USING A GIS PLATFORM FOR DESIGN AND ANALYSIS OF EMERGENCY RESPONSE OPERATIONS[1]

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ABSTRACT

Analytical models for optimization of emergency response operations in electric utilities study the effect of district designing and dispatching policies of the emergency repair units on the duration of the service interruption. A Geographic Information System (GIS) allows the efficient presentation of the analytical results and gives the capability to the end user to modify the assigned districts and evaluate variations to the proposed solutions. An off-the-shelf PC-based GIS system is used in our study. Different layers of the GIS allow for presentation of more or less detailed maps of the area depending on the decision to be evaluated. Trouble calls (tickets) carrying type, priority, and time information from available databases are overlayed on the map. Experience with the system has shown that it is user friendly, easily acceptable by the electric utility personnel and preferable to the computer outputs of the districting models.

INTRODUCTION

The continuous and uninterrupted supply of electricity is a very important criterion measuring the quality of services offered by an electric utility company. Usually, the quality of services is expressed by the Mean Number of Annual Down Hours (MNADH) per customer. Service unavailability has an adverse impact on the consumers and reflects negatively on the reliability performance of a given electric utility company.

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The electricity availability can be increased by improving the design, the maintenance, and the restoration time of system failures.

This work focuses on the analysis and optimization of system reliability through the optimization of emergency response operations though the use of a GIS platform as an assistant to analytical models that have been previously developed[1].

DESCRIPTION OF THE SYSTEM

Definition of the problem

The demand for emergency repair services is created from incidents causing power interruptions. These incidents occur randomly in time and space. When a power interruption occurs one or more customers call a service center to report service unavailability. Based on the customers' calls a work order (ticket) is created by a computerized system, called in this particular application Trouble Call Management System (TCMS). This ticket is assigned to an emergency repair truck (ERT) for further investigation and repair. The ERTs are mobile servers and at the time of dispatch can be located anywhere within a designated repair district. The service area is divided into contiguous areas called districts which are further subdivided into truck areas. Trouble tickets carry priority, type and shift information. There are four priorities into the current system. A certain type of equipment failure may be of different priority depending on the severity of the failure. Tickets of higher priority are dispatched first. Dispatching of tickets in the same priority may follow First Come First Serve or Nearest Neighbor dispatching policy or a combination of the two.

Available data for the analysis of the problem need to be collected and carefully evaluated. The data must provide complete information on the operations. The number and type of tickets issued, the time it took for the corresponding response of the ticket, the geographical representation of the area and the distribution of the available equipment need to be documented. Once data are collected their quality must be evaluated and data that are corrupted should be excluded. This exclusion should be done very carefully since oftentimes large values of some parameters are the result of the peculiarities of some response situations and not a data entry error. The record of each trouble ticket had information about the date, day and time of that the ticket was created by TCMS. Every record also had information about the area that the ticket was located as well as the actual address of the incident. In addition the record had information about the location of the incident based on a proprietary grid system of the utility company. It also had the number of the truck that responded to call and codes about the shift and the type of the incident. Finally, each record had four time components, each one representing the time that needed for the ticket to be created by TCMS (T_0), the time that was needed for the ticket to be assigned to a troubleman (T_1), the time that the troubleman needed in order to arrive to the incident location (T_2), and finally the time required for fixing the problem (T_3).

In our previous work we have focussed on studying the effect of redistricting and ERT deployment policies on the reduction of the dispatching time T_1 and travel time T_2, since the repair and ticket assignment time depend on technical characteristics of the system and should be evaluated in a different way [1].

In this work, the results of the districting and dispatching are made available to managers of emergency response operations through a GIS platform. This gives the opportunity to the managers to evaluate alternative scenarios, get appropriate statistical data and manipulate the results of the districting patterns to allow for districts that take into account peculiarities of the transportation network, the geography of the area and the corporate organizational structure in divisions other than the emergency response operations. Mahoney, R.P.[2] in his work "GIS and Utilities" gives a detail account of the advantages that GIS technology offers to utility companies in general and electric utilities in particular.

Geographic Information System Platform

The system consists of a software part and a data. The software part of the system has the following three components: i) Mapinfo™ for DOS, ii) TRALAINE™ and iii) programs that manage the integration of the various pieces. Mapinfo™ for DOS provides the geographic information system, and TRALAINE™ provides a system for conversion of the geographic coordinates from one system to another. The programs written in QuickBasic provide the conversion of the data from the proprietary system that the utility company used to a systemthat would allow TRALAINE™ to provide the conversion.

The second part of the information system is the data part. We integrated data from three different sources, i) map data for the required areas purchased from the U.S. Census Bureau(TIGER files), ii) data of the trouble tickets provided by the utility company, and iii) data created by the districting application. QuickBasic programs were required in order to transform the TIGER files to the format required by Mapinfo™[3], and also for conversion of the output of TRALAINE™[4] to the required format by Mapinfo™.

CAPABILITIES OF THE SYSTEM

The system capabilities can be divided in spatial analysis, and statistical analysis capabilities.

Spatial analysis capabilities.
The spatial analysis capability is a feature the utility company was not able to have before. By providing a visualization of the exact location of each trouble ticket, figure 1, the analysts of the company could identify patterns of trouble tickets and then try to explain the reason of such patterns.

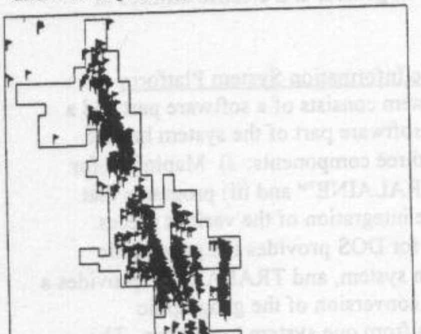

Figure 1: Tickets of all types

Especially the identification of the type of a trouble ticket could provide information about aging or faulty equipment which created frequent trouble tickets. Furthermore, reports generated by the system can include only part of the trouble ticket database based on criteria set up by the analyst using the system, figure 2 displays only transformer tickets.

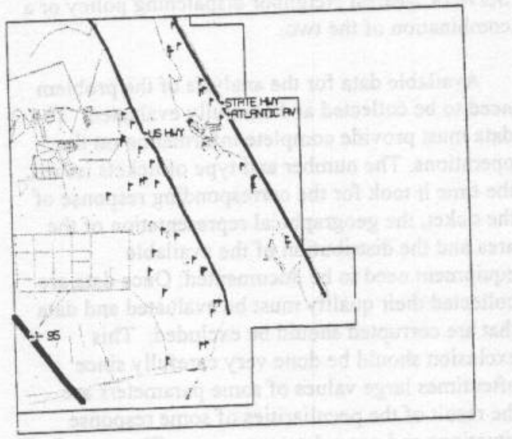

Figure 2: Transformer tickets (detail of the area)

Statistical analysis capabilities.
Improved visualization has helped the utility personell in their statistical analysis requirements. The various kinds of statisticalanalysis are: i) distribution of time for dispatch, arrival, and repair, and ii) number of tickets per area.

These two kinds of statistical analysis are very important because one of the concerns of the company is that all the trouble areas are balanced in the number of tickets as well as in area covered.

Dispatch time distribution This piece of information is important, because the identifiable problem in the company was a bottleneck at the dispatch area. Provided that there are four dispatchers and each one is responsible for a couple of trouble areas a distribution of the dispatch time could provide insight into the problems of dispatching(figure 3).

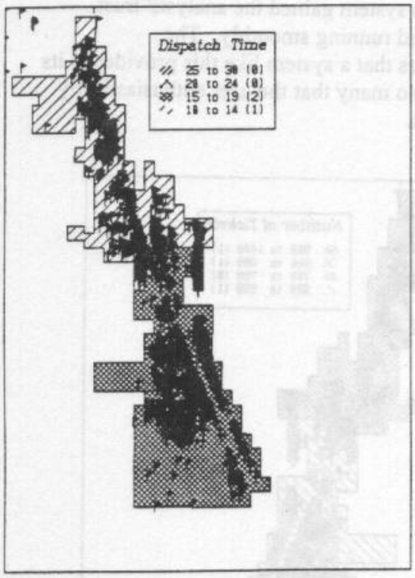

Figure 3: Dispatch time distribution

<u>Traveling time distribution</u> This information is important in order to verify that all areas are balanced in terms of time needed to arrive at the location of the trouble(figure 4). The company may set up its own time distribution classes and see how the proposed areas fit in them. Also based on the information of the shift, or other specific time periods, e.g. morning or afternoon rush hours, the analyst could see how the time distribution changes in a trouble-area, or in other specific zone, e.g. downtown compared to suburbs.

<u>Repair time distribution</u> This piece of information provides insight in terms of each individual troubleman. The analyst could identify differences in the time distribution between troublemen for a specific type of trouble, as well as the trouble tickets as a group(figure 5). Such information is important for identifying the stars among the troublemen in order to appreciate their effort as well as identifying troublemen needing retraining.

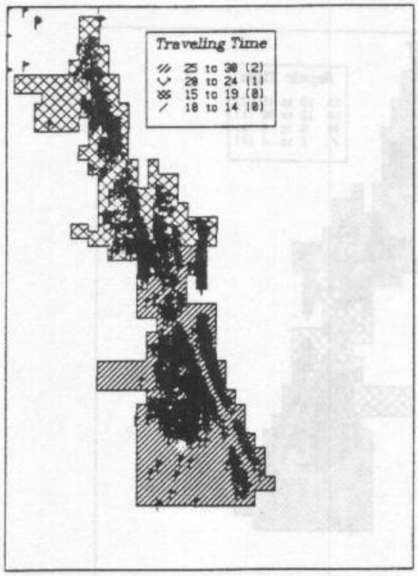

Figure 4: Traveling time distribution

<u>Number of tickets per area.</u> As mentioned earlier, part of the company's policy is to have balanced trouble-areas in terms of number of tickets or otherwise specified as workload. The distribution provided by this analysis would show the areas that are in different classes in the number of tickets as a whole(figure 6), or in the number of specific type of tickets. Combining this information with the information provided by the spatial analysis provides information about the areas that the troublemen work.

Another type of analysis that this system is particularly significant is the what-if analysis. The analysts of the company have the ability to change the shape of a trouble area and make it smaller or bigger and then perform the same type of analysis discussed earlier and compare the results. This is especially important for decision of reshaping the trouble areas in different time periods, e.g. late night to early morning shift, or in cases of special emergencies such as hurricanes etc.

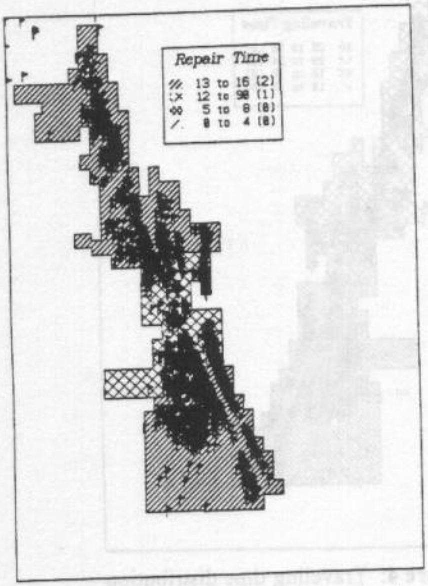

Figure 5: Repair time distribution

USER ACCEPTANCE.

The acceptance by the users was a major concern in the design of this application. For this reason the end-users were involved in this project from the beginning. Since the nature of the application was not job threatening for the end users of the application, but it was more a tool for the analysts in order to perform their task better and faster, their support was continuous and their interest was expressed by their active involvement in the development of this system.

The only problem that we faced was the unfamiliarity of the analysts with a system like that as well as the number of components of the systemthat the users had to learn. However, after a series of intensive training and as soon as the information system gained the analysts' trust things started running smoothly. The opportunities that a system like this provides to its users were so many that the user enthusiastically embraced it.

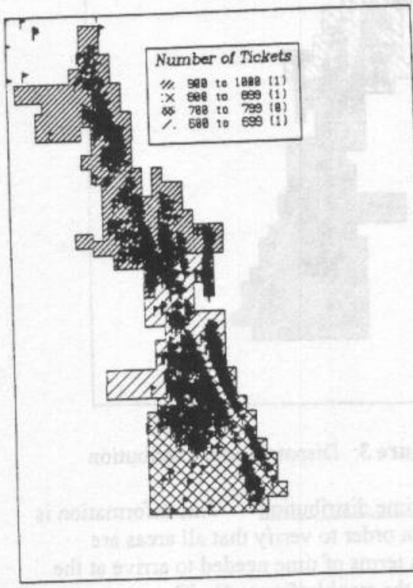

Figure 6: Ticket distribution across the area

CONCLUSIONS AND EXTENSIONS

The current information system has only the street network of the area under study. As was mentioned earlier problems in the distribution network of the utility could be easily identified by spatial analysis. However, after certain types of problems have been identified the analysts should look at the database with the information about the distribution network. The integration of this network in the geographic information system will be something that should naturally follow an endeavor like this one. Problems of information overload of the computer system should be minimal since the available technology provides for fast processors as well as hard drives with great capacity and very small access time.

Another area where this system may be enhanced is that for the moment the system is fed with off-the-line and after the fact information. An integration of such a system in the emergency response system of the company as well as the incorporation of Automated Vehicle Location (AVL) technology will improve the operation of the system greatly as suggested by K.G.Zografos and C.Douligeris in [5]

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Finally one of the advantages of this system is that it allowed the users from the company to become familiar with a technology that may be proven very helpful in cases of disasters. The ability of the system to run under DOS and the availability of notebook personal computers with great capabilities allows for the system to be portable. Therefore, such a system could be used from people out in the fieldwhen the occasions of a disaster require so.

From our discussion we can conclude that an integrated geographic information system enhances the operation of a company by offering a great number of advantages. Such advantages are ability of spatial analysis, statistical analysis, and what-if analysis. Most of these kinds of analysis were not possible with any other system and provide a great advantage to the company.

References

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