A Role-based Resource Management Approach for Emergency Organizations

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Abstract

Role-based resource management in emergency organizations' operative work focuses on allocating roles to the right persons during emergency operations. Role-based resource management is knowledge-intensive work of commanding officers, in which information systems are expected to support the processes efficiently. Based on our ethnographic field research of emergency organizations' operative work, a need for establishing a common role-based resource management approach has emerged. In this work we propose a role-based resource management approach to operative work in emergency organizations which 1) covers different phases of resource management, 2) describes their interdependencies, and 3) identifies the information needs of different phases. This approach has implications for both designing information systems and organizations' operative models. Its benefits include the ability to develop a real-time resource view, better allocation of right persons to handle the right roles, improved common practices, and understanding better the resourcing capabilities of other organizations.

1. Introduction

Managing responses to small to large scale emergency operations is the daily work of emergency organizations. Tasks can vary from mobilizing one emergency response unit in a small incident to forming task forces for crisis management operations. Effective command and control mechanisms are needed to enable managing the numerous simultaneously ongoing tasks and the resources performing the tasks. The command and control activities are greatly based on the tacit knowledge of the commanding officers [1, 2]. Even if information and communication systems would fail, the operation must go on and it will be handled the officers' experience and professionalism. This information is not available for others, as it is not documented and is based on experience.

The organizations have implemented various information and communication systems, e.g. C2 (Command and Control), PMRs (Personal Mobile Radios) and HRIS (Human Resource Information Systems), to support the activities in both command and control rooms as well as in field command units [3, 4, 5]. Nonetheless, relatively low integration of information technologies and communication technologies in the emergency management field has been issued already by Wybo & Lonka [1]. They view that emergency specialists are practitioners who manage incidents by applying codified procedures in which information, tasks to achieve, and communications to establish are well known. Wybo & Lonka have studied producing ICT experts for information system improvement with tacit knowledge of emergency management work, focusing their knowledge acquisition strategy to 1) accessing the individual knowledge on emergency cases, 2) provoking the sharing of individual knowledge between all participants, and 3) making a case from the management of an emergency. The methodology presented in [1] was initially designed to support organizational learning and sharing of experiences acquired during the management of emergencies and crises. As research in [1] focuses on overall emergency management, we specify the research to role-based resource management.

In our previous study [2] we analyzed current challenges in role management in the Finnish emergency organizations' context. As described in [2], role management refers to an organization's capability to manage in which roles each employee performs his or her job functions. In technological terms, role management refers to managing authorization and specifying the resources the users in application are allowed to access [6, 7]. The previous study showed gaps in information systems' effective utilization and integration from role management perspective in technical and operational terms.

The gaps cause challenges from several aspects. Management in operative work relies largely on tacit knowledge and intuition of commanding officers. Potential of resource capabilities is not effectively used, because tacit knowledge possessed by individuals is not accessible by others. Changes in personnel in ad-
hoca emergency situations can cause inadequate and inaccessible knowledge of the resources. Thus, using resources in optimal way is no ensured. Command and control systems do not fully support the resource view or are not fully exploiting the system capabilities for this, e.g. total number of human resources (in operative work, available, or prepared state) is not available, roles of the resources are not indicated, human or unit resource information is not described in detail or not available at all.

Essential information systems from the role management perspective within the same organization or inter-organizationally are not integrated or interoperable, for example HRIS and C2. For example, shift-planning done with HRIS systems is a separate activity from the operative information systems, although it directly affects the role management and real-time resource view as also the resource changes affect shift planning. Planning the training of resources to maintain needed capabilities and adequate responses is challenging, because operation history data and real-time data is not efficiently used for these purposes. Information systems do not effectively filter system views with needed information by management level. Often systems do not allow viewing other organizations' units, providing e.g. a task-based situation picture. There is a lack of understanding of the other organizations' workloads, response time, and delays in information exchange.

Response plans and alerting mechanisms are not currently used in an optimized way, because the resource capabilities are not effectively taken into account. Information systems do not recognize risk role combinations; which roles cannot be operated by the same person simultaneously, e.g. pose a work-safety threat or endanger objectivity. Temporary or permanent unavailability of resources is not expressed effectively. Even though according to resource status the resource is capable of performing a certain function, it is not visible that the resource may be temporarily or permanently unable to carry out this function for example due to constraints which a just finished function or operation has set. In situations when resources are tied, managing resources to function in a certain role sets challenges for task monitoring and resource optimization. For example, allocating ambulances with nursing level personnel or police patrols with a dog or with certain equipment and licenses to use those.

Roles change dynamically several times during a shift. It is not traceable in information systems and systems do not support ad-hoc context information transfer in emergency situations. Recording of actions to event log (technical or practical) is inadequate. It is not possible to trace, or at least not in accurate and exact detail, who did and what in a certain role and with what decision-making rights. At the moment, much of the actions and functions must be manually inserted afterwards based on recollection.

Successful role-based resource management is critical for efficient intra- and inter-organizational emergency handling, thus further research is needed. This work extends the research on role management by studying the different components relating to role-based resource management. The research question is: What phases does role-based resource management for emergency organizations consist of? We addressed this question by conducting multiple case studies in emergency organizations. The findings from the study can improve information system design and emergency organizations' role-based resource management.

The structure of this article is as follows: Section 2 presents the research method and settings. Section 3 presents the role-based resource management approach and discusses the benefits and challenges of the approach. Section 4 concludes the paper.

2. Research method and settings

The basis of the role-based resource management approach is grounded on studies of actual practice in order to identify how emergency organizations manage roles in operative work. For this reason case studies using ethnography were conducted in emergency organizations with a view to uncovering the reality of work within this context. Yin [8] suggests that case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence. Case study research is characterized by a search for similarities in seemingly different cases [9]. Case study enables the researcher to gain a holistic view of a certain phenomenon or series of events and can contribute to a more complete picture since many sources of evidence are used [10].

To increase the validity of our research, we have used three types of triangulation, proposed by Denzin [11] and extended methodological triangulation with [12] as follows: 1) data triangulation including time, space, and person: using several data sources, studying emergency situations in different conditions, a priori, in real-time during emergencies, and a posteriori, 2) investigator triangulation: involving two investigators in the research process, comparing the results throughout the data analysis and 3) methodological triangulation combining analytic approaches and analyzing the same data with two different methodological approaches. Use of appropriate multiple methods will result in more valid research findings.
2.1. Research environment

The research has been conducted in Finnish emergency organizations and in cooperation with the Emergency Services College. The studied organizations have been Emergency Response Centre (ERC), rescue department and emergency medical services, police department, rescue helicopter, and a university hospital. Voluntary organizations have been studied to a lesser extent. All of the organizations are participating in emergency response in situations where they have been included in the ERC response plans or their assistance is requested. Emergency organizations operate with their own resource management systems in their own command and coordination centers, but ERC handles the alerting and modifying responses and has the overall situation picture.

Our research focuses on presenting the role-based resource management approach in Finland, where effective and meaningful utilization of limited resources is crucial. The population is only around 5.4 million, unevenly distributed, with the majority located in Southern Finland. Distances are long and rural areas are large. Finding and allocating the right resources to emergencies is a challenge, as each citizen is to be ensured the same level of service depending on the situation.

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2.2. Data collection and analysis

The data gathering has been done since 2009 in all of the previously mentioned emergency organizations in the following ways. Extended periods of field observations with diaries (on-site and command and control room/information system usage and administrative processes), observations on what information is used and stored and for which purpose. The observations have been performed in actual real-world field cases and exercises in different types of emergency scenarios varying from small daily incidents to larger emergencies using recording, videotaping, and photographing. Data gathering has included reading reports and different manuals e.g. preparedness and response plans, information system manuals, development discussions templates, process guides, legislative documents and log files. Domain training, education, conferences and seminars have been participated in. One valuable information source was coffee room discussions where people were more relaxed and one can get more extensive and in-depth comparison of operations. Over a hundred half-structured theme interviews have been done by ethnography method where previous interview result can change the structure of the next interview. That way data collecting is developing to support expertise and end user point of view.

Figure 1. ERC's renewal and other changes

The timing for the study has been ideal due to Finnish authorities' renewal projects aiming at fully interoperable and integrated information systems in all emergency organizations. Emergency Response Centre information system and administrative/operative models are renewed. Simultaneously, all authorities' field command information systems are renewed and unified. Additionally, authorities establish and renew their own command and control center structures. Figure 1 presents how the number of ERCs will be reduced from 15 to 7, moving from stand alone centers to net-centric ERCs operating calls and dispatching anywhere from Finland.

Finnish ERCs operates all authorities' calls and resources in dispatching phase, thus the model is currently fundamentally different from other countries' models. The implementation of ERC system is ongoing and to be complete by 2015. Within this renewal, the ideas of the role-based resource management approach can be tested to some extent within budget and time constraints of the renewal.
categorized and put into comparable form. The combination of within-case and cross-case analysis reduces the risks of inferential errors that emerge from using either method alone. For the ethnographic method iterative interviews reflecting findings from previous ones was found suitable for analysis. The analysis was built on comparing ideas and data using validation interviews. After the analysis the findings were validated using reflective interviews with the previously mentioned organizations' key informants who have experience on the processes and technologies in their respective organizations [8, 13].

3. Results

Similarities in emergency organizations' role-based resource management work were identified in the analysis. Based on our findings, a role-based resource management approach, which has common features for organization, has formed. In this section we first introduce the relevant concepts which have emerged from this research. Then we determine the underlying ideas of the role-based resource management approach. We present the findings divided in four sectors of role-based resource management.

3.1. Relevant concepts of role-based resource management

Emergency organizations have various tasks to cope with, e.g. forest/building fire, a robbery, car accident, chemical spill, shooting. Emergency organizations perform command and control functions and mobilize emergency units to do functions in the field, for example functions in rescue services can be "extinguish fire", "smoke dive", in police "arrest", "inquire", and "patrol". Functions are performed by specific roles. The roles are occupied by identities, which have a position to assume the role e.g. officer, sub-officer, shift supervisor, fireman, and capabilities, e.g. education, license, or skill, to do function(s). Capabilities can be temporarily or permanently invalid.

Each person has an identity, which individualizes him/her. Each identity has a position in an organization. The position is comprised of several roles. A role defines what rights and responsibilities each identity has while performing functions of a specific role. Figure 2 shows, how an identity has a position, to which several roles are related to, and for which various functions are needed. Capabilities of an identity determine when functions can be performed.

3.2. Underlying context of the role-based resource management approach

In command and control rooms as well as field command role-based resource management the different organizations' commanding officers need real-time information about the resources. Figure 3 illustrates the levels of resource management in command and control rooms, field commanding, and on-scene action. Persons working in command, control and coordination need different information on role-based resource management depending on their commanding levels and responsibilities, and the phase of the emergency. These levels are studied in this research.
get one or more skills (e.g. training and certificate/license).

Previously mentioned issues affect role-based resource management with respect to role and identity of the employees. The data from roles and identities are a prerequisite, in addition to critical location information, for a commanding officer to be able to command and control the resources via role-based resource management, which tells about the identity's capabilities at different moments in time from shift planning to dynamic operative shift management.

### 3.3. The role-based resource management approach

As it was described in 3.2, what phases role-based resource management covers, we can describe these with the following structure. Based on our studies, similarities in role-based resource management can be found in each emergency organization.

**Sector 1: Shift planning phase.** Each organization has administrative person(s) working on shift planning duty. In some cases planners participate in both administrative and operative work. Shift plans are produced using the organization's resource pool. Planner(s) have overall knowledge of employees' work hours, vacations, wishes, workloads, capabilities etc. However, knowledge of personnel chemistry and knowledge of an employee as an individual is not usually adequate. For shift planning the planners use for example various HRIS, accounting and payroll systems, both home-made tailored systems and off-the-shelf products. Additionally various text and excel files are used. They focus on planning work to ensure resourcing and capabilities in accordance with response plans. Based on for example history data and knowledge of upcoming events, they know and can estimate what kind of resource strength is needed for each shift. They maintain the shift lists as they change during shift periods (e.g. three or five weeks shift planned periods). Additionally, they trace why resourcing in the list was changed.

**Sector 2: Shift execution phase.** Shift supervisors or commanding officers put the operative environment up and running based on the shift plan produced from shift planning phase. The person in charge of executing the shift is allocating the roles to the personnel with respect to the prevailing situation when the shift begins. The factors that need to be considered are e.g. number of ongoing incidents and tasks, predicted tasks, personnel chemistry, capabilities, and weather conditions. Based on the shift plan, the command and control room roles are distributed (ERC), field patrol pairs formed (police) and units' manning established (rescue/medical). While operating in shifts, which the commanding officer is not familiar with or operating larger regions/number of resources, a lot of knowledge about the persons' capabilities is lost. Allocating the proper roles to personnel is more challenging. Information systems should be able to propose to the commanding officer, based on capabilities and history data, how to cast the operative environment.

**Sector 3: Operating a shift phase.** When operating the shift begins, planned shift lists and casting of operative environment in each organization remain unchanged for different periods. This depends on the nature of the operations, e.g. constant operative work vs. alert-based work. The dynamic nature of emergencies changes resourcing as the incidents require and "task forces" to manage emergencies are formed. This takes place both in command and control rooms as well as in the field command (e.g. mobile command & control room/office). The work includes managing the shift and allocating the operative roles according to situation, optimizing the use of resources, and ensuring that incidents can be dealt with according to the organization’s response plans. For this, a real-

![Figure 4. The four sectors of the role-based resource management approach](image-url)
time situational awareness on resourcing is needed, how situations change and evolve, how resource work load and task queues are handled, is there a need to cast the field again, and ensure that different types of roles are available. Shift plans are often printed on paper and furthermore are not integrated to the command and control systems. Real-time resource follow-up is not possible and similarly, data on resourcing is not automatically stored to the information system but has to be inserted afterwards. Commanding officers should be able to maintain resource availabilities, monitor capabilities, and work load in real-time.

**Sector 4: Recruitment and training** phase. This involves administrative and human resource management work. Often in the context of emergency organizations public and governmental administration affects the processes in this phase, e.g. guiding and defining what type of personnel to recruit, how much money can be invested in training/education. In role-based resource management approach the overview and follow-up of an organization’s resource capabilities is the core knowledge in this phase. Maintaining and evolving the organization’s resource pool is done in this phase. Changes in capabilities of identities may affect the organization's possibilities to respond to emergencies in a required response. With each change in capabilities, upcoming or predictable changes, e.g. retirement or license expiration, the organization has to check whether it will still be able to provide adequate responses. This can trigger within financial possibilities a recruitment process or other needed operations, e.g. training, license renewal.

In role-based resource management the complete emergency lifespan from preparedness to recovery has to be considered. Figure 5 presents this interactivity. Moreover, in particular during the active response phases as several emergency cases are ongoing simultaneously, in the operative shift management the commanding officers perform active role-based resource management.

In role-based resource management in Sectors 2 and 4 the work is more planned and slowly paced. During response phase the operative shift management, Sector 3, is dynamic and unpredictable, best possible effort is sought. In response phase it is not always possible to achieve the right person fulfilling the role, but information systems could support in the process of finding the best possible one.

### 3.4. The benefits of the role-based resource management approach

As described in this paper, emergency situations are demanding from the role-based resource management perspective. The extraction of relevant data from a great number of different types of repositories, information systems and tacit knowledge, with more or less difficult procedures has become a part of daily work. Recognizing the possibilities of information systems to better function as role-based resource management tools both in operative work and preparedness can provide benefits in each sector of the role-based resource management approach. Knowledge acquisition, knowledge systematization, knowledge deployment, and defining organizational processes are benefits of role-based resource management approach. If the information systems would be efficiently integrated and interoperable in a way that they would support the role-based resource management in its totality, several benefits could be gained. The benefits described regarding each sector in the following are based on the research findings from our case materials that are described in data collection. The overall benefits concerning the information system design with the approach conclude the section.

**Shift planning.** Shift planner of the organization can benefit from handling the overall shift planning by using one system, which extracts personnel information from several other systems and data repositories. The system can provide employee's capabilities, absence, vacations, salary, history of handled cases, and other relevant information for a shift planner in a particular organization. Additionally, the system can provide support to shift planning by proposing base shift lists and their modifications. For example history data, such as workloads, response adequacy based on estimated loads, and types of cases handled can be used for this. The ad-hoc changes during shifts can indicate changes in short-term and long-term shift planning. Planning can be based on structured knowledge in information system rather than on tacit knowledge and scattered knowledge. The modifications and updates in shift lists, done in either the field or command and control room, use interfaces to shift planning system and also update the lists there.
with minimal delay. The system supports traceability by whom the change was made, to which, and why.

Shift execution. Commanding officers and supervisors, who begin the shift in the briefing, use the shift lists and often tacit knowledge for casting the command and control room/patrols/field units. When bigger areas or resources are operated, the officers' knowledge of individual resources becomes rather limited. If the information system, e.g. the command and control system, has integrated shift list, the commanding officers could use detailed knowledge of current capabilities and resources for allocating the roles. Last minute changes due to e.g. sick leaves or prolonged operations can cause changes in shift lists. These last minute changes can be updated in the shift list and the shift can be planned and casted according to new resourcing and capabilities. The shift planning can be contacted with in early stage to check what resources would be available in case of ad-hoc changes.

Operating a shift. Commanding officers in control room as well as in the field can use their main information system, e.g. command and control system, to view their resources and their capabilities in real-time. The printed shift lists can be more a backup for management work. Additional work of sending modified shift lists back to shift planning can be excluded. When the shift list and resource information are integrated to main system, it is possible to plan the operations and functions according to resource capabilities. As the emergency situation evolves, the officer can maintain a real-time resource view in the information system as the shift lists can be updated constantly during operations. This could be done for example by using communication means of voice/status/text and information can update either by oneself in the field or by officers in the command and control room. One example is when an officer is commanding and coordinating an emergency situation and a need for additional resources emerges. It would be possible to request to target alerting of additional task forces with needed capabilities or to plan operation accordingly to resources that an officer can get.

The information system can be used during operational shift for storing role and responsibility information. The changes in roles and changes of person handling a role can be stored. This is information can be significant for example for accident investigation boards, for after action analysis, and improving organizational processes.

Recruitment and training. The capability requirements of roles and validity periods of capabilities are determined by the organization. Common capability requirements and role-specific capability requirements are documented using HRIS systems to store requirements and related information. These can be modified accordingly when a new capability requirement emerges or old ones are removed or validity period of a capability changes. The information system can be used to monitor (automatically) the expirations and validities of capabilities and to inform about needed capability expirations, updates or losses. The system can monitor the organizational capability to respond to emergencies with needed capabilities. This phase is a crucial element of knowledge management in the organization, which can be used for planning the training according to capabilities and their expiration. Additionally recruitments can be planned based on capability requirements and estimated loss of capabilities due to e.g. retirement or expiration of temporary contracts. This enables organization's early intervention on maintaining overall capability and capacity to respond according to response plans. For example, when the shifts of command and control center are planned and they are in charge of bigger regions, it is crucial to be able to ensure adequate number of certain roles and role combinations in command and control rooms.

The information systems can provide support for work processes and benefit the after action analysis. The system design goal should be effective and optimized resource alerting, management, and utilization in emergency situations. Role-based resource management is a key element in the system and practical operative levels in emergency organizations' environment where dynamic shift and role changes occur within or between organizations and persons. Information systems can provide role-based views for the commanding officers with relevant information for management work. Integrated and interoperable system reduces data inputs and updates to different systems. Knowledge can be retrieved from fewer systems. Information needs and emergency lifespan interdependencies are identified, which enables improved resource management. Data base structures are designed to store and maintain meaningful information. Needed information exchange interfaces are defined. Information systems can provide information to support decision-making in resourcing providing proposals for field casting and finding right persons to fill roles. Both history data and real-time data can be used for this.

3.5. Challenges and limitations of the approach

The maintenance and updating process for capabilities requires modifications to not just in information systems but planning of organizational processes and responsibilities for updating the
capability information. The model requires a change to mind-set of relying on tacit knowledge and intuition and allowing instead the system to propose potential allocations and combinations of roles to support decision-making. A change of mind-set in understanding operational role management in addition to technical role management can be challenging. Information system designers' understanding of operative role management should be enhanced to reduce the gap to the views of emergency organizations' operative personnel.

It takes effort to plan role-based system views to managers, commanding officers, and employees themselves. The views need to filter who is allowed to see or modify and what parts of the capability information and to also provide needed information for command, control, and coordination work. Inter-organizational planning and possible shared resource views require also overcoming cultural and management boundaries. Costs of planning and implementation of information system applying role-based resource management approach can be notable and can require renewal of several systems. The implementation requires integration and interfacing of several information systems and turning several manual systems into computer-based information systems.

4. Conclusions

Role management in emergency organizations operative work was studied with multiple case studies in various emergency organizations. Role-based resource management is human-centric work, involving processes utilizing tacit knowledge and knowledge, which is retrieved from several information systems.

Based on the research the need for establishing a common role-based resource management approach has emerged. The research has identified and validated it to include the sectors of shift planning, shift execution, operating a shift, and recruitment and training. The approach combines different phases of resource management, defines their interdependencies, and the information usage of different phases. Focusing on totality of emergency management and managing operative work does not lead to effective role-based resource management. The role-based resource management approach has to be taken into consideration throughout the emergency lifespan and while managing simultaneously several emergencies.

Applying the approach to developing and improving operative models and information system design and implementation should be considered. The benefits cover ability to develop a real-time resource view and understanding better the resourcing capabilities of own and other organizations.

The approach supports more efficient knowledge management from operative work and information system perspective. It enables system interoperability and integration, rational information system design, real-time resource view forming and optimized resource usage. Access control mechanisms are useful in information systems, but do not fully support the actual operative role management, which also has implications on access control. The real-time resource view needs to be in the main command and control system, thus a role-based resource management approach is needed. By taking into consideration the system design implications, the approach can support in proving relevant and real-time information on role-based resource management to commanding officers where ever and whenever they need it. The provided information can be used for decision making with respect to commanding officer's judgment and management skills.

Further research goes into more detail on variables and processes which are needed while using role-based resource management.

5. References


