic critique of the Waterfall Model was due to the changing circumstances of systems development and usage. When the machine was in the centre, the Waterfall Model was considered to be effective. But as the demands for putting human needs more in focus in systems design, other models emerged such as the Spiral Model [70] but also models in evolutionary prototyping. This paradigm shift in design from product to process orientation was recognized by Floyd. With the human in focus, mental models were introduced by Preece and Norman providing a perspective of the human to be modelled with The basic idea behind mental models, is that the design of the system is made so the user can develop a mental model of that system that are consistent with the design model. A person worth mentioning in this context is Suchman [48] that made pioneering work on the human-machine communication. Basically shifting the focus from humans having a predefined structure of handling work with copying papers using a copying machine, towards understanding that the courses of the persons actions are made within the situation using the functionality available.

10.5 Modelling techniques

Leaving the requirements issue, turning to models that are used in industry. The Unified Modeling Language is described as:

"*The Unified Modelling Language is a language for specifying, visualizing, constructing and documenting the artefacts of software systems, as well as for business modelling and other non-software systems*." [47]

UML includes to some extent a user perspective via use cases, interaction diagrams such as system sequence diagram and more. The work practice perspective is handled in models, and diagrams are made including for example models of how the interaction between the user and the machine is supposed to work. The UML notation is an interesting attempt to include a serious perspective of the user. However two issues need to be considered in relation to ethnography. First of all, including a user perspective is not equivalent to including an ethnographic perspective. The UML notation today holds nothing that could be labeled as ethnography. The second issue is about that the modeling can be seen as just another layer, shifting from understanding of the work place to the understanding of the work place via the UML notation. Returning to the first issue, attempts have been made to include ethnography in UML by the Coherence method [72]. At a first glance the Coherence method would be a perfect solution, modeling the engineering view, and including the ethnographic view. However, one important issue that still remains is that of the viewers' perspective. If a Coherence document were to be handed over to the designers, the designers would interpret the ethnographic data from a designer's point of view, with a risk of formulating perfect solutions to the wrong problems. Returning to the second issue, that of shifting the focus from understanding the work place to understanding it through the documents, this effect probably holds true for any modeling technique putting an extra layer between the ethnographer and the technical solution. One interesting way to solve this issue is to bring the ethnographer and the implementation

as close as possible. In the next section we will try to do this with the means of ethnography and mathematics.

10.6 Ethnography and mathematics

Rosenberg and Devlin, an ethnomethodologist and a mathematician, has provided some interesting work in combining their research. In their own words:

"*We wanted our analysis to have enough mathematical precision to be of use to an engineer trying to design a computer support system and yet was flexible enough to reflect on the subtle observations that would result from a social science investigation. Since we had no way to decide on the balance between the sparse mathematical formality and the ethnomethodological richness (and fuzziness), we let the data make the decision for us."* [41]

What they have made is to combine ethnomethodology and mathematics. They use Conversation Analysis from the ethnomethodological side, and Situation Theory from the Computer Science perspective. More specifically the Situation Theory is used to analyze the data from the Conversation Analysis, and this analytical method is called *Layered Formalism and Zooming* (LFZ). Conversation analysis is basically about finding structures of human behavior in conversations, and Situation Theory is a mathematical theory of information. Basically, what the authors have made is to structure and formalize information so that it can be described and interpreted by humans but with the formality to be easily interpreted into computerized instructions. Starting with a situation of thick descriptions, ending with a simple equation to describe the situation.

There are some comments that need to be raised towards this attempt. The first comment concerns the LFZ analysis being quite similar to predicate logic, why then not use predicate logic? The authors agree to this critique but argue that this is just the analysis part, and the result of the analysis couldn't have landed in the interesting results without the Situation Theory. There are other comments and critiques, however one of the most important critiques is the need for a person skilled in Situation theory, i.e. a situation theorist and an expert of the company to carry out the analysis. The idea of combining ethnomethodology and mathematics was, as stated in the quote:

'*to be of use to an engineer trying to design a computer support system*' [41]

where including a Situation Theorist would be a more or less side-step. Thus we are back in a problem similar to that of the Coherence method. However, strengths in this Situation Theory attempt beyond this critique is shown in other writings by Devlin.

10.7 Knowledge Engineering & Management – the CommonKADS methodology

One attempt, that has turned out to be the today leading methodology to support structured knowledge engineering is the CommonKADS methodology developed in the European ESPRIT IT context. The CommonKADS methodology was developed in the middle of the 80´s. Some of the fundamental principles in CommonKADS are that knowledge has a stable internal structure analyzable by distinguishing specific knowledge types and roles and that knowledge engineering consists of the

construction of different aspect models of human knowledge [37]. The methodology covers issues both in knowledge engineering and knowledge management.

Basically the CommonKADS consists of five building blocks in a methodological pyramid with feedback between the blocks. The five blocks are the worldview, the theory, the methods, the tools and the use. The model suite of the CommonKADS, which is the practical expression of the principles, constitutes the core of the CommonKADS methodology. The model suite consists of three groups of models, answering the why, what and how questions. In the model suite there are six squares, these six squares are organized in the following layers, context, concept and artefact. In the context layer, the three squares organization-, task-, and agent are put, in the concept level, the knowledge and communication are put, and in the artefact level the design model is put. Furthermore, the methodology provides forms with questions and related information to fill in. The methodology provides knowledge elicitation techniques, models of communication aspects, with message patterns, design of knowledge systems with implementation. Modelling techniques such as UML are presented, as reliable models for management, such as the Boehms spiral model that have been mentioned in 10.4.

The methodology is interesting both for its focus but also for its richness, both that it covers two research areas, but also for its details. However, there are some parts that could be developed, such as a group perspective, and perhaps also a distribution perspective.

Concluded, this is an interesting contribution for bridging descriptive and modelling techniques. There is no ethnography in specific however there are similarities to ethnography in some of the elicitation techniques.

10.8 Participatory design methods

There is a Participatory Design (PD) research community with roots in the Scandinavian tradition of IS/IT design, which is concerned with actively involving future users of the product in the design process [56][57]. A variety of different methods and techniques for participatory design have been developed over the past three decades. This is of course another way to bridge the description - engineering issue, by engaging the users, taking their experiences and use situations in to consideration. There are different methods and ways to approach and go about participatory design, such as for example future workshops, scenarios, paper prototyping, card sorting, brainstorming etc. These methods range from being of a more visionary and/or analytical character, such as brainstorming and future workshops, towards being of a more engineering character. Like paper prototyping, from which a system - in principle - can be implemented with the prototype as base. In all these methods, when used within a participatory design approach, communication is taken into consideration. Documentation and implementation aspects are also highlighted. Participatory design methods are of interest to the description -engineering dilemma. However, from an engineering point of view, the issues of prioritization and selection from the input from the future users needs to be further developed.

10.9 Activity theory

Engeström [61] makes a description of the development of Activity Theory, starting with the Russian psychologists Vygotsky, Leont'ev and Luria. They initiated the cultural-historical activity theory in the 1920s and 1930s. Basically Activity Theory can be seen as a descriptive tool, with the object of understanding the unity of consciousness and activity. Activity Theory can be seen as a paradigm or a framework where activities are in focus. When using Activity Theory, specifically the triangle that is one interesting tool to use, the perspectives of the activities becomes apparent. In applying the structure of a human-activity system, a triangulation including rules, community, division of labour and tools are handled in relation to the subject and the object, leading to an outcome. A specific focus upon Activity Theory research and Human Computer Interaction initiatives has been made [60].

10.10 Multiagent systems (MAS)

A consideration towards agents is made. Defining agents are a complex issue and no universal definition exists. However some attempts for definitions are made. According to Wooldridge and Jennings the following definition holds:

"An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives." [62]

The definition holds for an agent as a computer system, however turning the focus to multiple agents, the definition becomes more complex. At least the following characteristics can be included in a multi agent system. Multiple agents constituted in an environment, providing an infrastructure, specifying for example communication and interaction protocols. [63] The agents are considered autonomous and can be modeled following different structures, as for example according to the BDI model. In the BDI model, the *Beliefs* represents knowledge of the world, the *Desires* can be seen as the goals, and the *Intentions* can be seen as reactive behavior, changing state dependent of the feedback from a changing world. [64]. One main motive of using multi agents instead of just a single agent is that the agents can reach further than individual agents can, and solve specific problems of multiple character. Multi agent systems can include cooperation, coordination and communication between the agents. Humans can also be modeled as agents, and becoming a part of a MAS. Multi agent systems have been considered as in figure 10, where roles for agent technologies are presented.

10.11 Concluding remarks on methodologies

In this chapter a configuration of methodologies has been presented. From the social science perspective an ethnographical, ethnomethodological perspective has gained most focus. The computing perspective is dominated by a requirements and modelling perspective. Some methods solve the basic issues and some generates new issues to be handled. Such as including other methods and perspectives as in the 'ethnomethodologically-informed ethnography' case, or as in the Situation Theory case, were one suggestion is that an interpreter of the analysis could be of importance to reach the information.

Connecting descriptive to engineering methodologies can be a complex and cumbersome issue. One concluding but most serious comment on this discussion is

that in some research communities it is more important to show that the methodology has been properly used than that of developing the methodology and gain an interesting result from using it. As an example, many researchers who use ethnomethodologically inspired ethnographic field studies do not subscribe to the research practice of "translating" work practice studies into work flow models. On the contrary, work practice studies are often used to show the limitations and problems with over-simplified work flow models. The focus turns to the tensions between the research paradigms instead of progress in the research. Of course we need to consider how well the user of the methodology knows the method. But having a to strict view upon methodology as such could probably be unproductive.

A last concrete comment concerning this issue is to reflect further on, is concerning the importance of using the same ontology both descriptor and engineer is to consider recommended practices as one example the IEEE recommended practice [58]. However, this can probably pose new challenges, when using the same ontology is there perhaps some grain of definition being missed.

11 Design proposal

Based on the discussions and analysis above, we suggest the following architecture of future service-oriented workflows. (compare figure 9)

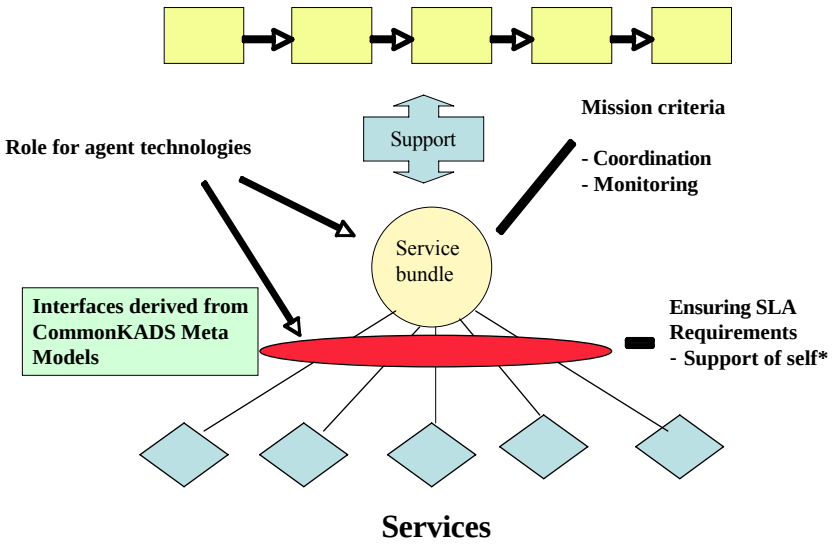

Figure 9. Design model of experimental platform enabling testing of service qualities.

Thus in this thesis a presentation of normative workflows and the actual workflow is made. This with relating the studies and cases made at the Emergency Service Centers. The actual workflow is made in parallel and the coordination can be considered as a risk driven blackboard-based spiral model. In line with fulfilling the mission criteria, coordination aspects and monitoring aspects are of specific consideration. Since these are critical points in fulfilling the mission, and need to be

carefully considered. One such concrete example is the hand-over situation depicted in chapter 9. Including first of all coordination aspects, but also monitoring aspects of the handling. For the support of the workflows, a service suggestion is considered. Where a Service Level Agreement (SLA) is constituted and agreed upon between the different organizations involved, external as well as internal. The connection to *figure 9* and the meta models with the interfaces and the coordination and communication aspects are considered. The requirements are considered both in the SLA and in the building of interfaces. The role for agent technologies is considered both in the service bundle, as in intelligent support of coordinating services, but also in the requirements in the SLA. We can consider MAS with suitable structure.

A suggestion for SOS-clusters on a general level is to have an information ecological view upon the emergency call handling. Having the ecological view, thus avoiding a too strong focus on just the technology or the organization, but to have a proper focus on the tasks. Having this contextual view upon taking the workflow serious, most probably dysfunctional ecologies can be avoided. If such perspective doesn't exist, it shouldn't come as a surprise if dysfunctional ecologies appear. Another general issue is that this organizational change differs to some extent to what ordinary centralization or decentralization changes do. It is rare to see reorganization where the work in the current form, i.e. the connection to the local features, is to be saved even though the reorganization where the focus is on centralization. It is more common that the new advantages with the reorganization are in focus, like collecting all staff in one location.

Potentially SOS-cluster reorganization can be disruptive. Concerning such reorganization, it can be made without any breakdowns, even though some issues are not properly considered. It can be covered by the good memory of the 'old operators'. In such circumstances, the workflow could run smooth until the 'old operator' retires.

Suggestions for SOS-clusters on a more specific level are to take the increase of information serious, proper analyses in language science. But also to consider the mission of saving lives and minimizing damage at accidents seriously, thus focusing on the centralization and decentralization issues. Having a proper view upon empowerment of the edge. Taking the parallel handling of the tasks, serious, thus having a workflow perspective. Changing the object type categorization towards a SOS cluster handling is thus vital, if this is made in agreement with the suggested object type categorization in chapter nine isn't the core issue. The awareness of and proper acting in agreement are more important. A recommendation of a gradual transition towards clusters, with a search for suitable support of clusters before entering a cluster structure is recommended.

The risk for double work, the importance of synchronizing parallel activities, the collective establishment of 'are we doing the right thing', and the issue of understanding the issue of workload in holding to many cases in parallel are concluding suggestions. A recommendation of considering use of CommonKADS methodology is made as a last comment in this section. The CommonKADS includes both engineering and management perspective, and are specifically directed towards information intensive domains. What can be labeled the ethnographical perspective in the CommonKADS concerns elicitation techniques.

12 Validation principles

The validation principles build upon an implementation of figure 10. Using the design suggestion in the figure we thus can go back to the work practice using mock-ups, validate if the requirements hold, if the suggestions are relevant or if we need to go reconsider. Such iterations can be done according to the Developmental cycle in the CommonKADS methodology.

Validation examples:

1. Ethnographical + science of information analysis of workflows leading to requirement engineering.
   -test of qualities RQ1, RQ2 (have we missed important information related issues?).
2. Validation of crucial qualities RQ3

On a more general level, providing measurement criteria in validating the design in figure 10 can also be of interest. A reason can be that the ethnographical methods are of descriptive character and are not easily applied in a measurement context. Difficulties appear for an outsider when evaluating the quality of the ethnographical findings. This is a serious issue, since most probably it decreases the trust in the ethnographically based findings. A part of this problem is captured in the following quote:

"*In practice, it is very difficult for anyone apart from the ethnographer to interpret these records so this limits the use of the raw data, particularly if there is a need to come back to it after the ethnographer has moved onto other things*." [27]

In this quote, the problem for a non-ethnographer to interpret the ethnographical data is presented. The issue that the ethnographical data are connected to the researcher/s makes it even more difficult to handle. Using the raw data, connecting it towards computerized solutions will then be an even greater issue. The issue of trusting the ethnographical findings, with or without 'proof' such as raw data is also an important question. Methods such as work shops with the users, is of course a methods to use. But for an outsider not participating, measurement criteria can be of interest. To be aware of is if the measurement criteria are shaped in a general manner unaware of the context that it is to be implemented in. Perhaps it is of importance to consider such criteria, how they are built and used since they functions as a qualitative measurer. As for example, since the operators are working in different group constellations, it can be of interest to focus on measurement criteria for usability issues in groupware systems.

12.1 Introduction

The need for measurement criteria concerning usability issues in groupware systems is obvious. Existing measurement criteria are insufficient in different respects. The main critique is that they are uncritically 'built on' quite general criteria derived from single user context, and they take the domain of appliance in consideration just on a very general level. In this chapter, an attempt is made to reach beyond the current research front in measurement criteria concerning usability issues in groupware systems. This is done by considering ethnography and in usability contexts well-known concepts applicable to the emergency service centre domain.

Measurement criteria are important tools in establishing and maintaining quality. Traditionally there is accordingly a strong focus upon metrics and measurements in computer science contexts. Huge efforts have been made since the 1930's in addressing basic complexity and performance issues of computational models and algorithms in theoretical computer science. More recently, from the 1950's and onward, measurement models and tools have been introduced into the engineering disciplines of software development and implementation. Introduction of distributed systems and networking still poses challenges in methods assessing and guaranteeing aspects of Quality of Service (QoS), not the least in security and information integrity areas.

During the 1970's new user-centric applications highlighted the need to address user support in user-system interactions (Human – Computer Interactions, HCI). R&D efforts in this area are now a big undertaking worldwide. Traditionally, the aspects of *usability* under investigation have been focusing on generic interaction models between one user and one computer (system) supporting a generic task. An illustrative example is the MS Office suite, including tools supporting browsing and e-mailing.
Measuring functionalities and system performance is one key method in verifying system quality. However as a method of assessing usability, traditional measurement of computer performance are not enough, even if response time is an important user aspect. Usability criteria also include ease-of use, intelligibility (cognitive overload) and ergonomics. The differences between how to measure computer performance, functionality and usability qualities are partly natural, derived from the evident differences in assessing computer performance and performances by users. There has been, and still is a debate on what to address (measure) and to what end in HCI research agendas.

However researchers and practitioners in the field of computer science are responsible for handling these challenges as has been exemplified by many researchers, e.g., by Nardi and O'Day dealing with information ecologies [28] and experiences in the NEC efforts. As earlier presented, Nardi and O'Day exemplify breakdowns in introduction of ICT's in hospitals due to neglect in understanding sustainable system invariance criteria such as maintaining work place integrity.

Addressing HCI issues have an embedded difficulty – how to understand and model a user's skills and/or cognitive capabilities and needs. These are very much open challenges and are only partly understood in areas related to problem solving (knowledge based systems). In our setting we focus on group behaviour in solving tasks together. This means that other aspects, e.g., social competence and organisational settings, come into focus to a higher degree than in previous research in HCI or even in contemporary CSCW (Computer Supported Cooperative Work). The field of usability has matured some; standards, methods, definitions and more have been developed. We maintain however, that quality criteria in groupware usability are one area where more effort needs to be made.

Considering the SOS cluster issue, the positive effects of a centralised solution are arguably that; the effect of any operator answering any incoming call are that more operators are available to answer incoming calls independent of geographical location of the accident. Peaks in the handling of emergency calls could then be levelled out

ensuring lower delay. However, connecting distributed operators cooperating in handling the time-critical calls poses challenges both to the organisation and on the design of the computer support system. The handling of the time critical emergency calls has to be fast and accurate. Important issues related to this are as stated in one of the challenges:

- How can we identify and maintain critical qualities during technology enabled transition.

This chapter addresses important aspects of and gives some partial answers to this challenge. The remaining part of the chapter is organised as follows. In *Section 2* we give an *overview of usability assessments in groupware*. A selection and presentation of important criteria that need to be fulfilled in groupware applications in our context, i.e. the issues related to *common situation awareness and common situation assessment and task/team awareness* are described in *Section 3*. In section 4 a contribution of a definition of usability in groupware – specifically directed towards distributed emergency call handling are presented. A process model is complemented to the definition, and the initial questions are given answers. This chapter ends with section 5, *Conclusions.*

12.2 Assessing definitions of usability for groupware

There is more or less a consensus that the objective for design and implementation of CSCW systems is to increase usability for the users in performing joint tasks. Upon closer inspection the issues involved are, however, much more problematic and complex than originally envisaged in the late 1990's. At that time most of the CSCW efforts were focusing on articulation work (setting up and wrapping up group work) and control issues related to video-shared work area interactions. In short the CSCW participants could see and hear each other and also share information through different media that also could support a common workspace (e.g., the Xerox PARC Liveboard system). In CSCW we could have the emphasis on either, or a mixture of:

- Computer support
- Cooperation support
- Work support

Usability has different readings in those settings. So, what could we mean by measuring usability or having high usability as a system requirement or comparing usability of two systems? What are the differences between use-centric or user-centric approaches towards increased usability? The answer is, of course, we have to qualify the different aspects of usability and also define what we can, and how to measure qualities such as usability. In this section we give a short overview of discussions and models of usability related to CSCW systems or, more generally, groupware.

Issues concerning requirements and evaluation of groupware systems, usability criteria, have attracted considerable efforts in international R&D due to their importance in supporting user acceptance. However, the research community has not yet been able to establish agreed upon criteria and measurement methods to assess usability in groupware or in CSCW. Several interesting descriptions and findings of evaluation tools supporting cooperative work have been presented, however the issue

is still quite open. The following statement from Pinelle, et al [29] captures the situation:

"*Yet there are currently no modeling or analysis schemes appropriate for groupware usability evaluation. The problem is that existing task modeling schemes are either unable to represent the flexibility and variability that is inherent in real-world group task behavior, or use a level of analysis that is too broad to allow for usability evaluation of a groupware interface."* [29]

In this quote requests for relevant measurement criteria in groupware usability evaluation is quite clear. Also the need for schemes that can represent the flexibility and variability inherent in real-world group task behaviour is made obvious. The authors present their own definition of groupware usability:

"*This becomes our definition of groupware usability: the extent to which a groupware system allows teamwork to occur* – effectively, efficiently, and satisfactorily – *for a particular group and a particular group activity*." [29]

Their definition of groupware usability clearly emphasises the contextual dependency of usability and is built upon [29] [31] which originally was intended for single-user environments. An ISO standard has also been built upon these three concepts: effective, efficient, and, satisfactory [32]. Also in [23] definitions of, and methods for measuring efficiently and satisfactorily are presented. However, the perspective is limited to user interface issues. In the article, [23] the authors work with the definition, but find it difficult to use these qualities since they cannot directly be observed. They have found what they call indirect measurements that fit well to their conception of groupware. In the article [23] they develop own measurements like completion time, verbal efficiency and characterize them to fit into the indirect measurements. In [29] they take one step further and propose a mechanical approach to analyze the interface, as an answer to the traditional view of teamwork. They do this as an attempt to fill a gap in the research on methods and tools to implement useful interfaces to support computer-mediated teamwork.

The same authors also express their dissatisfaction of practitioners of social science and in CSCW community expressing the need to dissemble the concept of teamwork far enough to allow assessments towards interface designs. The bottom line of their argument is:

"*Even though social issues may still affect the system's eventual success, our goal is that groupware development teams should at least be able to identify and solve basic mechanical usability problems before having to deal with more subtle organizational concerns*." [29]

From these lines it becomes clear that they have a waterfall development model in mind rather than an iterative development perspective. The analytical tool of the mechanics they propose is interesting in itself, however, what comes first in their methodology isn't clearly stated. In [34] the authors take a step further and make a heuristic evaluation of the mechanical approach presented in earlier articles. Methodologies such as CommonKADS [37] clearly show that management and engineering parts can be analyzed and worked on simultaneously and iteratively.

However, in the CommonKADS methodology, the problem of assessing teams and groupware remains, due to the classical focus of single user environment. However, it should be noted that groupware naturally is in focus in methodologies developed within the multi-agent system R&D community.

To summarize this section: contemporary models and methods for assessments of usability of groupware or CSCW systems are not well enough established to be useful in our investigations and in future assessments in emergency call centers. We will outline a model for usability assessments in Section 6. Our model is based on identifying different aspects of usability (with different measurement models) and with a clear context dependency.

12.3 Common Awareness and Common Situation Assessment

Awareness is a well-known challenge and a key issue when supporting distributed work [31]. Considering support of distributed group work context, as in this chapter, the issue is even more complex. Awareness is by nature, context dependent, highly dependent on the structure of the work. Qualitative empirical data from ethnographical studies are required to define what awareness means at a specific work centre, with a specific task and a specific team. Comparisons with other centres are required to hinder a single case or single centre based definition to propagate onto the design. Measuring usability for groupware systems is of importance in supporting users working collaboratively in a geographically distributed organisation. Glaser and Strauss originally developed the awareness concept [35]. The concept of awareness was developed to facilitate analysis of:

'*the total combination of what each interactant in a situation knows about the identity of the other and his own identity in the eyes of the other*'

… and in this way to aid understanding of the social organization of knowledge and activities. The aim in this section goes beyond Glaser and Strauss spirit, implication towards the design of computer support for distributed emergency operators are included. But aiding understanding of the social organization of knowledge and awareness is included. The concept of awareness in distributed group work has been used and developed in human-computer contexts for over a decade. Sub concepts have been developed, diversifying the concept. Some of the sub concepts have been developed following technological trends. In recent years the field of human computer awareness (HCA) has been initiated. This emerging HCI sub field focuses on:

"*a growing problem in a number of complex domains, where groups of people are often involved with multiple automated systems in the pursuit of multiple objectives*" [33]

The reasoning in this section could be categorized into the field of HCA, the focus is partly on issues where groups of people are involved in using multiple automated systems. With the exception of the interview/conversation part of the emergency handling, done with extended use of the computers as a support, not to be categorized as automated in the proper definition.

12.4 Task and team awareness

In this chapter the concept of awareness is further specified into the sub concepts *task*- and *team* awareness. The main reason for selecting these two sub concepts is [30] the combination of both single and multi user perspectives. Providing an understanding of the concepts, the following definitions are presented. One everyday explanation of task awareness is found in Kraut el al. [36]

"Task awareness, which includes collaborators' beliefs about the overall project, including its history, current status, and future directions, is crucial for successful coordination. When collaborators divide work, they need to monitor their partners' activities for personnel management and to understand the impact of their partners' progress on their own work. This monitoring can help people determine when and which collaborative actions they wish to perform." [36]

A description of how frequent the awareness needs to be updated varies in relation to the nature of the task. The handling of the task is of great importance, done in teams cooperating individuals. Team awareness is the second sub concept of awareness in this section. The definition of team awareness used here is:

"Team awareness, […], refers to collaborators' beliefs about both stable and changing attributes of their partners." [36]

An understanding of the cooperating partners knowledge, skills and motivation can help collaborators assign for proper tasks. Roles, interdependencies, current status and availability of team members are included in this category.

12.5 Measurable qualities

Finding proper measurement criteria is critical and can be a cumbersome issue. Today we cannot ask for the publication of all the constant numbers known in the sciences and arts as Charles Babbage, the inventor of the digital computer, did in 1832. [59] In fact Mr. Babbage would most probably argue that such qualities as of effectively, efficiently and satisfactorily could not be measured, using traditional ways of measuring. In fact he is true. But having a 'measurement attitude' towards such criteria, we can take a serious approach in including them in the engineering of a system or similar. Excluding such issues is critical, and we need to find a gauge suitable.

One way to measure common awareness can be to focus on ways the computer support mediates common awareness. How can an operator at a remote centre know about the workload at other centres? One way could be to measure how many cases they are handling at the moment, categorizing the cases into cases just answered, cases with dispatch and so on. Concerning task awareness, the history and current status of the case are quite easy to measure. Future directions are a bit harder, however given a certain category of case; just some predefined actions can be selected from, limiting the actions to be taken in the case. I.e. if a traffic accident has occurred, then the operator has to dispatch at least an ambulance and notify the police, if there is a fire at the scene, or if people are stuck in the vehicles, rescue vehicles have to be dispatched. Team awareness is much an issue of roles and relations to cases. If an operator has a predefined role of being the dispatcher of rescue vehicles, i.e. the division-of-labour is strict, distributed cooperation can more easily be accomplished.

However in smaller centres were the operators are too few to be divided into strict cooperation, they would rather case by case declare their roles, also making available which role they have. The operators would also be able to put themselves unavailable in a certain role, or any role, if they need a break.

12.6 How to Compare and what to Measure

The basic aim in this chapter is to find quality criteria in usability measurement for groupware that are more directed towards the specific group, the way of working and the specific activity. There is an articulated need for measurement criteria concerning usability issues in groupware systems. The current measurement criteria for groupware usability: where groupware systems allow teamwork to occur: **effectively, efficiently,** and **satisfactorily** are not enough. The main critiques of the existing quality criteria is that they are built on quite general criteria derived from single user context, and they do not take into consideration the domain of appliance.

Returning to the questions stated in the beginning, firstly what to measure and how? The answer to this first question is to use the existing measurement criteria and rebuild it into defining the specific group, the specific task and add the specific way of working. It is one way of balancing the abstract general perspective and the concrete examples of findings from the real domain. Concerning the critique of task modelling schemas that are unable to represent the flexibility and variability that is inherent in real-world group task behaviour, [29], we will present a suggestion of such criteria, meeting the critique. Our measurement criteria for groupware, taking the definition of groupware usability one step further, built upon the ISO standard [32] and Pinelles definition would then be as follows where our contribution to the measurement criteria is highlighted in fat text:

The extent to which a groupware system allows teamwork to occur – effectively, efficiently, and satisfactorily – *for a particular group,* ***a particular way of working*** *and a particular group activity*. **If the particular group is emergency operators working distributed, and the activity is the handling of emergency calls, then** *effectively* would **include time,** *efficiently* include **awareness,** and *satisfactorily* **include workflow**.

These measurement criteria can be built on and used in other settings with the specifics for that certain domain. Returning to the second question of how we can evaluate the results in a meaningful way? In figure 11 below we present a process model of when to use the measurement criteria. In this process model, the findings from the ethnographical or similar studies of the work place is done, the definition of the measurement criteria can then be evaluated in work shop or similar with relevant participants. The lack of arrows in the figure indicates that it is an iterative process.

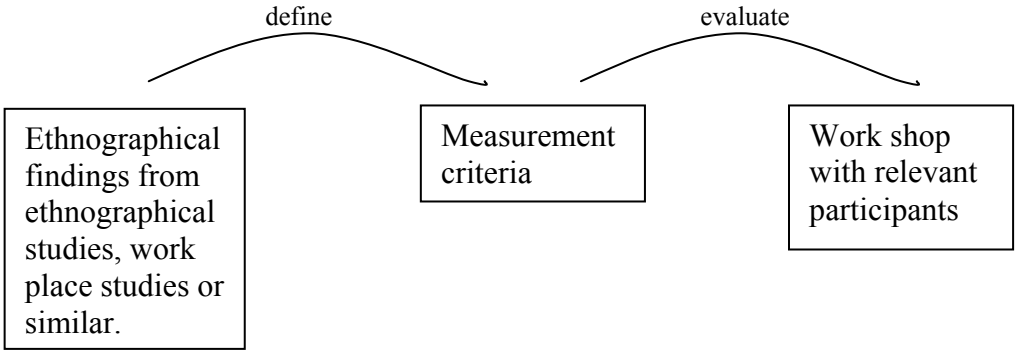

Figure 10. Process model of an example of when to use measurement criteria in ethnographical finding contexts.

Returning to the challenges stated in the introduction, how we can identify and maintain critical qualities during technology enabled transition, such challenges are of importance in providing the bigger picture. Complementing the measurement criteria and process model, hopefully improving the chance for at trustworthy system.

One way to assess the differences and trade-offs between the old solution and the new proposed solution is to make ethnographical studies both before and after the transition, and compare the outcomes of the study. Another way is to compare the requirement specifications; this view most often excludes the use of the system, focusing on descriptions of functions. Measuring the system before and after the transition with different measurement criteria could be another solution. Focusing on different functions, trying to measure them in time or other aspects, comparing before and after the transition are another way. Returning with the findings to the work practice asking for comments is also a possible way.

One answer to this question is to become aware of the critical qualities, perhaps by using ethnography. One way of maintaining them is by trying to capture and define them not only in requirement specification, but also in case descriptions, case based scenarios, scenarios, assessment, demand specification and prototypes. Both before during and after the transition, work shops can be a method to find and keep the critical qualities. After the transition trying to evaluate the critical qualities by using the system, to see if they have been kept. But also to observe and identify if potential dysfunctions in the workflow can be a method to use. Avoiding dysfunctions in the real workflow, can be to use team simulation trying to capture potential dysfunctions and handle them before implementing the real system. Carefulness from simulation towards real world needs to be taken. Furthermore, different types of validation can be made. Concerning the development of the technology, of the workflow, the development as such, and concerning the information types.

It is of importance to handle personnel and organizational issues that can be concerned if the stated objective will be invariant during the transition seriously. One line to follow is to make the personnel and the organization involved in the transition, making it transparent, easy to follow and to see the progress. Of course to raise objections if they have any critique. Work shops, participatory design methods and more are tools that can be used here. Complementary can be to review the

development of documents and organizational discussions concerning the transition. As conducting research with high involvement of personnel, awareness that the users can have contradictory views can be of importance. One great misunderstanding of user involvement is that the users provide you with the correct solution, however what is the outcome is most often a richer picture, from the users point of view. Be aware of that user involvement takes time. As an example, a comment from a user concerning the user interface could potentially be solved by teaching or change in the division of labor, and vice versa.

12.7 Concluding remarks

In this chapter the focus has been on *trustworthy handling of time-critical emergency-call in distributed call centres.* We have presented issues that are commonly known in groupware contexts. We have presented the specific domain of application and built further upon the ISO standard [32] and [29] Pinelle et al definition, and ethnographical findings and issues well known in groupware context, and the creation and answering of some important question concerning technology enabled transition has been made. With this definition of measurement criteria for groupware, the process description, we have made some contribution to the ongoing discussion. The issue is not solved, every other domain needs to define their measurement criteria and find ways of evaluating them according to suitable methods for their domain. With this suggestion field studies, measurement criteria and user involvement can be combined, hopefully making a fertile ground for trustworthy systems.

A serious focus upon education concerning a SOS cluster handling is of vital importance. In some research communities there is a misunderstanding that displaying the correct functions in an intelligible way education can be reduced. However, education is a vital issue to consider, taking education serious towards SOS clusters would most probably include issues in relation to systemic requirements.

13 Conclusion

The main contributions in this thesis are, the assured workflow findings within the socio-technical approach. The reconsidered object-type categorization and the suggested science of information structure are another important contribution. The assessment of the current work practice derived into *systemic requirements,* with specific considerations is also of importance. The design model of experimental platform enabling testing of services is the main design contribution in this thesis. The validation, measurement and methodological perspective are other important contributions.

In this section a conclusion of the main contributions are presented. The structure of this section is as follows. A presentation of the workflow principle is made. Presenting the main findings of parallel execution of workflow tasks and the nature of the coordination. Research questions and challenges follow, where the systemic requirements are presented. A discussion about information ecologies mainly concerning requirements is made in the following section, last, a specific section with suggestions for SOS clusters is presented.

The focus on principles of workflow support in life critical situations deserves attention. Without a fundamental understanding of the same, there is a clear risk that

the requirement process, and in the end support for handling workflows will end up insufficient. Issues covered in the research questions and challenges related to SOS clusters such as an increase of information, and a structuring demand from that perspective is covered. The importance of identifying and maintaining critical qualities during the transition and maintenance are of vital importance. Such issues could potentially be lost while only focusing on strict engineering requirements aspects. Important aspects of how to validate workflow models and measure groupware usability are such examples. Issues that furthermore are important and concrete questions in the wider methodological question concerning the issue of ethnography in connection to models of computation. Potentially the answers to these questions could be useful in other time-critical areas of research, such as real time surgery as in beyond telemedicine. Returning to the findings and the workflow principles. From a workflow point of view, transcribing and analyzing several cases, of which four cases are presented in the thesis, it is seen that the tasks constituting the workflow are made in parallel mainly to save time and increase quality. The coordination of the tasks can be modeled as a risk driven blackboard based spiral model. Thus we have derived at the following workflow principle:

Workflow principle
The workflow at present day single SOS centres is characterised by a parallel execution of workflow tasks. The coordination of the tasks can be modelled as a risk driven blackboard based spiral model.

Furthermore a focus upon making the workflow transparent, comparing the cases, finding out how far it is possible to draw comparisons between the cases is also made. A validation with the result that the cases fit into the object type categorization is made. The relevance of this is to find out if the current object type categorization is sufficient, and holds for the cases. If otherwise, a consideration towards supplementary categories supporting the current way of handling cases should have been considered. The finding of this workflow principle are important, having the knowledge about the parallelism, a structure making space for such handling can be made. Considering an implementation model without space for parallel execution could potentially increase the time for handling a case, thus resulting in a decrease of quality in handling the cases. Concerning the coordination aspects, without the knowledge of blackboard based spiral model, a dialogue model could perhaps bee wrongly chosen. Resulting in critical aspects getting lost, and potentially establishments of workarounds. Furthermore, two research questions are stated in chapter 2, the first one is:

Research question 1
In what way can the workflow model of single SOS centers be transformed to a workflow model of SOS clusters while maintaining or increasing the quality of service?

The Challenge related to this research question have been stated as:

- Identifying normative and actual workflows in work practices at SOS emergency service centres.

This question has been answered by presenting different perspectives relevant to the issue. A conclusion that the SOS cluster would make the handling of emergency calls partly virtual is made. A matrix presenting centralization, decentralization and SOS cluster and empowerment of the edge extremes are made. Conclusions such as in an extreme of SOS cluster and empowerment of the edge, there could be issues in coordination between cases. An assessment of the current work practice at SOS is made a conclusion derived there from is that handling persons in stress are an important part of handling emergency calls. Also that categorizations, time criticality, ground service connection and local knowledge are important issues in the emergency call handling. From the assessment, systemic requirements are presented. A conclusion is that concerning the functional requirements, an implementation with a focus upon information structuring could be productive. The point covering most issues in the functional requirement is the bullet with nationwide access to categories, plans, maps, and vehicles. In this requirement one could easily get lost in finding an implementation strategy not taking the whole information structure seriously, as in the science of information initiative. Ending up with a great amount of unstructured, unrelated information. However, having an awareness of the science of information perspective from the beginning, knowing its strengths and weaknesses applied in the emergency domain, we are hopefully closer to avoiding information breakdowns.

Concerning the second research question, stated:

Research question 2
In what way can the object type categorisation of single SOS centres be transformed to a workflow model of SOS clusters while maintaining or increasing the articulation of the work?

The answers to this question are made by a reconsideration of the object type categorizations. New features such as the quality, praxis, debriefing and statuses in SOS clusters are considered. A conclusion to draw from this suggestion is a change in articulation work from in centre to information in the computer system concerning articulation. Concerning requirement such as exercise, could potentially give a more serious adaptation of new technology and new ways of working. New functions and technology goes hand in hand with exercise. There are several examples to find concerning this issue. Building new routines such as knowledge about the dispatch handling, the geography etc is of vital importance.

Research question 3
Design of suitable experimental platform enabling testing of service qualities.

The challenges related to this research question have been identified as:

Methodological issues related to:
- Identifying a suitable service oriented architecture supporting workflows.
- How can we identify and maintain critical qualities during technology enabled transition.

A service-oriented architecture to support workflows is the main design suggestion, with the perspective of testing the service qualities. This service-oriented perspective

is of vital concern since the advantages of service oriented management and system opportunities potentially can be positive for the organization structure in focus.

Concerning the methodological issues related to the challenges, there is a gap between descriptive methodologies such as ethnography, and engineering methodologies such as computing. However attempts to bridge the gap are of importance, and a conclusion to make from this is that in being able to connect the different sciences, perhaps we should tolerate that it can be difficult to trace the original methodologies in the result. Also the focus should be on the question itself, not on the methodology as such, and one way of interpreting the rigor of the methodology is how it suitable it is in solving the question. An approach of configuring different methods is another important conclusion of this thesis. A last conclusion concerning validation principles is that the measurement criteria towards groupware usability need to be made more specific and suitable to the specific domain of implementation. A suggestion for such measurement criteria is made. Built upon the current existing criteria for groupware, adding values for the specific domain of emergency handling.

Adding to the concluding contribution, are the following insights. There are parallel flows of activities in the handling of emergency calls. A matter of synchronization is of relevance in this concern. As an example, the operator answering the emergency call can ‘hold the interview’ to get relevant information concerning for example road descriptions. This would be requested from the dispatching operator, while having a conversation with the ground service. If the operators have a well functioning synchronization, the answering operator could hold the caller, and make direct requests based upon the dispatching operators conversation with ground service. Potentially saving time by such parallel execution of activities.

A most important issue concerning SOS clusters is the issues of gaining time and quality. In this respect, the collective question to ask is the question of ‘are we doing the right task’. An important question for the operators to ask, potentially harder to establish such if they are working distributed. Another issue concerning that the operators are coming from one centre, are the perspective that the communication between the operators needs to be augmented, so it is visible what the communication means. Concerning a time analytical perspective, the issue of ruling parallel workflows without mixing the cases. How many cases can the operators hold in parallel, and are certain cases more difficult to hold, and are cases in SOS clusters more difficult to hold? In the centres today the time surveillance concerning the respond of ground service to a dispatch can be seen as relieve of pressure concerning the holding of multiple cases. The operators can focus on other cases, and there is an alert if the ground service doesn’t respond in a timely manner. Similar automated solutions could be useful.

A synchronization of parallel processes, thus separating different cases, and a collective check-up concerning if they are working with the right tasks are of relevance. Double work issues that could result in too many vehicles and personnel at the scene are important to consider. As well as non-dispatch issues due to coordination and delegation issues. Such issues could be considered by synchronisations of the parallel activities.

14 Future work

Building from these *Principles of workflow support in life critical situations* a list of possibilities are open for further research, including but not restricted to the following four points:

- Distributed digital support for cooperation in groups
- Information structuring
- Services
- Multiple views

14.1 Distributed digital support for cooperation in groups

One suggestion for a future of SOS clusters is to set up team simulation a' la Turing. Where the operators could simulate working in SOS cluster organization. This could be an interesting challenge, both to engineer and make it run, but also to evaluate and consider possible breakdowns, and how to engineer to avoid such. Interesting challenges in how to structure the team are presented by Mark Driver, NASA. Basically concerning the foundation for decision principles, providing the right amount of information to the specific person, making him or her decision able. Where the decision ability and the quantity of information necessary to make a decision are put in a matrix. Thus discovering which tasks to delegate to whom for best possible results. Another important issue, presented in the functional demands, is to support the operators in not just handling several tasks in parallel, but also to handle several cases in parallel.

14.2 Information structuring

Building upon what AI people consider is one future for AI, where [49]:

"Artificial intelligence is also becoming increasingly important to the scientific community, where the aggregation of data is outpacing scientists' ability to analyze it."

From this perspective, information, and information structuring and analysis are an important field to consider. Having a proper information perspective with a serious perspective upon distribution, information management agents and time criticality could be a fruitful approach. A serious consideration towards semantic analysis, multi agent perspective in information handling and distribution, concerning time criticality and the ability to create shared awareness could be an interesting focus. Reconsidering Knowledge Engineering & Management methods for knowledge intensive organisations, from single user perspective towards multi user, highlighting the information perspective could be further productive.

14.3 Services

In the era of global computing, possibilities for exchange of services increases. New Service-Oriented-Architectures (SOA) [51] [52] enabling connections between businesses, opening up for new ways of working. The resources and organisations become more virtualized, functioning in 'on-demand computing' style. However this poses challenges on the organisations to understand that the future issues will not be lack of memory, capacity, network recourses, or other computation related issues restricting us in how we can interact and make use of the computers. The ability to

capture the core of our competence, structure information and make use of the communication channels. To understand the competences in other organisations, focusing on development. And the skills in setting up a proper structure to do so. The competence in deciding which tasks we as humans need to handle, and what to create intelligent automation for. Whether it will be agents, robots or other artificial tools that will support us isn't the core question. It is about services and our needs.

Using different kinds of networks, the question is how to cooperate with other companies exchanging services. There is a risk that current local solutions of networks aren't scalable and secure to the extent we wish. Because of the new possibilities of working, what will happen to the old structure in the organisation, will they partly remain, most probably there will be new services, or will the persons just strive to keep track of every task they has to solve, trying to remember the structure of the virtual organisation, struggling with getting to know new partners and special designed interface for the services? Some organisations are adapting to service oriented approaches, some is born out of the service orientation.

Today the operators cooperate with several organizations such as ground-services, hospitals, road authorities and more. The cooperation is well structured, and some exchange of information, and support are taking place. However structuring the cooperation with a service orientation can be of interest. The basic reasons for suggesting a future research on service orientation are then two fowled:

1. The organizations are already connected and a service orientation makes it smoother to exchange services, change and making new services

2. The interoperability issue will be solved

14.4 Multiple views

Concerning the issue of using cameras and display the operators in an attempt to create 'in room' collaboration while sitting distributed. Multiple views on the same event, where the operators can see each other from different angles are an interesting issue in this respect to consider. Related issues such as which angle to choose and privacy issues concerning broadcast and recordings need perhaps to be considered. Important aspects to consider can be the Nardi and O'Day discussion about dysfunctional ecologies.

The French football player Zidane case in the 2006 FIFA World Cup can illustrate an interesting example concerning multiple views. The Zidane case concerned his criticized head butt on the Italian Materazzi, as a reaction to a negative comment from Materazzi. This event appeared outside the official camera view, and would probably not have been considered in the former days. But a new camera approach where players can be recorded even when 'not being in football focus' made this event public afterwards. There are some interesting issues to consider in a multiple view discussion from this case. First the fact that this event happened outside the official view raises the question of multiple cameras, and the ability to record and play events and make them the official view after the event has occurred. This could perhaps be interesting for SOS clusters. Recording and selecting recorded events. However, due to the time criticality, recording and analysis takes time. But in some cases, the quality

gain from recordings could balance the loss in time. It also raises the issue about which camera that holds the official view, if using multiple cameras. Who is responsible for the official view, and who decides which view that is the official. Some sort of time critical version management handling could also be interesting. There could are also some interesting issues concerning time criticality and distribution and multiple views in surgery, telemedicine and beyond.

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15.1 Figures and tables

16 Glossary

Agent – artifact or human

Centre-to-centre - term invented in the SOS organization concerning a closer cooperation between the centers. In this vision the SOS operators should be able to handle emergency calls independent of the callers geographical position.

CoordCom system – refers to the current systems of G1 and G3 that are in the process to be changed.

Emergency service centre – a centre that handles emergency service calls from the public, as well as automatic alarms from buildings, safety alarms from elderly and similar services.

Information ecology – a system of people, practices, values, and technologies in a particular local environment. In information ecologies, the spotlight is not on technology, but on human activities that are served by technology. Defined by Nardi and O´Day [28]

Listening-in - As the "to be" dispatching operator receives the "listening into" the conversation with the caller and the answering operator, he or she can begin the dispatch parallel to the ongoing conversation with the caller.

Partly virtual organization – partly ostensible organization, where parts of the tasks are performed via computer support. What differs is that a full virtual organization can have members that only interact through the computer support

Principle - Basic sentence or rule that often constitute norm for act

Science of information – Based on the book of Devlin [19], influenced by the work of [20] basically concerns a structuring from information point of view. Based on types of situations.

Service – in difference to task, a service is performed by someone else or some other company.

Socio- technical systems – a set of interacting, interrelated entities covering social and technical aspects

SOS-cluster - term invented at BTH in this research context, to catch the definition of the SOS organization, but also to see potential issues of concern in relation to centre-to-centre

System - a collection of components organized to accomplish a specific function or sets of functions

Workflow –is concerned with the sequential relationships that hold between what the workaday activities are in a setting and how they connect together to form distinct

interrelated processes through the production and transformation of information over the course of the assembly and coordination of work. (A. Crabtree)

Workflow reconsidered – **normative** workflow is concerned with the sequential relationships that hold between what the workaday activities are in a setting and how they connect together to form distinct interrelated processes through the production and transformation of information over the course of the assembly and coordination of work. (Reconsideration of Gustavsson, R., and Lundberg, J., from Crabtree. A., definition)

17 Appendix

The outline of this appendix is as follows:
A presentation of four real world cases are presented, it is the **Heart lung rescue case,** the **Little town case**, the **Diabetes case** and the **Giving birth case**. (Excerpts of these cases are presented in the first chapters of the thesis.) After the cases, lists of object types at SOS are presented.

17.2 Cases

These four cases selected are in the first place not selected for a specific reason they are common cases. However, they are selected from the cases collected since they are the ones described in most detail. Comparing the four cases in advance, what is specific with the HLR case is that it has an active dialog part. The LT case a not involved from the beginning operator coordinated in the case. In the D case there are no comments to make, and in the GB case, the coordination of tasks and vehicles are extensive.

17.2.1 Heart lung rescue case[15]

This case (described also in iris 26) is about an old man that probably has got a heart attack and is in need of an ambulance for treatment in hospital. The incoming call is answered by receiving operator (RO) she does the first conversation with the caller. The caller, HS, is the son of the unconscious 83-year-old man.

1[16] RO SOS 112
2 HS Yes hello, my name is Lars Persson[17]
3 RO Hello
4 HS I could need an ambulance
5 RO Yes, what is your emergency?
6 HS It is my father, he has fallen (HS exhale)
7 RO He has fallen, yes.
8 HS (inaudible) he, went to the basement, yes I heard a bump you know…
9 RO Have he fallen from the cellar stairs?
10 HS No, probably he has got a heart attack or something like that
11 RO Aha, is he awake?
12 HS No, he is unconscious.

In this first section of conversation RO are trying to state what is the caller's emergency. As this is going on, RO simultaneously categorises the case, typing in the event type for the event code, M1.23. The M is for an event with a person involved, the 1 is the priority for the case, the highest priority, meaning acute case, and event type 23 means unconscious. RO sends the position to the address over to the computerized map system, and the exact location of the house has got an X, Y coordinate position, visualized on the computerized map system. Meanwhile, the dispatching operator (DO) (physically located sitting next to RO) starts to work with the case, opening the event plan[18] for the case, searches for the most available ambulance and dispatches the ambulance X967, marking with an x in the event plan that this is made. She puts a time surveillance on the ambulance to make sure that the paramedics receives to the case. If not, the system will remind her that they haven't answered. Meanwhile RO continues the conversation, makes sure that the old man are breathing and enters his name. Checks the phone number and address (visible from the address database) and gets a narrow road description of how to get to the house. She asks for which road is the best road to take according to the son, since there are at least two different ways for the paramedics to get to the house. The close road descriptions are of vital importance since this address is situated on the country, with small roads and houses that can be hard to find. The son says that his father doesn't breathe and RO starts to

[15] This case has been found, transcribed, analyzed and translated by J. Lundberg
[16] Translation of conversation, the original conversation was in Swedish
[17] All personal identifiable information is changed, such as name and address
[18] Event plan, is the plan based on the event code that the is presented in the CoordCom system

prepare the son for a mouth-to-mouth rescue. She types the comments, fallen, doesn't breathe, HLR in the system and DO sends a mobitex[19] message to the paramedics. As ambulance X967 has acknowledged the case, DO dispatches the second ambulance for the case, X992 marking the dispatch in the event plan. At this time RO is initiating a HLR for the old man.

1 RO Can you put your ear next to, and listen if you hear him breath and look at his breathe?
2 HS No, it is bad with that…
3 RO If you now try to blow down… if you yourself take a deep breath and put your lips over his, and
4 then blow down two times…and you have to squeeze the nostrils too…
5 HS Yes
6 RO Have you squeezed the nostrils?
7 HS Yes I did that yes
8 RO … and then you do two hard in blows almost as blowing up a balloon
9 HS (silence)
10 RO Have you done that?
11 HS Yes we try (silence approx. 80 sec, you can hear that he does the mouth-to-mouth method
12 RO Yes, can you see if the chest rises now?
13 HS Yes, little he did… he has a wheezy chest
15RO It does …and… if you then, because then we have to do some conclusions[20]. Has he got
16something on, has he got a shirt or something?
17 HS Yes, he has a t-shirt
18 RO Yes, can you pull it up?
19 HS (rustle)
20 RO … and then you have to stand on your knees then, close to the chest…
21 HS Yes
22 RO put your hands on top of each other on his chest
23 HS yes
24 RO in the middle between his nipples
25 HS yes
26 RO and push powerfully down with straight arms and pull up again fifteen times in a row
27 HS yes
28 RO … and then you count, one-and-two-and-three fifteen times, one-and-two-and-three
29 HS (rustle in 30 sec)
30 RO (here you can faintly hear breathings and that RO talk with paramedics on the dispatched
31ambulances. "Could you interpret the address?" RO asks the paramedics, after the position has been
32sent)
33HS Yes
34RO Yes that is good work
35HS Yes
36RO Can you see if, is his chest raising?
37HS No
38RO So we continue, it is two blows again. First you have to make sure that you have taken a big
39breath
40HS (sound of deep inhalation)
41RO It is good, really good
42HS Now the chest has risen again
43RO Good, then it is 15 pushes again
44HS (rustle 40 sec + beeps from the phone) hold
45RO Yes, you are very good, is it hard?
46HS Yes (inaudible) phone
47RO Yes, now you have done the conclusion again and then you continue. I am with you all the time
48HS Yes, I have to put my phone down…
49RO Yes I am with you all the time
50HS (rustle, breathing, the man speaks in the room)

[19] Mobitex, data sent to the paramedics via Mobitex system, case relevant information is sent such as the position of the person in need of help
[20] Medical, meaning heart conclusions

51RO ([talking with DO][21], does 67 know where to go? … yes can you connect them? It is Sjömå halt,
52towards Tranå, a sign to the right where it is a yellow house (paramedics talk is heard in the
53background)
54HS Here comes my sister here
55RO Yes that sounds great now when there are the two of you, she can take over while you are
56resting
57HS Yes
58RO Because then you can help each other then, if one of you blow and the other pushes
59HS Yes she is a nurse
60RO They are approaching now the paramedics
61HS Yes, I can go outside…
62RO I don't think so … does she do anything now?
63HS She goes (as in she is about to give mouth-to-mouth rescue)
64RO Now you have been working so well…
65HS Go!

As RO has got the road descriptions, she starts to give the son advices on how to perform mouth-to-mouth rescue, and how to do heart- conclusions. RO asks DO to call the paramedics dispatched in the case. On row 30-32 and on row 51-53 DO is talking to the paramedics active in the case *simultaneously* as she is supporting the heart-lung rescue. Orally she gives the closer road descriptions to the team[22] in ambulance X967 and then to the second ambulance that has some difficulties in finding the way. RO continues the HLR and the daughter to the 83 year-old has arrived and assists the son in making heart-lung rescue, simultaneously one of them does the inhalation and one the heart massage. The ambulance arrives and probably takes over the rescue.

Case analysis
This case is an emergency case where the operators involved in the case has to react and respond quickly, selecting and dispatching units. AO doesn't type extra road descriptions into the system to the paramedics, sending them to the paramedics, instead she asks the DO to call the units up so she can give them the descriptions orally. Reasons for this can be that she is in the middle of giving HLR advices, making the calculation that talking with the paramedics would save more time in the effort of getting the ambulance to the old man, than typing in extra road descriptions. When having addresses on the country, which the paramedics perhaps have not been on before, the operators usually give extra road descriptions. To avoid misinterpretations, the operators usually types short, if the road descriptions are long, the typing takes time, and so does the reading and interpretation for the paramedics. Calling the paramedics also gives the operator the opportunity to ask for extra road information, perhaps being connected to the caller, getting other important information about the case.

17.2.2 Little town case[23]

This case is about a traffic accident outside a grill kiosk in Little town. Two private cars are involved in the accident. We have chosen this case since two calls are coming into the centre concerning the same case with five second between. The first answering operator AO1 are sitting at table 2, see figure 4. The other call are answered by operator two AO2 sitting at table 3. Two cases are made, but the operators only perform activities (such as the dispatch of ambulances and rescue service) in only one of them. The case is also interesting since several operators are involved in working with the case. Except for the two answering operators, two more operators are involved the ambulance dispatcher at table 11, and the operator at table 9.

We present the transcription from the call answered at table 3, which is the second call concerning the same case. We used two video cameras to capture the case, one with close focus upon operator at table 3 and one with an overview of the centre.

[21] [] brackets indicating that another conversation within the ongoing conversation are taking place
[22] Always at least two paramedics for a case, one driving and one taking care of the person in need of help
[23] This case has been found by J. Lundberg and M. Pettersson, transcribed by J. Lundberg and M.Pettersson, analyzed by J. Lundberg and M. Pettersson and translated by J. Lundberg

(AO1 takes the first call concerning the Little town case)
1 AO2: SOS112, what is your emergency? (Looks down at the keyboard, starts typing)
2Woman with foreign accent (W): Hello, I am calling from Little town; it is a car accident that has 3occurred.
4AO2. A traffic accident you said?
5W: Yes, a traffic accident.
6AO2: Have two cars collided, or?
7W: Yes two cars have collided. (AO2 looks down at his keyboard, types as if adding some
8 more text)
9AO2: Two cars have collided… does it seem to be any injuries?
10W: It seems so, because I work in a kiosk huh, and I can see some outside, I think it is two girls 11and a bit older man,
12AO2: Are they still sitting inside the car, or?
13W: This guy is sitting there.
14AO2: The guy is sitting in the car.
15W: Yes, wait I'll check through the window.
16AO2: What is the address?
17W: It is Snack bar, Safire street 1.
18AO2: Safire street 1, outside Snack bar (looks down as he says Snack bar, keyboard key sounds are 19heard as he says outside, operator sitting at table 9 (O9) rises and says, -In Little town or? and nods 20her head towards AO1 sitting on the opposite side of herself. O9 sits down after about two seconds.
21W: Yes
22AO2: (Looks at his screen)
23W: Little town.
24AO2: In Little town
25W: Yes
26AO2: Yes… all right. My colleague are sending every already, but it is two private cars? (Pushes the 27keyboard hard, leans forward, looks at the screen. O9 says aloud: -Traffic accident in Little town it 28is. AO2 turns and nods towards her. O9 starts to work with her keyboard)
29W: Yes it is this estate car.
30AO2: Yes, can you check a bit closer; my colleague has already dispatched rescue service here.
31W: Yes wait.
32AO2: Yes I'll wait in the phone. (Operator at table 11 says: - AO2 has got the case. O9 says: AO2's 33case. (AO2 turns towards O9)
34O9: You take the station there or (talks towards AO1)
35AO1: No I couldn't reach them. (AO2 looks at O9, and then it is heard that DO is dispatching 36ambulance H971)
37W: Ok, wait (conversation is heard in the background, "Hey you is it good with those people, I am 38calling the ambulance here, is it good with them (I don't know) Are they hurt?)
39Yes it is a man that is hurt, he has a bubble on his head, or, it seems so.
40AO2: Ok, it is a man that has got a knock on his head.
41W: Yes
42AO2: But he is not stuck is he?
43W: No, they are not, everyone is in the car, no one goes out.
44AO2: Ok, but they are alarmed here, so they will come as soon as possible.
45W: Ok (AO2 looks at his keyboard)
46AO2: Ok, thanks, bye. (The call is finished)
47AO2: You have taken care of the rescue service, or shall I? (AO2 turns his head towards O9, O9 48turns her head towards AO2 and says, -I have not been able to reach them until now.) (DO 49dispatches ambulance 951)

17.2.2.1 Comments on Little town case

O9 says on row 27-28, -*Traffic accident in Little town it is.* This sounds as verification, as if to tell AO1 that it is a call concerning a traffic accident. That it is the same accident that AO1 answered is commented on row 32 - *AO2 has got the case.* A third operator does this at the *same time* as two conversations with two different callers concerning the same case.
During the ethnographical studies it is sometimes seen that two or more cases are created concerning the same accident, and that the operators agree on which case they will continue to work in. in the list with *ongoing events* in the computerized system it is possible to see all cases as soon as they have been

created. In the list it is also possible to see the address for the accident, in this case: “Snack bar, Little town”.
The dispatch of ambulances is visible from row 35-36. As the ambulance dispatcher has assigned the ambulances to the case, it is visible in the performance form for the case. In this case AO2 has a computerized map, where it is seen that the mobitex is answered by the dispatched units and the units geographical position. The operator can mediate this information to the person making the emergency call.

17.2.3 Diabetes case[24]

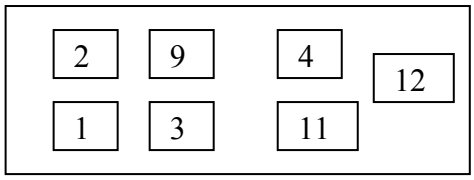

Figure 4 The operators’ physical place of terminals in the SOS centre.

This case concerns a 112 call and is answered by the operator at terminal 3 see figure 4, requesting listening-in from ambulance dispatcher on table 11. The case is interesting since the paramedics call the ambulance up before the operator receiving the initial call has ended the conversation with the caller, thus before all important information is typed into the basic form – and thereafter sends out the tasks via mobitex.

1 Answering operator (AO): SOS one one two, what’s your emergency?
2 Man calling (M): Yes we have a diabetic here that we cannot contact (AO turns, the DO to be looks
3at her screen)
4 AO: You are not at all able to wake him up?
5 M: No, it gets no contact with him. (AO sends listening-in)
6 AO: He… for how long time has you not been able to get (DO answering listening-in and turns
7towards her screen) **contact with him?**[25]
8 M: **We don’t know, we just got home from work, and found him in the bathroom now.**
9 AO: **Ok, but is he breathing?**
10 M: **Yes.**
11 AO: **He is. Ehh, what kind of number are you calling from?**
12 M: **It is a mobile.**
13 AO: **A mobile number**
14 M: **070**
15 AO: **070**
16 M: **111**
17 AO: **111**
18 M: **222**
19: AO: **222**
20: M: **333**
21: AO: **333 and what is the address?**
22: M: **It is Kings Corner 99**
23: AO: **Kings Corner** 99 in Royal town.
24(DO pushes on numbers on her keyboard, points at the screen
25 to the computerized map. AO looks down and then on
26the computerized map) ok and what is his 24name?
27: M: His name is Ingmar Västman (spells)
28And it says Västman on the door also.

DO call the Royal town ambulance up.
Paramedic (P): Yes it is 967 it is Staffan.
DO: Hi Staffan, it is Pernilla here.
P: Helloo Pernilla.
DO: You will get an emergency ride to Kings Corner 99.
P: Send it.
DO: Yes it is a patient having diabetes that most probably cannot be made conscious. He talks to them right now (turns to RO) so I don’t know anything more, but it is diabetes.
P: Send out.
DO: Yes I’ll do so, bye.
P: Bye.

[24] This case has been found and transcribed by M. Pettersson, analyzed by Lundberg and translated by J. Lundberg
[25] Fat letters to illustrate the listening-in

29AO: Yes. How old is he?
30M: He is a bit over 70.
31AO: A bit over 70… ehh, but he is laying on the floor now or?
32M: He sits on the toilet, leaning over the bathtub.
33AO: He sits on the toilet, leaning over the bathtub.
34M: I've tried to push him up, but it didn't work well.
35AO: It would be good if you laid him in semi prone position.
36M: Yes
37AO: That you lay him half on his tummy
38M: Yes, he is laying a bit like that.
39AO: He is laying a bit like that, because the most important thing now is that he has space to breathe
40, so that he can breath for himself, so that… if he is breathing good as he sits, then you could leave
41him there, just keep an eye on him.
42M: Mmm.
43AO: And the Royal town ambulance was home in Royal town so they will be with you really soon,
44but Kings Corner 99, Royal town.
45M: M.
46AO: And the street door is open down there?
47M: Yes it is
48AO: It is
49M: Yes, we look? As they are coming, it is a regular thing.
50AO: It sounds good.
51M: Mm, we say so.
52AO: Thanks, bye. (AO closes the call and answers a new emergency call)

17.2.3.1 Comments on the Diabetes case

What is interesting with this case is that the ambulance dispatcher alerts the ambulance for a dispatch before the answering operator has finished talking. According to the log straight after the man calling has stated the address (row 23). An interpretation of that is that she waits to send the mobitex to get as much information as possible, and to save time. As DO says to the paramedic "*Yes it is a patient having diabetes that most probably cannot be made conscious. He talks to them right now (turns to RO) so I don't know anything more, but it is diabetes.*" she turns towards AO and looks at him. Then DO sends the information via mobitex. What AO writes becomes visible to DO as DO answers the listening-in, and as she thighs one ambulance to the case, that is visible in the basic form for the case. The computerized map gives the information that the Royal town ambulance is available and geographically in Royal town. The fact that the paramedics have accepted the case gets visible for the operators with access to the computerized map. AO says to the man that has made the emergency call that "*And the Royal town ambulance was home in Royal town so they will be with you really soon*". Both AO and DO has access to the computerized map, and they are sitting close to each other so they can *overhear* each other's conversation. On row 32 AO is repeating what the man calling just said "*He sits on the toilet, leaning over the bathtub*." This repetitive behavior in the conversation with the caller can be interpreted as filling different functions, such as making the other operators such as the DO aware of what is happening in the case.

17.2.4 Giving birth case[26]

This case has been answered at one of the bigger centers. A pregnant woman, going two weeks over are about to give birth, her husband makes an emergency call since blood lumps are coming out. The answering operator (AO) categorizes the case as a A1.14.06, ambulance case priority one, delivery after week 20 in pregnancy, major bleeding. In this sequence, the husband wants the operator to talk to the woman giving birth (GB), most probably in an attempt to calm her. *Simultaneously* filling in the case form in the CoordCom system.

AO: SOS 112, what is your emergency?
Caller C: Yes, hi.

[26] This case has been found by J. Lundberg, transcribed by J. Lundberg, analyzed by J. Lundberg, M. Pettersson and M. Normark, and translated by J. Lundberg

AO: Hi
C: Hi, can you send and ambulance?
AO: What have happened?
C: It is a late stage in the pregnancy going over due time, the water has broken, and it is coming blood…
AO: Yes
C: It is Silveryard 6B
AO: Silveryard 6 Bertil, which floor?
C: It is second floor.
AO: Second floor
C: Yes
AO: You said that the water has broken
C: Yes, the water has broken… (he continues to talk)
AO: (she terminates his talk) Is she bleeding much?
C: What?
AO: Is she bleeding much?
C: Yes, she is bleeding much now. They sent us… it is over a week now.
AO: It is a week over,… ok. What is your wife's name?
C: It is Anna Bengtsson. (Anna Bengtsson is heard crying in the background)
AO: and her personal identification number?
C: it is… (the husband is interrupted by AO, AB is crying in the background.)
AO: Tell her to calm down, she shouldn't be upset.
C: Yes.. (calm, he says to his wife) … yes… you talk to her (asks MO to calm her)
AB: Yes hello (sounds sad)
AO: Yes hi. You shouldn't be upset for it.
AB: Big blood lumps are coming out.
AO: Is it big blood lumps?… Yes, I'll send an ambulance right now… so they will come to you.
AB: (Sobs.)
AO: … so calm down a bit now.
DO: I am in.
AO: Yes… but the baby is supposed to come out now.
AB: (Sobs) Yees.
AO: Yes, so the ambulance will come to you.
AB: Yes
AO: Mmmm
AB: Bye
AO: Bye (the conversation is closed)
DO: Was it a delivery or?
AO: Yes, and big blood lumps and water was broken, I cannot find it in this dam… there… gynaec, delivery, there was, there (marks in the comp. form)
DO: Should they go and get a midwhife or something or?
AO: Well, yes no, she didn't say anything about the baby being on the way out, but she was bleeding.
DO: Yes… you, I'll take rescue vehicle and ambulance.
AO: Yes
DO: Ok
AO: It says bleeding after… fourteen … (work with marking the case in the system)

Radio call to emergency car M994 and ambulance M942

DO: (Joddel, an invented word for the sound that is heard before they can begin talking on the radio) M942, M994. Ambulance alarm, Silveryard 6 Bertil in Landskrona and it is delivery, one week due, water is broken and big blood lumps are coming… (repeat this information)

DO: … dials them selectively 32 994…
DO: (Joddel) M994 together with M942 we have ambulance alarm, Silveryard in Landskrona and it is delivery, one week due and water has broken and blood lumps are coming (repeat this information)

Emergency car 994 answers the case via radio.
DO: M4, over
M4: Yes, 9-4 Silveryard 6 Bertil, over

DO: Yes, 6 Bertil, it is a woman going one week due, the water has now broken and blood lumps are coming from the genital area. record 3-3-4, over.
M4: Yes, it was the floor, can you take the name, over.
DO: The woman's second name is Bengtsson, over.
M4: Yes, woman, Bengtsson, got that. 994 on its way, over.
DO: Yes, this is clear, and it is Silveryard, floor 2, over.
M4: Yes, this is clear, Silveryard 6 Bertil, second floor.
DO: Yes this sounds really good, thank you, over and out.

Conversation with emergency car 994 on its way.
DO answers.

M4 Yes hi Belinda (the operators name) it is Åke 9-4
DO: Hello
M4: Will you get us a midwife from Helsingborg for us, over.
DO: I can do that if you want to, shall…
M4: Yes, my nurse anesthetic thinks so
DO: The nurse anesthetic thinks that I should get a midwife?
M4: Yes please.
DO: Yes, I will solve this, will you go and get her?
M4: No, we wont go to Helsingborg really and get her…
DO: No, well this is Helsingborg, yes, alright, I am sorry, yes we will solve this.
M4: Okay
DO: Thanks, bye.

The coordinating operator, CO contacts emergency car 994 for more information.

CO: …has the midwife…
M4: Yes 9-4, it is Åke
CO: Hi Åke it is Marie
M4: Hi.
CO: You…
M4: Yes.
CO: …where would you like to have the midwife?
M4: What do you say Bengt? (talks to the other paramedic)
CO: Do you want the midwife in Silveryard or, or do you want it in the car or… or what… what do you want?
M4: Yes we are at the address now so we'll wait, we thought that we perhaps could meet her.
CO: Yes, because in such case we would have to send her with the police from Helsingborg.
M4: Yes.
CO: If they have got something, or.
M4: We can take, we'll hold it and then we call and say if we want it.
CO: Yes, good.
M4: Yes, hi.
CO: Hi

Conversation with the police in Helsingborg
Po: The police.
Co: yes hi, it is Marie.
Po: Hi
Co: SOS Alarm
Po: Hi
Co: Do you have a patrol available, maybe?
Po: Maybeee? Well, yes, well
Co: Ehm, because we could need a midwife from Helsingborg to Landskrona fast as hell, **maybe** (maybe is said with emphasis)
Po: A midwife from Helsingborg?
Co: Yes
Po: Towards, eh Landskrona.
Co: Landskrona, but it is not certain yet.

Po: It is not, ehe.
Co: But in such case we will return in a minute or two.
Po: Then I can take someone that will be placed on the road meanwhile then…
Co: I
Po: … in case.
Co: Yees
Po: Yes, but you can return and then I've got one in case.
Co: Yes where have you got it?
Po: Yes, then I'll put him… eh… what do you want to have…
Co: No because he gets to pick up… well pick up…
Po: It will be the hospital direct.
Co: They will get… they will get directly on the hospital, yes, and then go down to Landskrona.
Po: yes, then he'll be at the hospital at the emergency entrance.
Co: Yes! Good!
Po: Hi
Co: Hi

Conversation with Jocke in ambulance M942 that is at the scene
Jocke M942: Yes it is Jocke (says something that is not audible like "and Gert") here. You, this midwife.
DO: Yes.
J: We will drive it from Lund instead, since she will go to Lund, this.
DO: Okidoki, otherwise we have a police car that stands on ehh, delivery in Helsingborg and just waits to bring one.
J: Yes, but as said this patient is treated in… or patient… mother… in…
DO: Yes, then we'll take it… then we'll take it… then we'll handle it in Lund instead, you.
J: Yes.
DO: But do you want it in Landskrona.
J: Yes you can send someone that meets… then I call on (not audible värf nis) then we'll se where we are.
DO: Yes, ok, yepp, ok, thanks, bye
J: Bye

Inform the police in Helsingborg
The police effort from Helsingborg will be annulled since the nurse will be picked up in Lund instead (the mother to be has been there during her pregnancy). Only the end of the conversation is heard.
Po: yes, he is already on his way, but then I know that.
CO: Yes, thanks, bye.
Po: bye

DO dispatches another ambulance M934 that will bring a midwife to Lund

DO: JODDEL M934, then you will go to ambulance alarm, get a midwife on the emergency, Lund, and from there you will go to Landskrona and meet ambulance M941 that is on its way down to Lund with a delivery.

CO seeks midwife in Lund instead

CO: … yes, I'll call them now…
Midwife (M): Lokring, Eva Vittfelt, midwife
CO: Yes hi, it is Marie at SOS Alarm
M: Hi
CO: We could use a midwife that fast go up to Landskrona to help an ambulance on its way down.
M: Aha, you could
CO: Yes
M: Yes, then I'll send immedia… will you come and get her?
CO: Yes, an ambulance will come and get her.
M: Yes, thank you.
CO: Thanks, bye

DO: contacts ambulance M934
M934: Yes it is Magnus
DO: Hi, you got the wrong note, did you notice
M934: No I didn't
DO: No ok
M934: In which direction are they driving
DO: They are driving from Silveryard in Landskrona down to Lund
M934: On the highway, or?
DO: Yes
M934: Ok
DO: So it is right that… eh… that they want, it was… I don't know… you will get a note here you.
M934: Yes, hi! (says hi to the midwife that they are picking up)
DO: Bye (misinterpret and thinks they says bye to her)
M934: No! I was just… the midwife, it… ehe…
DO: Yes it is really good, lets see here, dutt… dutt… Well, it was a bit strange… it, it over
M934: They are on the high way.
DO: Yes they are driving on the highway, you will meet them on the road there.
M934: Yes
DO: Yea and it is 4-2-, 9-4-2… eh… that you will meet here.
M934: Yes, do you know which sort of patient it is, is she a woman having her first baby or?
DO: I only know that she is one week over time and now the water has broken and big blood lumps are coming.
M934: What did you say, one week over…
DO: She is one week over the time and now the water has broken and big bloodlumps are coming.
M934: Yes, but you don't know if she is a woman having her first baby?
DO: No I don't, not anything, but we have both emergency car and ambulance there now, and they will go down, it is M9-4-2 and 9-4 did you get the note?

M934: yes we got the note.

DO: Really good.

M934: you, let's do like this, as you see that they have loaded…

DO: Yes

M934: … can you call us then so we can connect to them...

DO: Sure

M934: Great, good.

DO: Ok, thanks, bye

M934: Bye.

DO update M934 about the new situation

M934: Hello
DO: They have just loaded now. The emergency car is driving in front.
M934: Yes.
DO: So you'll se them first, but I'll connect you with the ambulance so you can talk, if there is information or something that you would like to have.
M934: Yes, exactly.
DO: Yes, then we'll se here (types) and he said that you will meet up at Lundåkra or something, but you, I'll connect you, here they come.
M934: Yes it is good. (connects)

Final update CO and emergency car M994

M4: 9-4 it is Åke.
CO: Hi 9-4 it is Marie.
M4: Hi.
CO: Hi, how did it go with this little baby then?

M4: It went good with the little baby.
CO: Yes, that was good to hear… it didn't … it didn't come out until
M4: I don't think it has come out yet.
CO: Well, well, then…
M4: It was quite easy
CO: Yes it was. Well, it is most that with the blob lumps and all that… you thought… I didn't really know if it was bleeding or blood lumps, or…
M4: No (other paramedic talking in the background) but it was a couple of hundred milli litres of blood that she had lost
CO: Mmm
M4: But otherwise it was quite easy.
CO: Yes, that was good to hear. Good, and it was good with the flow and all this, so there wasn't anything odd?
M4: Noe.
CO: Oh babie (sweet voice)
M4: Yeees (sweet voice)
CO: But since it is midwife and all this so…
M4: Yes, of course, it is nothing to play with that. But it was just ok.
CO: Have a good time until…
M4: Same to you
CO: Bye

17.3 Object types at SOS Alarm

Objecttype **H**1.11.23
An example is H1.11.23 where H1 means human involved, first priority, 11 means animal bite/insect bite, and 23 means unconscious. From the codes, an event plan is established, the operators mark what actions to take, and perform them.

H = Human
B = Building
P = Production
T = Traffic/Road
O = Other
A = Automatic alarm

H**1**.11.23

1 stands for highest priority; there are four priorities at the SOS centers. The first is of highest priority, acute case. The second priority is critical, and the third priority is more or less just a drive to a hospital. The fourth priority are of lowest priority and can also be considered as a drive, but could be made by a taxi or similar vehicle.

H1.11**.**23

This is an example of how priority one cases are categorized. There are corresponding lists for second priority and for other object types such as building etc.
human priority one cases.

1. Allergy
2. Difficulties to breathe
3. Children, toxicities, 0-8 years
4. Child- decease
5. Transport to/from health institution
6. Bleeding, no trauma
7. Burn, electrical injury
8. Breast pain, heart
9. Abdomen, urine
10. Diabetes
11. Animal bite, insect bite

12. Drowning accident
13. Dive accident
14. Extremity, small wounds
15. Fever
16. Poisoning, overdose
17. Delivery
18. Gynecological, pregnancies
19. Headache
20. Hypo- hypothermia
21. Chemicals, gas
22. Cramp attack
23. Unconsciousness
24. Indistinct problems
25. Accidents (trauma)
26. Spinal injuries
27. Stroke
28. Suicidal, psychiatric
29. Violence, assault
30. Eye-ear-nose-neck

The list for **priority one, building**, rescue service with life saving is as follows:

1. Extensive fire
2. Fire, smoke
3. Attic fire
4. Basement fire
5. Smoke scent, investigation
6. Explosion, risk
7. Gas discharge
8. Chemical discharge
9. Oil discharge
10. Flood
11. Avalanche zone / risk
12. Storm / risk
13. Pinned
14. Shut in
15. Bomb menace
16. Discharge other
17. Attempted suicide

25 Called automatic alarm

26 Discharge, small

There are other lists for prioritizing cases such as for production building, traffic and road cases.

ABSTRACT

The prime objective is to investigate how technology and work organization can support the workflow in handling time critical emergency calls, having the prerequisites of giving the highest priority to saving human lives and minimizing the effects of emergency situations. The challenge is to maintain and improve the quality of service (QoS) during and after a proposed technology driven organizational change. The application basis for this thesis is derived from empirical work including extensive ethnographical studies of emergency call handling at Swedish Emergency Service Centres, SOS centres. Today the SOS centres are basically organized as independent centres. The new proposed technology enabled organization with the contingency of handling emergency calls nationwide, in SOS clusters. One of the desired outcomes of this reorganization is that peaks and falls in the handling of emergency calls will be levelled out. It is assumed that any operator will be able to handle the call independent of the location of the emergency situation, opening up for a more efficient handling of incoming calls. In principle, introducing new information technologies enables this reorganization of SOS centres. However, the basic claim of our investigation is that a transition to the new organization has to take into account not only functional, but also non-functional requirements, to support a non-disruptive change.

The first of the three main results concerns essential aspects of technology based organizational changes. From the empirical work, we have concluded that the tasks constituting the workflows at SOS centers are conducted in parallel, and that the coordination of the tasks can be modeled using a risk-driven blackboard-based spiral model. We have also concluded that there is a rich face-to-face communication and body language situation within the centers supporting coordination of workflows. This coordination is context-dependent, and the means of creating awareness of the overall situation in the center, support the acquisition of important extra information in the specific case.

The second result concern methods and models to increase the quality of the requirement specification process. The principal approach is to specify assessment and divide the assessments into functional and non-functional requirements. Furthermore, issues such as how to validate empirically based workflow models, as well as how to measure groupware usability, and how to support the information sensitive change is considered. Suggestions concerning methods and models that could provide means to that end are presented.

The third result concerns identification of relevant research and development challenges coupled with new insights about combining ethnographical approaches with system modeling. Identification and suggestion of suitable experimental platform design, enabling testing of service qualities, including a suggested role for agent technologies are presented.

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