DEMONSTRATION OF THE INTER-ORGANIZATIONAL SITUATION AWARENESS SYSTEM TO MAJOR DISTURBANCES

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ABSTRACT

There have been several problems in information exchange between organizations in the disturbances of the electricity supply. For instance, in Finland one municipality had problems to reach their local DSO (Distribution System Operator) during a disturbance in 2011. They had only the phone number of the DSO's customer service, which was congested. Usually in disturbances, municipalities and authorities receive information from DSOs' web pages, like transformer level maps or lists that show the outages and their duration, and by phone conversations. In general, it can be said that the inter-organizational situation awareness in disturbance situations is needed. After the storms in Finland in December 2011 the Finnish Electricity Market act was changed so that DSOs should participate in the formation of situation awareness and supply any information relevant to this purpose to the responsible authorities.

The paper presents a demonstration of the inter-organizational situation awareness system developed in this research. The demonstration consists of an internet service which combines information about disturbances in the electricity supply from DSOs' information systems and information from other actors. The demonstration illustrates how the exchange of information between actors can be executed by using a situation awareness system. It extends the integration of DMS (Distribution Management System) in an unusual direction by taking the other actors into account.

INTRODUCTION

There have been several problems in the information exchange between organizations in disturbances of electricity supply. Usually in disturbances, municipalities and authorities receive information from DSOs' web pages, like transformer level maps or lists that show the outages and their duration and by phone conversations. Most of the time the information is shattered and poorly processed. The problems that municipalities and fire and rescue services have in disturbances are just a tip of the iceberg. [1]

Storms like Pyry and Janika in Finland in 2001, Gudrun 2005 and Per 2006 in Sweden, four storms in the summer of 2010, storms at Christmas 2011 and two storms in the autumn of 2013 in Finland, caused widespread and long lasting disturbances of electricity supply. In those storms, some individual customers were without electricity for a few weeks. In January 2011 and January 2015 snow load on trees caused widespread and long lasting disturbances in Finland. In addition to storms that affect the rural area, the hurricane Sandy caused widespread disturbances 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. [1]-[9]

Typically, the disturbances caused problems in telecommunication, water supply, animals' conditions in farms and with the coldness in private houses. The coldness of the houses has led to even some evacuations. The problems with telecommunication effected also to safety phones and buttons. [1]-[9]

After the storms in Finland in December 2011, the Finnish Electricity Market act was changed in order to mitigate the risk of major disturbance both by reducing their probability and by improving their management. One addition to legislation was that DSOs should participate in the formation of the situation awareness and supply any information relevant to this purpose to the responsible authorities. However, the law itself does not define what relevant information actually means and how the information should be delivered. [10]

In this research, a major disturbance of electricity supply 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.* [3]

In major disturbances, there are multiple actors involved, like DSOs, contractors, fire and rescue services, emergency response centres, police, municipalities, voluntary organizations and customers. All the 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 and check if elderly people need help. [3]

In similar studies, they have noticed several problems with inter-organizational situation awareness in major disturbances in Germany. There are problems with distributed information, missing awareness about available information, policy issues of information, handling the uncertainties of information, terminology issues and perceiving interdependencies between information. The policy issues and workload issues prefer that there is no need for common awareness for every actor. Instead shared information should be individualized or localized. The same issues have been noticed also in Finland. [1]-[5],[11],[12]

This paper presents results based on research done by the Tampere University of Technology. In this research a demonstration of the situation awareness system has been developed to improve inter-organizational situation awareness. Demonstration consists of an internet service which combines information about disturbances of the electricity 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. In addition to present ways, the demonstration has a database which contains information of customers highly dependent on electricity.

PRESENT INTER-ORGANIZATIONAL SITUATION AWARENESS SYSTEMS

When the concept of the demonstration was developed in this research, there was no similar concept of an inter-organizational situation awareness system for the major disturbances of electricity supply. However, some DSOs offer information about outage on their webpage. Recently, several situation awareness systems that can be used for disturbances of electricity supply have been published. Some of them are designed only for disturbances of electricity supply and some are situation awareness systems for emergency situations. [1]

In Finland, some DSOs offer SMS (Short Message Service) service and map service in their website for the customers. Usually, these methods give information about outage's beginning time, status information and ending. SMS service informs only about outages that effect on the customers' own sites. In addition, some DSOs offer the DMS service for their local fire and rescue services. These services give the view access to the DMS for the authority in disturbances. One DSO's service bases on the system that was earlier developed for network repairers. In addition, some DSOs have mobile apps which a customer can use for sending a picture about possible fault place in network. The fault place can be located from the location information of the picture. [1], [13]-[15]

In Germany, there are also few situation awareness systems developed for disturbances of electricity supply. DSO MITNETZ STROM has developed a system which delivers information about outages to authorities. For the rescue coordination centres the system sends email, which can be integrated in to their system. Municipalities receive SMS which includes DSO's phone number. [1], [12]

The other project in Germany is Infostrom, where they have developed "Sicherheitsarena" (SiRena) system to help information exchange between different actors in disturbances. The system is based on a digital map and a resource repository. It allows adding different types of internal and external information e.g. place marks, new information resources and weather information. In addition, users have opportunity to show and hide information resources from the map. [1],[16],[17]

In Canada, the Multi-Agency Situational Awareness System (MASAS) has been developed for exchanging emergency management incident relevant information between multiple agencies and jurisdictions. It is used as the national situation awareness system for emergency management of Canada. The MASAS can be used for sharing information in disturbances of electricity supply even though it is not designed specifically for that. Users of MASAS can be representatives e.g. of municipal, provincial, territorial and federal and emergency management, police, fire and rescue services and infrastructures. The architecture of the system is hub based so that the amount of the interfaces could be minimized. [18],[19]

The main commonality between the above systems is the variety of the presentation methods. The other common thing is that the DSOs and authorities are always part of the user groups. The common for all present ways to offer the information in disturbances is that there are only a few bidirectional functions on these systems. In addition, present ways are not usually personalized to different user groups. [1]

INTEGRATION OF DISTRIBUTION MANAGEMENT SYSTEM

The integration of DSO's information systems are constantly evolving. At present, integration use mainly point to point architecture. The evolution of the electricity network towards the Smart Grid has increased the amount of the ICT (Information and Communications Technology) in the network. This makes integration too complex. The amount of data exchange between participating parties and components inside a Smart Grid ecosystem and the requirement for system openness has caused need for standardization. [20],[21]

In standards IEC 61968 and IEC 61970, the integration of DMS is defined like presented in the interface reference model in Figure 1. The model is focused mainly on the integration of the DSO's own systems and pre-defined interfaces between DMS and automation parts. However, this model does not include information exchange between different actors which have been noticed to be crucial for managing the disturbance situations. [1],[20]

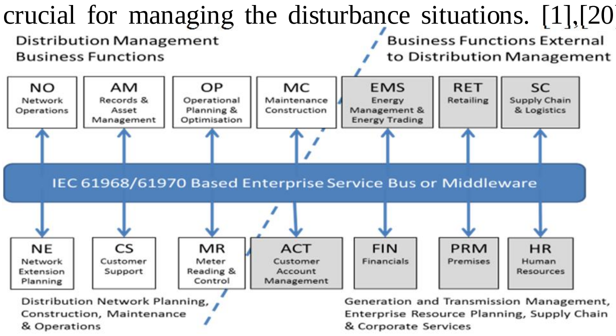

Figure 1. Interface reference model [20]

THE DEMONSTRATION OF SITUATION AWARENESS SYSTEM

The concept

The demonstration has been developed based on the cooperative workshops of the research and user need interviews. The development process has been iterative and the results of the interviews have been taken account in the development.

Two fire and rescue services and one municipality were interviewed to clarify the user needs of the system. The main results in the interviews were that the authorities need information from all DSOs which are operating in their operation area. The fire and rescue services want a simple view, where they can quickly get an overall awareness of the disturbance situation. All interviewees expect possibility to deliver information also back to DSOs. The results from the interviews were taken into account while developing the demonstration.

In the concept of the demonstration (Figure 2), all information related to the disturbance is gathered to one system. The information can be e.g. outages of electricity supply or telecommunication, weather forecasts and traffic reports. A new feature compared with the existing systems is that it is possible to bring information about outages to the demonstration from multiple DSOs and telecommunication operators.

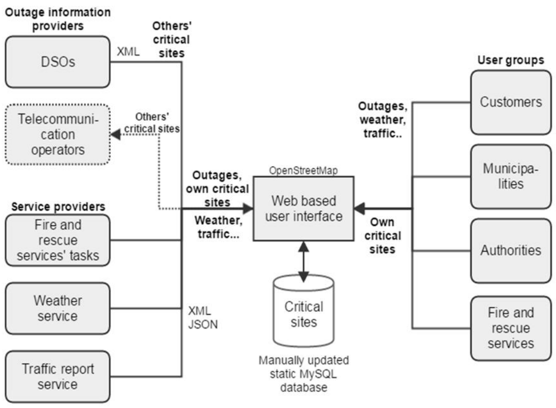

Figure 2. Structure of the demonstration

The demonstration has a web based user interface which shows outages on the map (Figure 3). It offers a personalized view to different user groups based on their needs of information. It enables user to filter information shown on map with different layers e.g. municipality can choose a layer of all citizens who are older than 70 years. OpenStreetMap is used as a base of the user interface. However, it can be easily changed to some other map service like Google Maps.

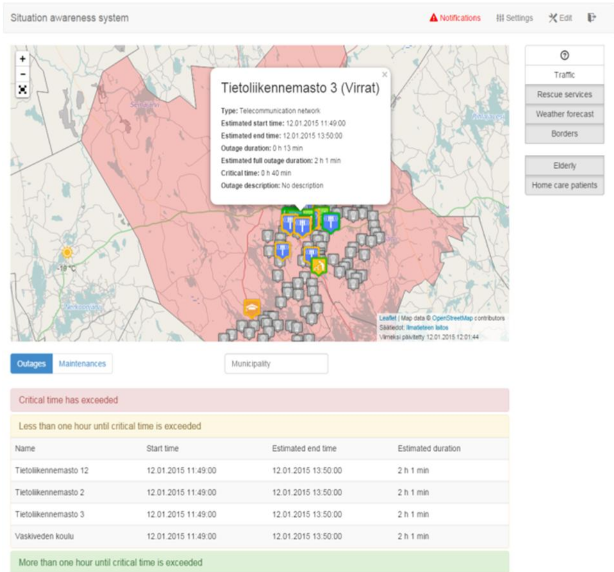

Figure 3. User interface of the demonstration

The demonstration enables the filtering of the information from the users' own operation area. The outage information from different DMSs is brought to the web service where it is combined. From the user interface, the user can observe either the whole situation or they can choose an area of one municipality (Figure 4).

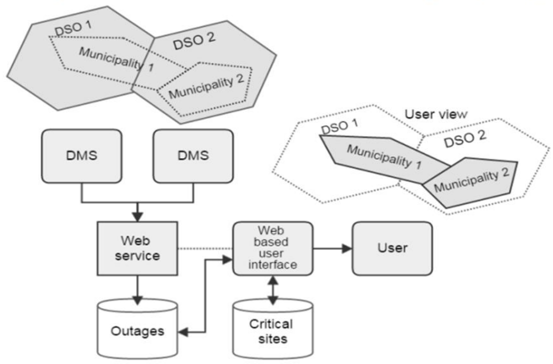

Figure 4. Filtering the user's own operating area

The demonstration brings new information compared with the present systems, by adding the so called critical sites database. Users can add their critical sites, which are highly dependent on electricity to the critical database. The authorities and DSOs can see all critical sites while critical customers can see only their own sites. In addition the demonstration enables bidirectional information exchange to actors. This enables DSOs to have an updated database of critical sites locally allowing them to direct restoring actions to critical sites.

The demonstration resembles the other systems developed in Finland. However, compared with the existing systems the demonstration enables bringing information about disturbance from several DSOs to the same system. The demonstration can also be extended to cover other emergency situations unlike most of the systems designed only for the disturbances of electricity supply. [1]

Criticality database

The main feature of the demonstration developed in this research is the criticality database. It is a MySQL database which has information about sites that are highly dependent on electricity. These sites can be for example hospitals, home care patients and critical infrastructures. The information from the database helps DSOs to decide the restoring order in major disturbances of electricity supply. The information can be used also for network planning. In addition, the other actors can use the information to help these sites.

The users maintain information about their own sites. The information is fed when the site is created in the system and it can be changed whenever wanted. The criticality database includes information about how long the critical site will manage without electricity so that there will not be any severe consequences to people or property. The seriousness of the consequences if the critical time is exceeded is also found from the database. If the critical site has a backup power generator, it has been taken into account when deciding the critical time. In addition, critical sites are grouped by their type.

The information from the critical database is used to present the critical sites on the map interface with different symbols by their type. The size of the symbol is dependent of the given consequences. The critical time is presented by frames that have traffic light colouring. Frames are always green if there is at least one hour left to critical time exceed. When there is one hour or less, the frame is yellow. After the critical time has exceeded the frame turns to red. The colouring system will help the user to notice those sites that need electricity or evacuation mostly.

Technical Execution of the Demonstration

The execution of the demonstration bases on the existing systems and methods, which DSOs use with their web pages and SMS services. The demonstration uses two types of outage information that DMS generates. Transformer level information is generated every time a change of state happens in the network. When a change occurs, the DMS generates an XML (Extensible Markup Language) file with information about the entire network. A proxy application watches changes in the file and sends the outage information to the situation awareness system every time the file changes. The outage information can be sent using multiple protocols. The outage data upload can be done using any of the commonly used data transfer protocols such as FTP (File Transfer Protocol) and HTTP (HyperText Transfer Protocol). A local file copy can be performed if the system and the DMS are running on the same server. The generated XML file format can be seen in Figure 5.

```
<outage ID="1" type="fault" start="14.05.2014 07:15" end="14.05.2014 15:31" desc="Equipment failure.">
    <station code="1" lat="00.000000" lng="00.0000000" area="North" customers="15"/>
</outage>
```

Figure 5. The generated XML outage information file format

The XML file contains information about each outage on the network (start time, end time, type and description) and about each transformer station in the outage. The station attribute area is an area defined in the DMS. The data is generic and customers can only be identified if the customer transformer code is known. The data format may slightly change between DMSs from different vendors. In such case, the proxy application parses the file and creates a file using a unified format.

The DMS also generates outage information in level of customer identification number. This data is normally used for sending SMS messages to clients in outage areas. Each outage information message has information about the outage (such as certainty, state and reason) and a list of customers the outage affects. The DMS implements a SOAP (Simple Object Access Protocol) client that connects to the proxy application implementing SOAP server interface. The DMS sends data to proxy application whenever a change in outage state occurs. The data is parsed and forwarded to the situation awareness system using HTTPS-protocol (HyperText Transfer Protocol Secure). The outage information is then saved into a database. The transformer level and customer level outage information is used to identify critical customers by either transformer code or customer number.

While it is important for municipalities and fire and rescue services to be aware of where the critical customers are it is also important for the DSOs to know where the critical sites are. This is why an interface for getting the critical site information from the system is implemented. Using this interface a DSO can keep information about customers' criticality updated without having to commit many resources to it. The interface is a simple HTTPS API that requires HTTP Basic authentication. DSOs can use this API to list all critical sites added by other users. In addition, the list can be filtered e.g. to list sites which are added since a defined time.

CONCLUSION

Lack of information exchange in the major disturbances of electricity supply has been noticed in many researches. The interface reference model of DMS, presented in standards IEC 61968 and IEC 61970, is inadequate in disturbances, because it is focused mainly on the integration of the DSOs' own systems and it does not enable information exchange between multiple actors.

Some inter-organizational situation awareness systems have been developed in recently to the emergency and the disturbance of electricity supply situations. The demonstration presented in this research resembles the other systems that have been developed. The main difference to the present systems is that, the demonstration presented here brings criticality information to DSO and other actors.

The results of the user needs interviews done in this research were that authorities need awareness of the disturbance situation from their own operating area and they need more bidirectional information exchange.

Usually it means that the information from multiple DSOs has to be combined. The demonstration presented in this paper is developed to fulfil these needs.

FURTHER STUDIES

The developed concept covers the communication between actors in disturbances of electricity supply and further it will be extended to cover disturbances of telecommunications. This combination of information from both networks disturbances can be utilized in maintaining the reliability of both networks and in planning them.

In future, the developed system should be tested in a few different cases e.g. with the social care of the municipality and DSO could be users for the system. Testing could be arranged as a part of emergency drill or disturbance exercise.

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