FUTURE TRENDS IN UTILIZING ADVANCED TECHNOLOGIES FOR FAULT AND DISTURBANCE DATA ANALYSIS

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On behalf of working group B5-03

This paper gives an overview of future trends in utilizing advanced technologies for fault and disturbance analysis. Special attention is given to the issues of the existing solutions, new needs resulting from recent industry changes, the technology impact and future trends. It is indicated that the transition to the new technology requires definition of retrofitting strategy as well as new standards. Moving towards more "open" solutions supporting data integration and information exchange is an important trend. An example of the integrated fault analysis is given at the end.

Keywords: Fault, Disturbance, Intelligent Electronic devices, Automated Fault Analysis, Automated Power Quality

1. INTRODUCTION

The existing technologies for fault and disturbance analysis are rather old and outdated for the most part. The recording devices are typically not computer based and flexibility in communication, data storage, automated analysis and user interfacing is limited. The role of operators in analyzing the events manually is prevailing in today's practice. An increased amount of recorded data and reduced availability of time to analyze it create a bottleneck in the ability to analyze the recorded data efficiently and timely.

A major development in the last decade is the deregulation, restructuring, liberalization and privatization of the utility industry. Irrespective which of the mentioned trends is present in a given country or region, it is clear that an increased competition is imminent. As a result, an increased emphasis on system performance and reduction in cost are clear goals. The reflection of these goals on the data analysis has resulted in a need to improve the analysis through automation and broader use of the data and information [1].

To answer the mentioned needs, the utility industry and vendors are carefully evaluating new technology trends to identify the best solutions for the future. The CIGRE Working Group has discussed the technology impacts and future trends and the main points of the discussion are presented in this paper. Data integration and information exchange are considered the two most important drivers for the new technology consideration [2].

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2. BACKGROUND

Fault analysis generally requires gathering the disturbance-related data (digital or paper recordings, targets, SER data, human reports) at a regional or central analysis center. Since this process is greatly facilitated by digital technology, it is essential to consider the existing digital fault-recording infrastructure, in particular recording devices and communication links. The most widespread legacy solutions are shown in the following table.

Case	Main data sources	Data gathering system
1	Digital protection relays (DPRs)	Substation automation, plus a centralization to a network control center
2	Digital fault recorders (DFRs)	Dedicated monitoring system using modem links

Fault-related DPR data (case1), consisting of analog and digital records and annunciations, can be collected thanks to the integration of the DPRs in the protection and control system, which has been standardized. Data analysis from the expert's office is facilitated when the SCADA system can forward the data through a wide area network (WAN), using Internet technologies (FTP, HTTP…).

Devices of other types, like DFRs (case 2) but also power quality recorders or phasor measurement units, are generally coupled with a proprietary solution for system-wide monitoring. Such a solution typically uses dedicated communication channels and includes some specific tools for disturbance analysis .

A utility or a third party may also want to build up a fault analysis independently of the data acquisition, according to its own requirements. Instead of interfacing all valuable recording devices directly, one can use the COMTRADE data format [3], resulting from early standardization efforts for the interchange of disturbance recordings [4,5], to integrate various data sources from different vendors into common data storage and processing framework.

After concentrating disturbance-related data, several kinds of analyses are possible. Beyond the traditional task of understanding the causes of every power system fault, fault and disturbance analysis is progressively being connected with other disciplines in order to address the expanding requirements of modern utilities. As shown in the Figure 1, the disturbance itself is no longer the only center of interest.

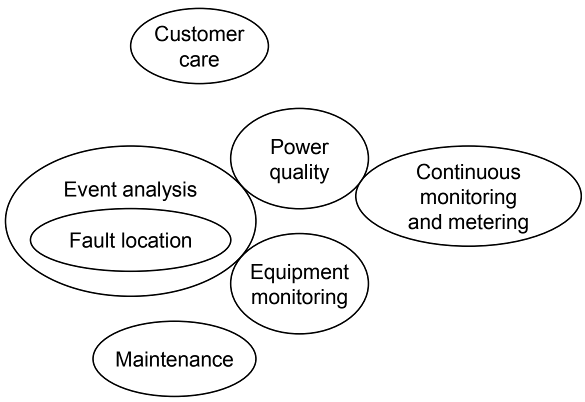

Figure 1. Present uses of the fault and disturbance analysis

3. NEW NEEDS

The new needs came about as a result of industry deregulation, restructuring, liberalization, and privatization. The mentioned trends did not occur simultaneously in any given country or region, but are rather a reflection of specific local circumstances. However, the outcome is almost the same across the world. The increased competition has resulted in an emphasis on achieving higher performance while curtailing new investments in the infrastructure and human resources if at all possible. More detailed list of impacts and consequences is given in Table I.

Table I. Cause-effect relationship of the new developments in the utility industry

Changes	**Impacts**			
New Utility Business Models	Increased Performance	Reduced Investments	Customer Focus	Stiff Competition
Reduction in Human Resources	Loss of Expertise	Need for Automation	Need for Re-training	Multiple Users of Information
Increased System Loading	Enhanced Monitoring	More Complex Event Analysis	Improved Maintenance	Documenting of Problems
New Company Needs	Data Integration	Information Exchange	Data Archiving and Viewing	Retrofitting Legacy Systems

From Table I, it appears that the new developments in the industry are posing a variety of requirements on the new generation of fault and disturbance analysis solutions:

- "Open" solutions that will allow integration, upgrading, retrofitting and other levels of flexibility in designing future systems
- Automated analysis implementations that will enable savings in man power and reduction in response time
- Multiple uses of the same equipment justifying the investments and even sharing the future investments among various utility departments
- Utilization of advanced Internet and Web applications combined with database and communication technologies to achieve system-wide, easy to access, solutions

The requirements should be understood in the most important context: faster and more precise assessment of faults and disturbances as well as related equipment operations and performance characteristics. The recent developments in the industry have resulted in creation of new entities and players such as Independent System Operators (ISOs), Transmission Companies (TransCos), Generation Companies (GenCos), Distribution Companies (DisCos) etc. The future trends in utilizing advanced technologies for fault and disturbance analysis have to be measured against the needs and related requirements that each of the mentioned entities may impose. This may result in: different approaches to the ownership of data recording instruments, subcontracting of data analysis services and wide uses of the results among various entities (internal company departments, regulatory agencies, etc). As a result some new designs and implementation strategies for fault and disturbance analysis may be needed in the future.

In addition to the mentioned needs that are coming from the industry developments, the technology developments are also very important. The utility industry is known to be technology driven since some of the existing solutions use rather outdated and archaic technologies. This topic is discussed next.

4. TECHNOLOGY IMPACTS

Technological advances and their rapid deployment in the industry have contributed to reshaping the field of disturbance analysis for a few years.

One can first observe progress in data acquisition, processing and storage, such as:

- Increasing level of functional integration in the devices, representing a decreasing cost per function (for instance, the DFR becomes a multiple-purpose digital recorder and system-wide continuous recording becomes affordable).
- Availability of precise time sources, making accurate system-wide timing possible.
- Increasing storage capacity, which allows capturing more information.

New communication media and approaches have also had a deep impact. It has become feasible to connect virtually every substation to the utility's WAN, using the most appropriate technology (fiber optics, xDSL, ISDN), thus increasing the available measurements base for disturbance analysis and allowing a full coverage of a given voltage level. The data gathering service has become more dependable than with former modem links. Transferring one megabyte of disturbance data has become faster and cheaper; breaking the old speed barrier is certainly an incentive for developing central data storage and analysis, which is simpler to operate and to maintain than a distributed solution.

Last but not least, internetworking all devices and systems has suggested new system architectures and applications, which take advantage of the broader data availability. A part of the disturbance analysis work consists of routine work, such as gathering the data sets, grouping and sorting them, looking for fault-related patterns in analog and digital signals, measuring amplitudes, phases, time delays, fault locations, and producing some short reports illustrated by disturbance plots.

Fortunately, some progress has been made in the field of automated analysis. As far as digital data are concerned, dedicated software solutions are available nowadays which gather the measurements into a fault database and automatically perform the routine calculations, in particular for the identification and location of high-current short-circuit faults on the basis of digital fault recordings [1,2]. Substation automation systems also increasingly support fault analysis applications by presenting all relevant data to the user.

Some automated disturbance analysis systems may also address some complex ("intelligent") applications, like analyzing dynamic system stability, monitoring the performance of switching and protection equipment, detecting high-impedance faults, providing clues concerning the original cause of the fault, assessing impacts on the customers (PQ features).

The fast development of Internet Technology (IT) has a strong and beneficial impact on the way modern disturbance analysis systems are being designed. Formerly, most of the effort needed to be devoted to communication and data management issues. Today, many powerful solutions for building web-based and database-oriented applications are available from the shelf and may be easily deployed in a utility's Intranet or through the Internet, so the designers will care more about functional integration in the company's information system and about end-user requirements. From a modern perspective, the whole field of fault and disturbance analysis appears as one of the many interesting functions of a power system information system.

5. FUTURE TRENDS

An illustration of future trends is depicted in Figure 2. Several characteristics of the future trends may be observed as follows:

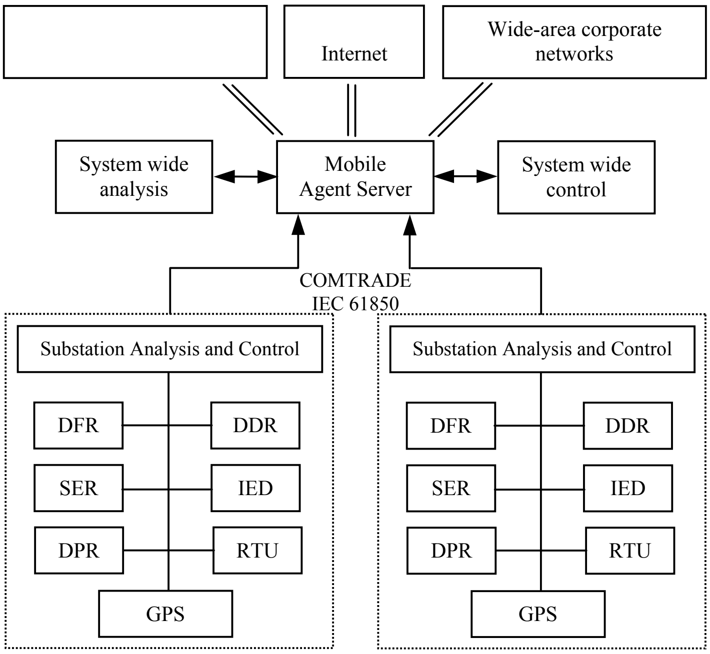

Figure 2: Future trends in the architectures for fault and disturbance analysis implementations.

- Data integration and information exchange will be facilitated by connecting various substation devices such as Digital Fault Recorders (DFRs), Sequence of Events Recorders (SERs), Digital Protective Relays (DPRs), Digital Disturbance Recorders (DDRs), Remote Terminal Units (RTUs) and other monitoring IEDs through a common communication standard such as IEC 61850 [6].
- The analysis will be facilitated if all the recording devices are connected to a Global Positioning Satellite (GPS) time reference [7].
- Due to a large amount of recorded data, it will be desirable to perform some level of automated analysis at the substation level, close to the data sources while the system level analysis may be performed at the centralized location [8].
- The utility industry emphasis on performance will require that many different users of data be presented with the result of the analysis, leading to the need to allow both local and wide-area communication facilities and user interfacing tools.
- The data exchange will need to be facilitated by further development of the data format standards including COMTRADE and the IEEE File Naming Convention [9].
- Some advanced software technologies, such as mobile agent software, may have to be employed to account for the use of diverse processing and data storage environments, which are introduced by various legacy solutions that need to be retrofitted and/or modified to accommodate the new needs [10].

6. CONCLUSIONS

The paper summarizes recent efforts within CIGRE WG B5-03 related to assessment of the future trends in the fault and disturbance analysis area. Special focus of this paper is the aspect of utilization of advanced technologies in developing the future solutions. The main conclusions of the points raised in the paper are as follows:

- Understanding the current business models and related needs of the utility industry is crucial when defining the future trends.
- It is clear that the advanced technology has a lot to offer but some ways of retrofitting the legacy solutions also needs to be addressed since the investments are substantial.
- The required level of performance assessment while there is a shortage of man-power has to lead to a much greater level of automation of the data analysis, storage, and retrieval tasks.
- Standardization of the data formats and application objects has to be pursued if the acceptance of the new solutions is to become a reality.

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