COMPUTATIONAL SYSTEM FOR OUTAGE CAUSES IDENTIFICATION AND ANALYSIS FOR ASSESSMENT OF DISTRIBUTION SYSTEMS RELIABILITY INDEX

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ABSTRACT

Nowadays, customer satisfaction and performance of electric power companies are constantly supervised by regulatory agencies, which establish reliability levels for each utility. This has increased the requirements to monitor the levels of customer service and system reliability in order to provide a consistent assessment. An important information for the effectiveness of this service is the identification and analysis of forced outage events This paper describes a mobile information system based on a handheld application for collecting and validation distribution equipment conditions and surrounding environment information at local of a forced outage event. This system was developed using Object Oriented Modeling (OOM) and Java Language. This is part of a system that is used to collect, identify and analyze forced outage causes. The system can be used to forecasting, using statistic and probabilistic process, potential or critical area subject on specific events.

INTRODUCTION

Recent changes in the electrical industry and the unbundling of vertically integrated utilities into separate financial and operating utilities have increasing concerns about reliability, continuity and quality services. Customer satisfaction is becoming an increasingly important factor in the new regulatory environment. In order to improve the customer satisfaction and their electricity supply it is very important collect and classify outage causes in the correct way. Reliability worth and continuity index assessment are important factors in distribution system planning and operation. The reliability of service and performance analysis of the system have been studied for a long time and there are several books, e.g. [1] [2], and technical papers such as [3][4][5][6][7][8] which present different levels of activity and applications related with performance, effects of supply interruption, reliability worth assessment and quality of energy supply. Basically, the assessment of reliability uses two main steps: measuring past and predicting future performance [3]. Both applications use a complex data collection with several information collected at the local of event. The degree and complexity of this data collection system are entirely dependent upon the method and technique used to collect and validate the forced outage events. Reference [3] presents some applications for a collecting system and equipment performance data, such as: provide data for a comparison of electrical system performance and a basis for individual companies to establish service continuity criteria; provide data for analysis to determine reliability of service in a given area and reliability history of individual circuits; determine how factors such as design differences, environment or maintenance methods and operating practices affect performance and provide equipment performance data necessary for a probabilistic approach to reliability studies. A critical step for statistic processing and probabilistic analysis is the correct identification of forced outage causes, since this provide a classification of interruptions by cause which is very important in recognizing weak points in the system and also to provide data for a continuity index analysis. This paper presents a mobile information system based on a handheld application for collecting and validation of distribution equipment conditions and surrounding environments information at local of a forced outage event. This application is part of a system which is under developing and will be used to collect, identify and analyze forced outage causes in order to provide information for support improvements in maintenance, operational and design practices, as well as provide data for analysis to determine the reliability of service in a given area and service continuity levels. The system can be divide in three modules: the first module consist of collecting, validation and transmission of the information to the system operation center; the second is a software that store the field data and make statistic analysis through graphics and reports of the outages causes and events. The last one shows the part of the system, which has more probability of occurrence of specific outage cause. This is a very important issue for prediction maintenance. In this paper is presented the first part of the system, which is called SADENP - *Sistema de Aquisição de Dados de Eventos Não Programados* in Portuguese and means in English*: Forced Outage Event Data Collection System*. This system will be used in an Electrical Distribution Utility of South Brazil to improve the service quality and to create a reliable historical database about forced-outage causes. Using this database the distribution utility could adopt a better maintenance policy and investment allocation.

THE CHARACTERISTICS OF COMPUTATIONAL SYSTEM

Mobile Computing

Mobile computing is used in many industries and service companies to provide an easy way for collecting and distributing information and is rapidly becoming a major growth area in many fields of information technological industry. It is natural that this technology should be incorporated in electrical companies for increase the speed, availability, security and quality of information data. In this

paper a mobile information system based on a handheld application is used to collect and validate data of forced outage events.

Object Oriented Programming Overview

Object Oriented Programming is a software programming technique based on a modeling method called Object Oriented Modeling (OOM) which treats the world as a set of objects that interact and interchange information [9]. Each object has a group of properties (called Attributes) that defines the object state and a group of functions (called Methods) that defines what operations the object makes other objects or in its self. Objects, with the same set of Attributes and Methods, are grouped in classes. A class is a data structure (a user-defined type) that contains the object definition. An object is a class instance (a variable declaration from a class) and is a computational representation of a real or abstract entity. An object oriented programming language is used to developing the handheld based application in this project [9][10].

Java Programming Language

Several factors should be considered to choose the technologies and methodologies that will be used in an application development software project. The cost, reliability, reutilization, wide free documentation and portability are some of these factors. Since the mobile computer industry provide more powerful and new devices every day, it is necessary that the programming language used in this project could be easily portable to another system. Java™ programming language meets all this necessities and for that reason is used is this project [10].

DESCRIPTION OF THE SYSTEM

The Handheld Application

Up to now, the distribution equipment conditions and other variables in the event site were collected without any methodology and the electrician needs to identify the cause of the forced outage event, write a paper report and send it to the operational center. The problem remains on the fact that the electrician has the propensity to indicate a symptom, a sign as a cause of the event. For instance, a car crashes into a power pole; following a short circuit and then the protection opens the feeder. The electrician probably will indicate the short circuit as the event cause. However, this not the main reason. In fact, this event is a consequence of a chain of events, and the primary cause is the car crash. The proposal application intends to eliminate the electrician necessity to identify the cause. This application is an implementation of a formal close questionnaire as handheld software. This questionnaire was developed with the utility engineers assistance. All the questions were created based on the engineers experiences covering almost all the possibilities of equipment conditions and surrounding environment variables usually found by the electrical company electricians in the local of the event. In this application the electricians only needs choose the most appropriate alternative and answer questions like "Yes" or "No". This methodology avoids logical errors and ambiguous answers by the electrician. The questionnaire structure is described in Figure 1.

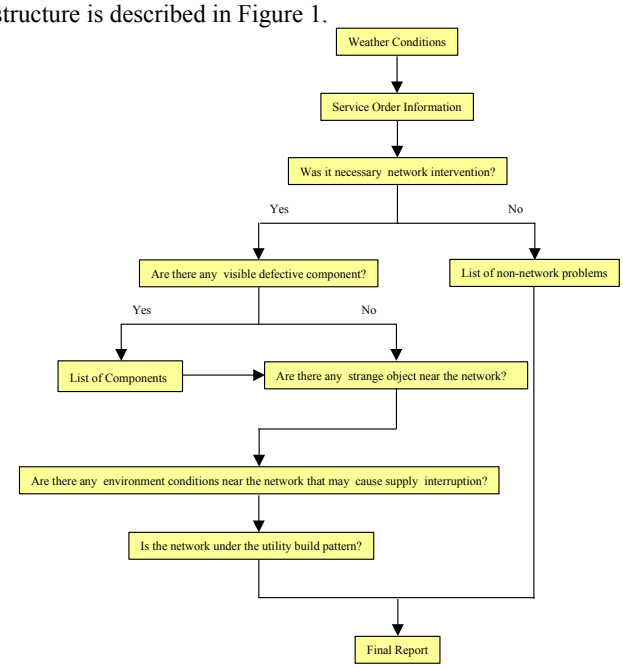

Figure 1. Questionnaire structure

In the questionnaire (showed in Figure 1) the electrician just need to choose the most suitable alternative about the distribution equipment conditions and surrounding environment variables like weather condition, human factor, and others. Consequently, the data quality provided by this methodology is appropriate to feeder a database in order to provide performance statistics index and allow interruption assessment. The conceptual design of the system is shown in Figure 2.

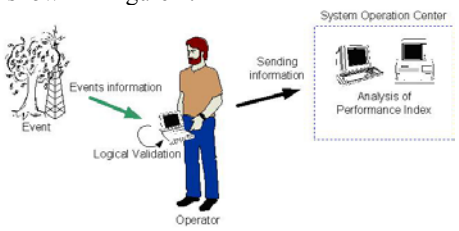

Figure 2. Conceptual design of the system.

The first question is about weather conditions. This question is not direct related to the forced outage event cause, it is just a complementary information to the electrical utility. Every time the electrician starts a new data collection he must indicate it. The forced outage event weather conditions, in the probably real moment that it happened, will be indicated by a external source based on the call center reported time. This information is supported by the question depicts in Figure 3.

Figure 3. The weather condition question

After this question screen is shown the service order question screen, Figure 4, where the electrician must fill the service order number provide by the call center.

Figure 4. Service order.

The question *list of components* shown in the questionnaire structure (Figure 1) cover the following main components:

- Capacitor Bank
- Load Break Switch
- Open Fuse Cutout
- Load interrupter switch
- Cable
- Connection
- Crosslet
- Fuse Link
- Connection
- Stay
- Metal Structure
- Public Illumination
- Electric Meter
- Muffle
- Lightning arrester
- Pole
- Primary Lateral
- Voltage Regulator
- Recloser
- Automatic Line Sectionalizer
- Distribution Transformer

The electrician must indicate the defective components and their conditions. For each component, listed above, there is a list of most founded component conditions and the electrician must choose the more appropriate one. For instance, in Figure 5 is shown the question about the fuse link component and its condition.

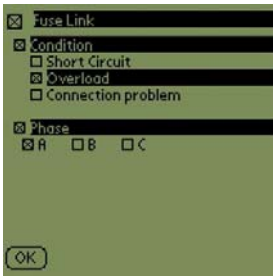

Figure 5. Fuse link condition screen

The last application screen is shown in Figure 6. The first logo in Figure 6 (SADENP - *Sistema de Aquisição de Dados de Eventos Não Programados*) means in English*: Forced-Outage Event Data Collection System*. The second logo (RGE – *Rio Grande Energia*) is the name of the South Brazil Electrical Utility, and the last logo (GSEE – *Grupo de Sistemas de Energia Elétrica*) is the name of the research lab that developed the application and *means Electrical Systems Group.*

Figure 6. The last application screen with the logos.

Logical Validation

The electrician has tree different ways to follow the questionnaire answering process. Each answer is checked for the computational system such as the logical structure of question is validated, and, for this reason avoids logical mistakes in the electricians answer process. Ambiguous answers and incomplete information about the forced outage event were very common when this system was not in use.

The application programming

Although, the data collected from the local of the events is considered very important, the major function of the electrician is to repair the distribution system and recover the energy supply. For this reason the questionnaire of the handheld application must be simple and easy to be filled. To satisfy these needs the application was developed using the graphical Java class named Canvas for the interface implementation. This class Canvas provides the necessary flexibility to design a simple and friendly interface. The electrician is able to answer the questions using the handheld touch screen and also the device buttons. For each forced outage event, the electrician will save an answered questionnaire data in the handheld, and then, in the end of the electrician journey, the data will be sent to the operational center computer. The data transfers is made using the TCP/IP protocol that is widely used and Java

supported. After the data transfer, the analysis application in the operational center will provide the probably forced outage event causes, store the field data and make statistics analysis through graphics and reports of the outages causes and events.

Practical System Implementation

This first module of the project was tested by an electricians group of the electrical utility. This group has provided a feedback of the system and identifies the application points that can be improved to meet all the electrical utility necessities. After this experimental project implementation, the forced outage data collecting system will be adopted by the entire company and will cover at least 11000 forced outage events by month.

CONCLUSION

The basic function of an electric power distribution system is to satisfy customer requirements offering a service with reliability, quality and continuity. Nowadays, it is very important for utilities have a distribution system performance assessment, such as historic and predictive data for improve process of maintenance, operation and planning. Assessment of the historical performance of the system, in special, forced outage events is fundamental for utilities.

The system presented in this paper has the follow advantages:

- Provide more reliable data for reliability analysis;
- Eliminate from the electrician the function to identify forced outage cause;
- Avoid ambiguous answers and incomplete information about the forced outage event by the electrician;
- Provide information to improve equipment performance analysis and maintenance policy;
- Provide a basis for electrical utility establish reliability and continuity of service in a given area, in order to determine how factors such as design differences, maintenance methods, environment conditions and operating methods are affecting the system performance;
- The system is easy and friendly to use by the electrician;
- The implementation on handheld is reliable and with high cost/benefits.

Additional developing has been made to improve this system and its integration with the electrical utility system for reliability assessment. New features and functions will be implemented in the SADENP system to improve system performance. The others phase is on developing.

Acknowledgments

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REFERENCES

[1] R. Billinton, R.N. Allan. *Reliability Evaluation of Power Systems*, Plenum Press, New York, 1984.

[2] R. Billinton, R.N. Allan. *Reliability Evaluation of Engineering systems, Concepts and Techniques*, Plenum Press, New York, 1982.

[3] R. Billinton "System and Equipment Performance Assessment", Reliability, Security and Power Quality of Distribution Systems, 1992, IEE North Eastern Centre Power Section Symposium on the, 5 Apr 1995 pp. 2/1 –216.

[4] J, Gates, G. Wacker, R. Billinton "Development of Customer Survey Instruments for Reliability Worth Evaluation in Electric Power Systems", *WESCANEX 95. Communications, Power, and Computing*. Conference Proceedings. IEEE , Volume: 1 , 15-16 May 1995 Page(s): 12 -17 vol.1

[5] G. Tollefson, R. Billinton, G. Wacker, E. Chan, and J. Aweya, "A Canadian Customer Survey to Assess Power System Reliability Worth", *IEEE Transactions on Power Systems*, Volume: 4 Issue: 2, May 1989 pp. 472 –478.

[6] R. Billinton, M. Oprison, F. Filippelli, and I. M. Clark "A reliability data system for the reporting of forced outages of distribution equipment" WESCANEX '91 *IEEE Western Canada Conference on Computer, Power and Communications Systems in a Rural Environment*, 1991 pp. 267 –270

[7] R. Billinton, R. Ghajar "The Canadian Electrical Association Approach to Transmission and Distribution Equipment Reliability Assessment", *The Reliability of Transmission and Distribution Equipment*, No. 406, Mar 1995, pp. 7 – 12.

[8] J. Endrenyi, S. Aboresheid, R.N Allan, G. J. Anders, S. Asgarpoor, R. Billinton, N. Chowdhury, E. N. Dialynas, M. Fipper, R.H Flecher, C.Grigg, J. McCalley, S. Meliopoulos, T. C. Mielnik, P. Nitu, N. Rau, N.D Reppen, L.Salvaderi, A. Scheider, and Ch. Singh, "The present status of maintenance strategies and the impact of maintenance on reliability", *IEEE Transactions on Power Systems*, vol. 16, No. 4, November. 2001.

[9] P. Meiler. *Fundamentals of object-oriented design in UML*, Addison Wesley Longman, 2001.

[10] H.M. Deitel e P.J.Deitel. *Java: How to program*, Prentice Hall Inc. , 2000.