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COMPARISON OF EMERGENCY SCENARIOS FOR FUTURE PUBLIC SAFETY COMMUNICATIONS

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Abstract

Development of emergency response communications technologies cannot be done effectively without taking into consideration the user requirements. Therefore several international user interviews were carried out during the Wireless Deployable Network System European IST project (WIDENS). Our paper discusses the information flow and spatial distribution of different European emergency response organizations. The main result of the study that, even several similarities were found in the organizational structures and hierarchical arrangements, still every nation react and handle emergency situations somehow differently. Main difficulties of emergency communications are lie in the efficient information transmission and the interoperability problems of the systems.

Introduction

WIDENS (Wireless Deployable Network System) is a system developed by the "Information Society Technologies" group of the European Commission, intended to provide rapid set-up voice and data communication for disaster response, using ad hoc networking technologies. This network will provide support for a number of applications such as transmission of real time video, high-resolution still images and large data files. The network is targeting to meet the user requirements for a robust, mission critical network for public safety, similar to existing infrastructure based networks such as the TETRA system. The paper focuses on description of the results of public safety user studies carried out within the project, following work previously conducted through WIDENS. It presents an international perspective of three different fire fighting scenarios, and information about the strengths or limitations in present emergency management for different user groups in different countries. The main goal is the identification of information flow, spatial distribution and certain operational details within and between organizations. All of these factors can have impacts on the design of effective telecommunications technologies related to features, functionality and required information.

Literature Review and Methods

Issue of Concern

The development of telecommunications technologies for use in the sector of emergency response is advancing quickly and discussion of the needs and potential uses for the users of this technology should be considered. This is of importance both in validating and rendering practical the work of advancing technologies as well as in order to reach the goals of efficiency in emergency response, which directly translates into reduced injury, loss of property and life. Attention to the needs of users in technology is not new as can be seen in

the industrial sector, which caters to the demands of their customers, followed by in-depth marketing studies. However, in the domain of public safety technologies, which is directed by somewhat different elements including public funding and political decisions, studies of user considerations are somewhat behind the advancement of technology. Negligence of user consideration is not isolated to this domain. In the diverse domain of public safety and emergency response there is a great need for efficiency in the work that is carried out and continuous improvements in effective response. Technology may support public safety and rescue services through a number of means:

1. providing communications,
2. taking measurements of critical variables,
3. monitoring,
4. allowing access to relevant stored information(maps, medical records etc.)

Literature Review

Emergency response and public safety telecommunications is widely discussed in literature, but the user's involvement into to research process in rarely discussed. It seems that the majority of research tends to be focused only on the technological development itself. Usually the user requirements are mapped on basic level, and most of the feedback from the user's side is coming just on the testing phases. This may be from user interface discussions to the development of new features, programs or tools . Other bodies look to the integration of different information sources, so as to be accessible to the right people at the right time in order to effectively prevent emergencies, and if needed subsequently coordinate response efforts e.g. (Ilmavirta, 1995). (Pintér, 1999). A great deal of this may be addressed through the extension of modeling or monitoring programs e.g. (Heino, (1998); Anogianakis, (1998); Ikeda,(1998); Luque, (2001)). Comparatively, literature addressing the needs of users directly, or acting to understand the organizational, information flow and tactical approaches of public safety personnel in the context of application to telecommunication is not great (Zografos, 2000).

Methodology

Through the involvement of various actors in public safety and emergency response, the methods of this research held the intentions of bringing forward the voice of the users for application and use in the development of telecommunications technologies. This included participation from decision-makers and policy writers to in-field personnel. The methods included the interviews, preparation of user questioners, participation of the researcher in relevant workshops and simulated scenarios. The key issues addressed in the study are:

- identification of large-scale scenarios relevant to Europe
- identification of specific reference scenarios as seen from different organizational and national perspectives
- identification of the organizational functions, importance of cooperation between organizations and actual activities during a scenario including communication flows

Development of potential scenarios and operations of organizations was the main focus of the study. The publication presents three user case studies, each from different national perspectives.

Scenarios, Case Studies

The following three fire related scenarios act to give an understanding of the organization and arrangement of emergency responses from different national and organizational perspectives:

1. Urban fires: Finnish example in Helsinki
2. Urban fires: Danish example in Copenhagen
3. Forest fires/later potential cause of Urban fires: Southern Europe (Greece, Italy, Portugal, Spain)

Urban Fires: Finnish example in Helsinki

Urban rescue services are prepared to cope with a wide range of emergency scenarios. An emergency does not need to be very large to trigger several different organizational sectors, such as the fire brigade and medical services and police. In the situation of a large-scale fire, the fire brigade, rescue services and medical services are all involved. The fire brigade copes with the fire and manages all things concerning the fire. The rescue team is specifically trained to rescue and remove victims from the fire risk area. The medical services give first aid care and then transfer the victims to appropriate locations for additional treatment, such as hospitals.

Communication between organizations and individuals happens at the lowest level of hierarchy to coordinate activities on-site. Members of a team have their own talk group, and one leader monitors the team group as well as the groups of any additional teams. If information from another team is important, this leader will forward it to their team members. If there is a special case, for example the presence of explosives, and the teams are separated, the communication goes through higher leaders and is passed back down to the team members on-site. Radio communications are used, with pre-defined talk groups for discussion. Management of these talk groups is done from a mobile command and control center if it is necessary.

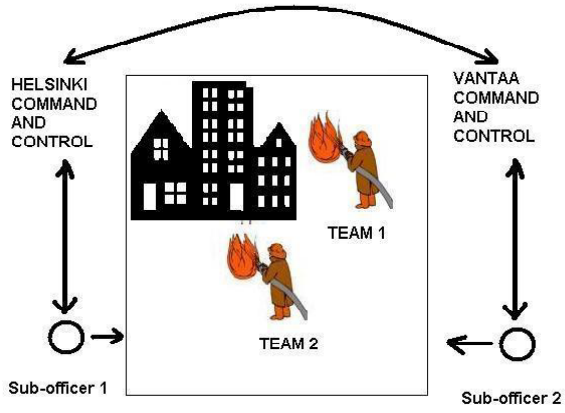

Figure 1. Urban Fire Scenario: Helsinki, Finland

When the fire has been put out and the responsibilities of the fire brigade are all met, the fire brigade will leave the scene and the police will take over management of the scenario. In this way we see that if an organizational sector isn't needed for a scenario, it is dropped out and other sectors take responsibility. All aspects of emergency management are highly pre-established at some level. Actions and decisions are often automatic and part of procedure, based on experience and careful planning.

Urban Fires: Danish example in Copenhagen

Denmark's emergency response units are well prepared for handling urban fire emergencies. Activities within and between different organizations are closely planned, including fire brigade, police and ambulance services. Cooperative agreements are existing between all of the Nordic countries. The emergency calls are usually handled by the police, but in Copenhagen, the country's largest city containing nearly one third of the total population, the fire brigade is the authority responsible for handling this calls. The advantage of this is that the fire brigade has the ability to dispatch police cars and ambulances in addition to fire trucks.

The first organization to arrive on scene is the one responsible for making the decisions for scene management and calling in additional help if needed. In the case of an urban fire generally the fire brigade is first to arrive. Fire scenarios of any size are identified by four categories, and the responsibilities of different organizations are given spatial limits within these category boundaries. The central location of the event where the fire is burning is the Red Zone. This area is absolutely controlled by the fire brigade. The area just outside of the Red Zone within which the fire brigade is operating is the Yellow Zone. This area contains the fire trucks, all equipment. Beyond is an area identified as the Green Zone. Here any necessary ambulance personnel and hospital equipment is located and operating. The police secure the boundary from access to the public. The final White Zone identifies any area outside of the scene management.

Medical assistance may be asked to enter the Yellow Zone, for example in order to remove victims who have been brought out of the Red Zone through to the Green Zone for treatment or removal to a hospital. During the scenario, one on-site mobile command post is established to maintain contact with all of the organizations present. The fire brigade coordinates its own operations within the Red Zone. The medical services coordinate their activities together with the needs of the fire brigade and the services of the hospitals. The police coordinate their own activities, and are guided by the areas of operation established by the fire brigade and medical services. Together, the organizational structure acts to efficiently and effectively cope with the emergency scenarios an urban fire might pose.

Forest Fires: Experiences in Southern Europe

In southern European countries where forest fires are a particular problem due to hot, dry summers such as Greece, Italy, Portugal and Spain, plans in place to mitigate the specific risks of forest fire smoke are limited. Forest fires are a risk not only to the timber and natural ecosystems that they engulf, but also to homes, infrastructure and human lives. In a virtual fire scenario of a large forest fire incident, the general public or police are typically the first to notice. Through citizens or the police, the fire brigade is notified. Depending on the seriousness of the fire, the first attack is made by plane if available, or by ground. Generally this takes place within the first one to two hours of identification of the fire. An area of 100km squared, could be considered typical for the fire site. Planes flying over the burn area observing the smoke plume and its movements can see smoke but are not able to judge the severity of risk the smoke poses.

Depending on the legal system of the country in question, generally the fire brigade is the organization taking charge of such a scenario. Flow of information during a scenario for control of a fire goes upwards through the ranks to the fire brigade center of operation, sometimes with involvement of the local authority such as the mayor or local prefect. The police act as “local sensors” on the ground, coping with all community related issues concerning the forest fire. Operational fire fighting decisions are made by the fire brigade, but larger decisions such as evacuation of a town are made by the Ministry of the Interior / Civil Protection. The actual evacuation is carried out by the police.

The main responsibilities of fire fighters during a forest fire are to prevent further advancement of the fire and protect property and infrastructure. By containing a fire, it is allowed to burn itself out. Containment is done by using anti-fire barriers such as lines cut into standing forest or use of fire retardant to delay the flames or growth of the fire. The wind direction determines the different orientation of these anti-fire lines. Often a multi-fractured polygon may be cut around the fire.Most European cities monitor air quality to cope with general pollution, and some indications of forest fire smoke risk may be taken from these stations. Smoke impact management is non-existent. No alert plan exists for high-risk air particle status. Most authorities do not have specific larger-scale plans for smoke inhalation risks to populations, and evacuation is based on past experiences of the decision-makers, with no real procedures in place. Considering the potential widespread and long-term impacts of

the public at large, there are strong grounds for the implementation of technology. This can be considered in terms of air quality and smoke monitoring capabilities, communicating this information to the appropriate authorities at the right time, and smoke risk planning and procedures for forest fires.

Discussion

The bulk of work in emergency response that considers standards development and discussion with users seems to come from the USA. This seems to help fill some of the void until one considers the inherent problems to be addressed in this research as identified earlier, considerations such as language barriers, incompatible technologies and accessibility, not to mention sensitive political perspectives and investments in technology. With a uniquely North American perspective, challenges may have been more standard to begin with at the very least by means of similar language and cultural approaches to emergency response. There is left a definite need to address the issues of users from a European perspective if efforts towards National, European and Global harmonization are to be optimized.

Differences and similarities of operational systems

There appears to exist some similarities and differences in the operational systems and arrangements of organizations during an emergency response Table I. This can be observed between organizations and nations, and is recognized both through the communication flow.

	Urban Fire Helsinki, Finland	**Urban Fire Copenhagen, Denmark**	**Forest fire Italy , Spain, Portugal, Greece**
Organization receiving the emergency call	Fire Brigade or Police	Fire brigade	Fire brigade
Responsible Organization	Fire brigade	Fire Brigade (but first who arrives is leading the operations)	Fire brigade
Hierarchical structure of the network	Decision-making kept on-site as much as possible –each organization coordinates themselves -inter-coordination with between group leaders	Decision-making kept on-site as much as possible – each organization coordinates themselves, and inter-coordinates with each other between group leaders	High level decision making High level coordination is needed.
Network Topology	Teams of 2-4 depending on organization/activity type	Teams of 2-4 depending on organization/activity type (smoke diver, firefighter, ambulance, etc.)	Big teams 10-1000 people
Estimation of inter users distances/area	Usually close distance tens of meters, 1-4km squared.	May be tens of meters, 1-4km squared.	Hugh distances, 1000km squared
Users mobility	Communication and movement is organization-specific, but inter-related at a lower hierarchical level.	Communication and movement is organization-specific, but inter-related at a lower hierarchical level.	Communication and movement is organization specific
Service availability vs. hierarchy/topology	Within organizations. Voice information, some GIS information; value for more accessible databases, GIS, sensors information in the future.	Within organizations. Voice information; value for accessible databases, GIS, sensors information in the future.	Voice communications, access is required for data bases, maps, Fire sensors etc.

TABLE I. DIFFERENCES AND SIMILARITIES BETWEEN THE SCENARIOS

Examining three scenarios all dealing with different aspects of fire fighting reveals a great deal of similarity between arrangements. We can see that in all three fire examples the fire brigade takes control of the scenario. This is to be expected considering their expertise in fire management. What is interesting is the fact that in all three examples, control of a scene or scenario is layered, and different layers of the scene may have different sectors in control of management. As mentioned earlier, a scenario does not need to be very large in order to involve several different organizations.

Hierarchy of Organizations

Organizations act independently with head members coordinating any cooperative efforts between them. In the Danish example, the head officer of the fire brigade determines how many medical members will enter the Yellow Zone for removal of victims. This message is given directly to the head officer of the medical team, who then arranges their personnel. In the southern European and Finnish examples, organizations similarly hold very specific roles and interaction between those roles is passed through higher personnel. Although communication between organizations is limited, that which does take place occurs through the lines of strict hierarchy. Information works its way up and then back down the chain of command from one organization to the next. That chain of command can be much longer than in the other cases, where on-site management is more likely and shortens the chain of command.

A high level of hierarchy seems to be consistent in all cases. As just indicated, this hierarchy can limit the efficiency of passing information from one organization to another. Hierarchy is important for control of a scenario and seems to be effective when fewer groups are coordinated together, the larger the scenario, the more complex communication becomes. Note that in a few cases such as the Finnish and Danish examples, decision making is kept on-site as much as possible, reducing the levels of hierarchy needed to pass through before taking actions.

Specific access to information and data can be critical in decision making. This can be seen in the case of risk from forest fire smoke. Specially designed monitoring tailored for forest fires, and distribution to the right officials can go a long way in reducing civilian and firefighter risks. In Such scenario-specific technologies can be valuable for each scenario described.

Results

It is important to understand the operations of organizations during an emergency scenario. A greater understanding of the underlying procedures, organizational and spatial arrangements of rescue services can go a long way to supporting the development of future technologies and enhancing the efforts of public safety activities. Figure 2 is a general flow-chart diagram indicating information flow in a general multigroup management scenario. Information from the scenarios demonstrated in this paper can be elaborated and built upon through future user studies in Europe. Further development of such diagrams can be done by elaboration and additional content from future studies. These, together with the case study content, serve as a valuable basis for user requirement mapping and system studies. The main focus in the case studies to get to know the organization hierarchy better and type and form of communication used inside and between the organizations, and what kind of information is required in certain emergency situations. Try to identify the strengths and limitations of the recently used systems, examine their efficiency, availability and response time. To find better technical solutions for the interoperability of the equipments used by different organizations is the key issue of the further studies.

The spatial arrangement of operations varies from scenario to scenario. Teams within organizations tend to be working spatially close together – from a matter of meters, to tens of meters. The distances between different teams of an organization will be slightly greater, and the distances between teams of different organizations can vary greatly. Two teams from different organizations may be working in close proximity, or they may be at a further distance, depending on the zones of operation of each organization. This brings us to a question in terms of the range over which equipment for telecommunications need to be able to function (Table II). These distances described for specific organizations may be much smaller, e.g. meters or tens of meters, than they might be for communication between organizations, e.g. meters to kilometers. Specifications should take into consideration the

needs, immediate or potential, for communication between all members for any given scenario.

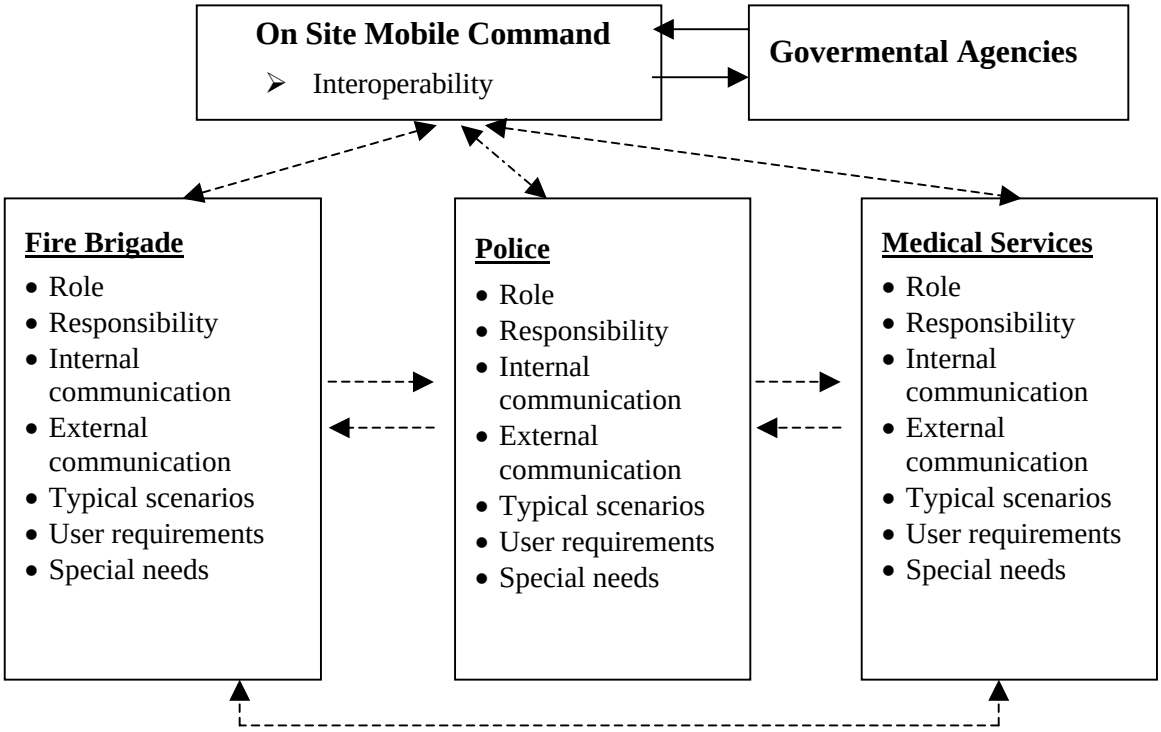

Figure 2. Multi group emergency management

Typical type of communication	**Data exchange between organizations**	
Voice and low bit (e.g. GIS)	Governmental Agencies, Public Works, and Water Management	National Police, Fire Brigade, and Medical Services Headquarters
low bit (e.g. GIS)	Municipal heads	Municipal heads
voice	Municipal heads	Team leaders
voice	Team leader/team member	Team leader/team member

TABLE II. DATA EXCHANGE BETWEEN ORGANIZATIONS

Conclusions

In Europe the public safety communication system is differ from country to country, and sometimes even from region to region or city to city within the same country. These differences can act to create barriers to successful cooperation between organizations, particularly in the event of international cooperation. Adding to the problems of variation in languages, standards for procedures or collecting and storing of available information, instruments for basic communication may quite simply be incompatible. This may further aggravate the complications of an emergency response in the case of loss of basic infrastructure.

It is clear that technology continues to advance in leaps and bounds, including within the domain of telecommunications and information systems. The problem seems to be access to

the multiple and diverse existing technologies rather than further development of new ideas, although the latter is certainly an area of keen interest and value. An additional challenge to simply making technology accessible to the users in terms of availability and affordability is the difficulty of making complex, intensely informative technologies practical to the working environment of individuals involved in emergency response. Information and access to that information needs to be understandable, readily available, and practical to use in often difficult environmental conditions such as high heat, low visibility or awkward protective clothing.

Key results revealed that similarities exist in so far as organizational roles are concerned, holding specific responsibilities in terms of location and task. Hierarchical arrangements and information flow may also be similar. However, difficulties lie in the efficient transmission of information due to slow information flow. Spatial distribution of personnel varies for scenarios, which is very relevant for the functioning of communication systems. Future European studies are recommended for the advancement of our understanding of these newly addressed issues in public safety user technologies and the needs of users in Europe, the results of which hold great value to the effective development of technology and their subsequent use in public safety.

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Adrian Boukalov received his M.S degree in radio engineering from Leningrad Electrotechnical institute (LETI) Radio System Department, St. Petersburg, Russia, in 1984. Next 5 years he spent in industry being involved in several R&D projects. Later he has been a managing director of private company that has been active in the area of software development and communications. Since 1998 he has been with Communications Laboratory of HUT. His research interests include system aspects of smart antennas, resource allocation, network planning and simulation. He is responsible for the research activity of a small group of engineers and students working in this area. In 2002 Adrian became an elected chairman of the Technical Specification Group System (TSG SYS) of the transatlantic project MESA. His management responsibilities in MESA include the co-ordination of MESA work on system concept and technology development, co-ordination of different international research initiatives related to MESA. Adrian is the WP manager in WIDENS (www.widens.org) and CELTIC project DeHiGate. Since 2005 he is Vice Chairman of OCG EMTEL /ETSI.