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OSS Tools for Automated Event Analysis and Lightning Data Correlation

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***Abstract*—This paper provides a brief overview of open source software (OSS) and some potential benefits it brings to the electric power industry, and includes a discussion of OSS tools for advanced, automated, power system event analytics. New techniques have been employed that automatically evaluate the quality of recorded sensor data and provide insights regarding recently recorded data in the context of historical performance for the same reporting point. It also includes a case study that describes the need for automated correlation between power system events and lightning data, and the OSS solution that is being developed to provide this functionality. The new OSS project presented in the case study draws on previous work to automatically determine the location of power system faults, then use the fault location data to interrogate the Vaisala TXD100 data service for possible lightning strokes that correlate with the system event. Conclusions include 'food for thought' to encourage the exploration of new ways to solve power system event analytic issues where lightning is a suspected cause.**

***Keywords*—open source software; OSS; automated analytics; lightning correlation**

I. Overview of Open Source Software

Open source software is software whose source code is available for modification or enhancement by anyone. The open source software (OSS) approach that we see today is not vastly different from the development community that grew organically around computers in the early days. In an effort to rapidly take advantage of the 'new' computational technology of that time, ideas were freely discussed and shared. Over time business models developed to extract financial benefit from the unique features in a company's software, and by 'closing' the source code so that it couldn't be copied and modified, they were able to maximize their financial return. The down-side to this approach was that it inhibited collaboration and forced the software development company to rely entirely on internal resources for creativity and skills in developing new products or correcting 'bugs' in existing products. Although this proprietary strategy has served some companies very well, the response in the development community at large was to create organizations that define and promote OSS.

Today we are seeing a dramatic resurgence in the development and acceptance of OSS for many reasons. The rapidly changing electric utility industry can benefit from a number of these potential benefits of OSS:

- Stimulates innovation
- Encourages and facilitates collaboration
- Reduces time to deployment
- Reduces cycle time for improvements
- Lowers total cost of ownership
- Improves code quality
- Improves security through community review

II. Building Blocks of an Automated System

An end-to-end solution to provide fleet-wide information from the aggregation of data recorded by individual devices across the utility's footprint can be described as three general divisions or building blocks.

The first of these building blocks is the physical transport of data from the sensing and recording device to a central repository. This task can be accomplished through a spectrum of processes that range from completely manual, to fully automated. A manual process could be as primitive as copying files directly from the device onto storage medium such as a USB drive, carrying it back to the office, and copying it onto a computer, or as sophisticated as opening up a desktop application and initiating a file retrieval operation that ultimately places the data in the same repository as the more primitive process. An automated process could be as simplistic as setting appropriate criteria in a vendor provided software application for each unique brand of device, or as advanced as fully automated retrieval/receiving process that runs autonomously to archive data from all remote devices. Regardless of the approach used, the first block in the process is to get the data to a central repository.

The second block is analysis of the data. And once again there is a spectrum of approaches that range from completely manual to completely automated. For this block a manual process often consists of opening a vendor supplied software application, manually locating the data to be analyzed, and visually reviewing the data with a calculator and note pad nearby. At this end of the analysis spectrum, it is often necessary to employ a separate desktop program that is specifically designed to analyze the data from the respective vendor. Moving up the analysis automation spectrum there are third party desktop tools that allow the analysis of a selection of similar data sources in a single software application. The manual or semi-automatic tools for analysis often do not facilitate the extraction and long term trends and system responses but are typically limited to the production of individual manually developed reports. A fully automated analysis system is capable of performing the specified analysis without any manual intervention, and providing automate reports and notifications of conditions that meet predetermined conditions. Ultimately, the automated system also builds a comprehensive database for long term trending analysis in addition to analyzing individual events. A database built from an automated analysis system can also position data for fleet-wide visualization through web based tools and dashboard applications.

The third block in this view of and end-to-end system is visualization of information derived from the analysis of the data. An ideal method for visualizing large quantities of information is through a dashboard. And just like the dashboard of a vehicle, the annunciations, displays, and images used to present the information can be tailored to the needs of the audience. For example, a crane operator at a construction site would have different displays and information available to him than the driver of a sports car but they both use dashboards. Again using the analogy of a modern dashboard in a car, when some information displayed on the dashboard indicates a cause for concern, such as a low fuel light, the simple click of a "More Information" button should quickly give you the needed detail of 'Thirty-six miles to Empty'. In a power system dashboard, the information should be presented intuitively with easy access to supporting details.

III. Automated Event and Trended Data Analysis

Beginning in 2012, OSS tools have been progressively extended and refined each year to incorporate more functionality into an automated analysis platform for electric power system event and trended data. Analytic functions that are now being applied automatically to power system event data in near real time include power quality (PQ) event classification, single-ended and double-ended distance to fault calculations, breaker timing evaluations, capacitor bank health assessment, input data quality assessment, and statistical performance evaluation of each input channel.

The statistical performance evaluation of each input channel of trended power system sensor data is a relatively new concept. To perform this analysis, a period of historical data is evaluated and normal operating limits are established for each channel. In our initial deployment, a year of historical data was used to construct the normal operating limits on an hour of the week basis. Subsequently, as each new recorded data point is analyzed it is compared to this history. When normal operating limits are exceeded, notifications and alarms are generated. The value of this new approach is to proactively notify when a step change is identified, even if standard alarm limits are not exceeded. For example, and typical voltage sag limit might be 90% of the nominal voltage. Using the statistical performance evaluation analysis, the normal operating range for a particular hour of the week might be between 103% and 94%. In this scenario, if the voltage dropped to 92% of during that hour, an 'off-normal' alarm would be set, even though the standard 90% alarm had not been exceeded. An example where this 'off-normal' notification would be important is when a calibration value is changed or a piece of equipment is an early failure mode.

IV. Lightning Correlation Case Study

Understanding when something has impacted the system, and how the system responded are two very important aspects of analyzing power system events, but certainly not the only ones. When a fault occurs on the system two other important aspects to consider are where the fault occurred and what caused the fault.

Our case study is a transmission system. Recorded data identifies the substation where the recording device is located, and the system parameters of the lines monitored by the device. The recording devices for this system are digital fault recorders (DFR). Using the available data, the time of the fault is known, a distance from the recording device to the fault can be calculated on the faulted line, and the automated analysis determines if a double-ended distance can be calculated. The notification and reporting system presents the fault distance and other fault related information but there is no source for spatial information to determine the longitude and latitude of the fault location. Discussions are under way to determine the most effective approach for this utility to obtain the necessary spatial information. Once the latitude and longitude of the fault is available, it will be combined with the fault time and a query will be assembled to interrogate the Vaisala TXD100 data feed. The components being used and developed in this case study are not new. They have all been performed manually to some degree, and partially automated in some systems. The uniqueness of this study is that once completed very accurate fault location and correlated lightning strokes can be reported automatically. This fully automated approach will reduce the time required for results, and provide consistent results. Output from the system will include email notifications, a database of all results, and a dashboard for fleet level visualization and drill-down for details.

V. Conclusions

Using OSS building blocks described here, fully automated advanced analytic systems can be built to perform any analysis that is appropriate for the type of data available. As they stand today, the blocks are functional and provide dramatically improved access to information compared to previous manual methods. However great the value is that we see today, it is only the tip of the iceberg. Other functions such as data quality and device availability and performance are also being applied in this environment. Each of these OSS building blocks is freely available for enhancement, extension, and adaption. Through the collaboration and innovation afforded by the OSS approach the functions of these blocks will continue to grow rapidly.

REFERENCES

For more information, see article What is open source? at: https://opensource.com/resources/what-open-source

For more information on OSS tools and building blocks see: http://gridprotectionalliance.org/products.asp

Information on the EPRI Open PQ Dashboard can be found at: https://sourceforge.net/projects/epriopenpqdashboard/