IMPROVING SHARED SITUATION AWARENESS IN DISTURBANCE MANAGEMENT

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ABSTRACT

Many major disturbances in the supply of electric power have taken place in Finland in last decade causing significant problems in the functioning of the modern society. In major disturbances there are multiple organizational actors like fire and rescue services, emergency response centers, police and municipalities along with distribution system operators (DSOs) and network repairers involved in the management of disturbance situations. In previous studies, lack of shared situation awareness in disturbance situations has been noticed. After the latest storms in Finland it is proposed that DSOs should be obligated to co-operate with public authorities and deliver information to them in major disturbances. In this paper, a concept of the shared situation awareness in disturbances has been presented. The paper also presents a demonstration based on the concept.

INTRODUCTION

Storms like Pyry and Janika in Finland in 2001, Gudrun in Sweden in 2005, four storms in the summer of 2010 and storms at Christmas 2011 in Finland caused widespread and long lasting disturbances in the supply of electric power. In those storms, some individual customers were without electricity for a few weeks. In January 2011 snow load on trees caused widespread disturbances in Finland. Typically, these disturbances caused problems in telecommunication, water supply, animals' conditions in farms and with the coldness of houses. The coldness of the houses has led to even some evacuations. In addition to storms that affect the rural area the hurricane Sandy caused widespread disturbance in Eastern parts of the USA in October 2012 including some cities. There were e.g. floods that caused outage to Manhattan in New York. In addition to major disturbances induced by storms and other severe weather conditions there have also been major disturbances that have not been especially long lasting but extremely wide spread, like the disturbances in the transmission systems in the USA and Canada in 2003 and in Central Europe in 2006, which have caused negative societal consequences. [1-7]

In major disturbances there are multiple actors involved, like DSOs, repairers, fire and rescue services, emergency response centres, police, municipalities and customers. All the organizational actors are obligated to maintain their capability to carry out their duties related to major disturbance. Major disturbances cause them also more duties e.g. fire and rescue services help people out from the elevators and municipalities arrange evacuations. A need to develop the information exchange between actors in major disturbances in the supply of electric power has been found in previous studies [1, 7, 9]. After the latest storms in Finland the Ministry of Employment and the Economy has proposed among other amendments that DSOs should be obligated to co-operate with other DSOs and public authorities and to deliver information to them as well as to their customers in major disturbances. [8]

This paper presents results based on research done by Tampere University of Technology and Technical Research Centre of Finland. DSOs and fire and rescue services participated in the common workshops done in the research. In this research, a major disturbance in the supply of electric power was defined as *a long lasting or widespread interruption in the supply of electric power, during which the fire and rescue services and one or more other public actor (municipality, police, etc.) need, in addition to the distribution system operator (DSO), to start implementing measures for reducing possible severe consequences to people and property.* [1]

In this research a concept of the shared situation awareness in disturbances has been created. The concept will extend the integration of Distribution Management System (DMS) in an unusual direction by taking the other actors into account. In addition to shared situation awareness, it is important that there is a possibility to use the information in network development and when training for disturbance situations. [1] The paper also presents a demonstration based on the concept. Demonstration consists of an internet service which combines information about disturbances in the electric power supply from DSOs' information systems and information from other actors. The demonstration illustrates how the exchange of information between actors could be executed by using a situation awareness system. The system helps actors to receive specific information that they need in carrying out their actions in an effective way.

SITUATION AWARENESS IN GENERAL

Three level model

Situation awareness (SA) is defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" in [9]. SA can be modelled as three levels 1) perception, 2) comprehension and 3) projection. The first level is to perceive the status, attributes and dynamics of relevant elements in the environment. Based on this information, the comprehension of the current situation

will be created. The projection about what will happen in the future is achieved through the knowledge of the status and dynamics of the elements and comprehension of the situation. [9, 10]

Shared SA

In major disturbances in the electric power supply, there are always multiple actors. All actors need to get SA from the disturbance in order to plan and carry out their actions effectively. [1] Term "shared situation awareness" comes from military. It is mostly defined as a common view of the battlefield or a common operation picture. In the case of the disturbances, the battlefield could be replaced by the word "disturbance situation". [11]

MAJOR DISTURBANCES AND SHARED SA

Present

In major disturbances, DSOs form the SA based on the information that they get from DMS, SCADA, weather services etc. Sources of the information are widely spread and the main information comes only from DSOs' own network. The information that other actors achieve from disturbance comes mainly from DSOs' public web pages and phone conversations. [1] Decision making and performance in disturbances can be improved by creating systems that enhance actor's awareness of the situation. [9, 11, 12]

SA Concept

Based on the common workshops, the concept of shared SA in disturbance situations was created. The concept is divided into disturbance management that creates the SA and into risk management that covers the network and preparedness development (Figure 1). This paper focuses on the disturbance management part of the concept.

In addition to the present ways of information exchange in disturbances this concept has a criticality information database, which contains the information of customers who are highly dependent on electricity. DSOs can use this information to network development and in the planning the order of restoring the network in disturbances. Authorities can use criticality information in order to get a picture of the disturbance situation. It helps them to carry out their own actions. The concept is based on the idea that the customer has the main responsibility of maintaining the criticality information.

DEMONSTRATION

The demonstration of the SA system has been developed based on the concept. The users of the system can be divided in different user groups depending on what information they need and based on the privacy issues. The user groups are DSOs, who will enter the information of the disturbance to the system, critical electricity users, who have sites that are critically dependent of electricity, authorities, who will observe critical sites and regular users, who are the customers of DSOs.

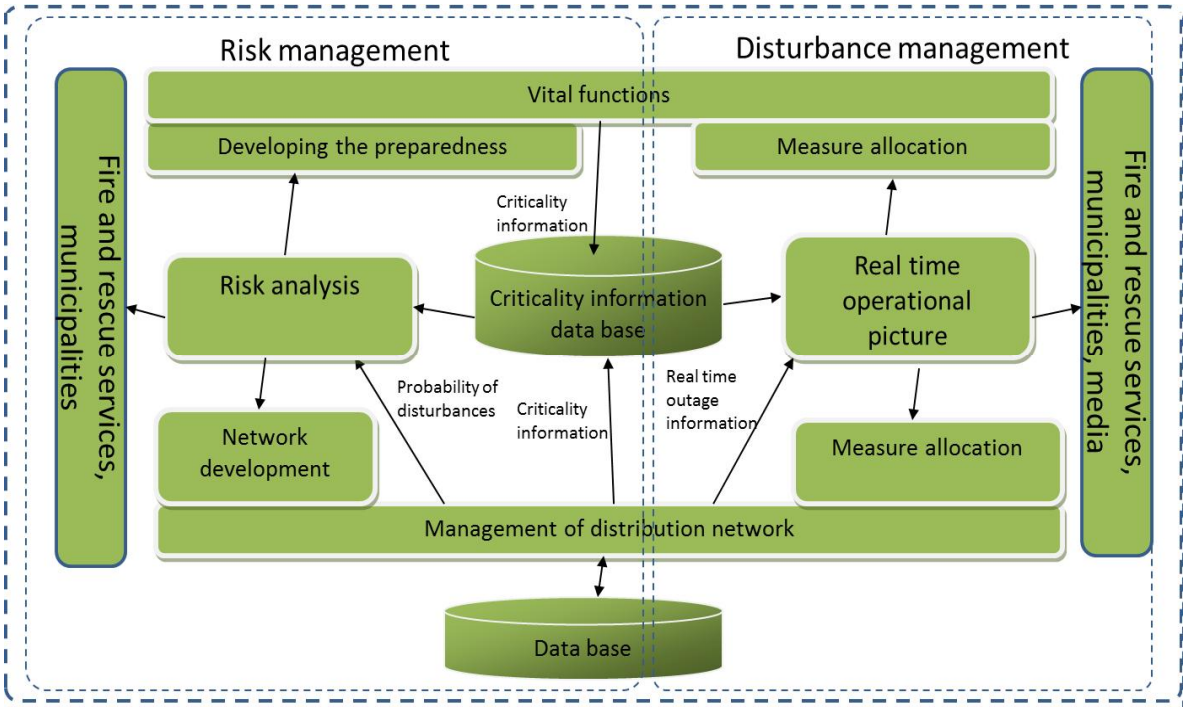

Figure 1 The concept of shared SA

There is a MySQL database that includes information about customers, their sites and dependence on electricity. The information about outages comes to the system as an XML-form (Extensible Markup Language) straight from the DMS. The demonstration uses Google Maps API, which is a programming interface, that enables creating own applications for Google's map service. The Google Maps API uses their own KML (Keyhole Markup Language) which is a file format based on the XML standard used to display geographic data. So the information about outages or any other situation can be brought to the map with XML or KML files (Figure 2).

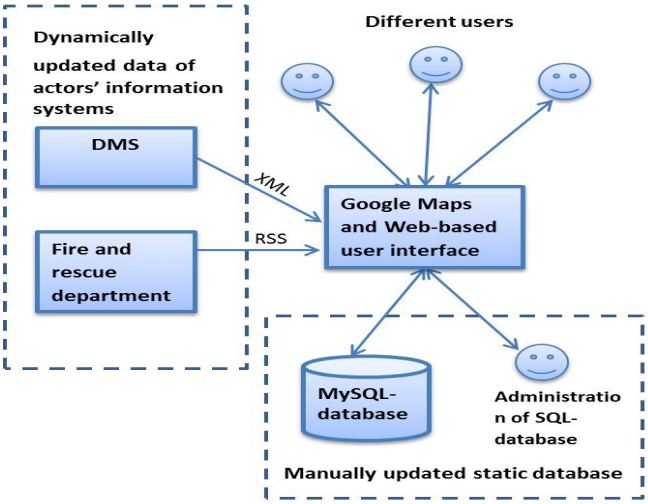

Figure 2 Sketch of the demonstration

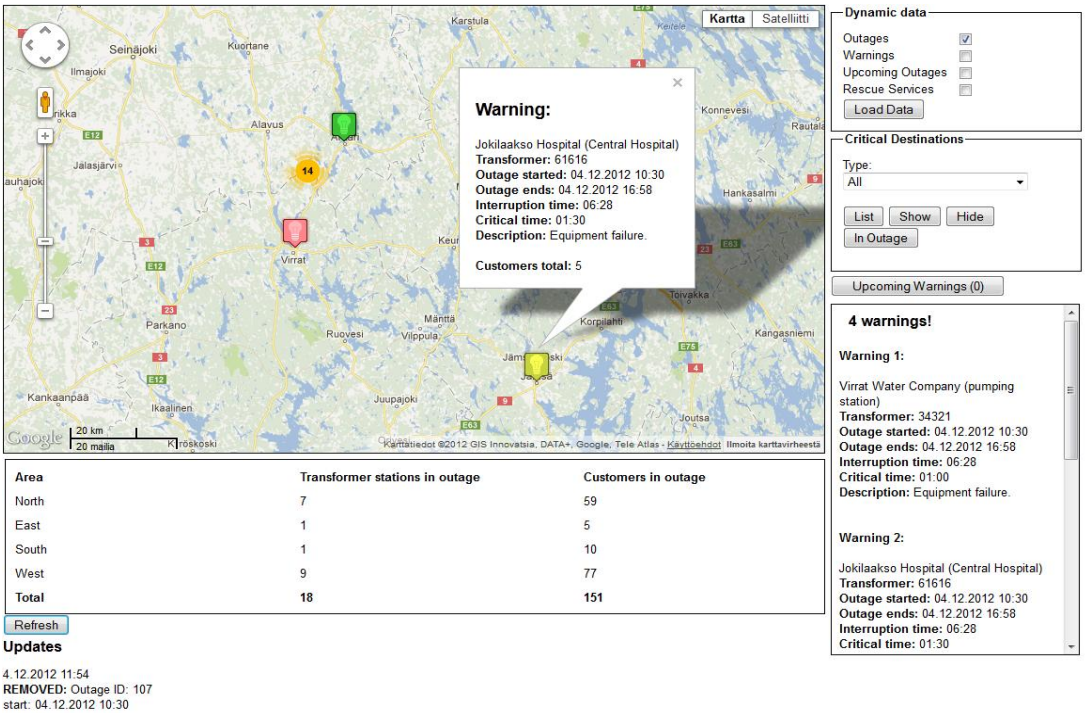

Figure 3 Demonstration of situation awareness system

The user interface is based on the web page (Figure 3). The user can enter information about his critical sites into the system and manages these later. This information goes to the database. The information about the outages comes from the DMS to the database. A combination of this information is delivered to authorities and DSOs.

In disturbance situation the authorities and DSOs can see all critical sites from the map. The critical electricity users and regular users see only own sites. From the map the users can see where the outages are, how wide spread they are and what are their estimated interruption times. The critical sites are shown in different colours depending on what is the relation of the current interruption time compared with their predefined critical interruption times. System use traffic lights colouring to that. In addition to map there is also the table that shows amounts of secondary substations and number of the customers in outages. The system also shows a list of warnings where user can see information about outage and the critical sites.

CONCLUSIONS

At the moment, the way to form the shared SA in disturbances of the electric power system is working poorly. The shared information comes from multiple sources of different actors, some public web pages, telephone connections etc. If a comprehensive picture on the situation is wanted, several information sources must be used. In a present situation of the shattered SA the management of disturbances is working ineffectively.

The way to improve shared SA in disturbance is to create a situation awareness system that would collect all the needed information to the same location. The information that the system shares can be limited to different user groups based on what information they mostly need and based on the privacy issues. Sharing the SA to the different actors is extension to the present way of thinking in the DSOs' information exchange. It will extend the present information sharing with information about the criticality of DSOs' customers to actors. Instead of the present public SA this gives specified view to those who need it.

FURTHER STUDIES

A few DSOs in Finland have started to share information from the DMS into their local fire and rescue services. It is based on the existing systems. It should be further studied how this works in practise. Developing the demonstration presented in the paper will continue by using the incremental software development methods. The participants of the workshops of the research were mainly from DSOs and fire and rescue services. Further, the representatives of the other actors like municipalities should also be interviewed.

The developed concept covers the communication between actors in disturbances and further it can be extended to cover any critical infrastructure. To develop this kind of system effectively, there should be a way to measuring the SA. However, the measuring the SA is uncommon in the field of electric power supply. Further it should be studied what method is the best to measuring the shared SA in the disturbances of power supply. After the right measurement method has been detected it can be used to develop the SA system. Further, comparing between different SA systems has to be done that the most suitable system for disturbance management would be found or developed. The developed system should be tested in a few different cases e.g. with welfare system for the elders.

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