IMPROVING SMART SCADA DATA ANALYSIS WITH ALTERNATIVE DATA SOURCES

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ABSTRACT

As the implementation of the Smart Grids increases so does the quantity and variety of SCADA (Supervisory Control and Data Acquisition) events. The experience of handling this large amount of data has given a new role to the DSO as a Data Manager.
With this in mind, EDP Distribuição (EDPD) started developing big data handling algorithms that transform this huge amount of data in information and act as a filter to deliver useful high quality information to the dispatch engineers and maintenance teams.
Yet as the potential to enhance the information coming from SCADA is huge EDPD is also starting to introduce data from sources other than SCADA in the smart event analysis programs. Information from maintenance teams, OMS (Outage Management System), voltage quality monitoring equipment, weather stations and wild fire stricken areas are cross references with the output of smart event analysis algorithms to provide some extra information about protection relays and circuit breakers performance and to help identity the fault probable cause.
Smart SCADA data analysis tools as the one presented in this paper benefits grid operation as it simplifies dispatching centres activity. They also come in handy to identify problems such as circuit breakers failures or protection relays malfunctions in a much easier and automatic way, thus, helping to assess the reliability of the protection system with direct impact on grid operation.
Furthermore, the algorithms provide information that can be used to identify geographical trends and to estimate the root causes of faults.

INTRODUCTION

Considering only the High (HV) and Medium Voltage (MV) network EDPD, as the Portuguese Distribution System Operator (DSO), is responsible for over 400HV/MV substations, over 30 MV/MV substation, more than 100 switching stations with protections relays and over 65 thousand secondary substations. All in over than 80.000 km network (82% overhead lines) containing more than 6.500 reclosers and sectionalizers. As this numbers tend to grow so does the quantity and variety of SCADA events and the number of events reaching the dispatch centres. To put things in perspective, over the past two years, for only the HV and MV network, the average daily number of SCADA events is around 350.000. There were days where this number overpasses 1 million events.

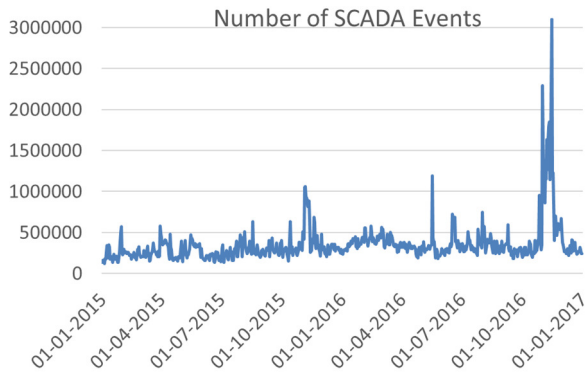

Figure 1 – Number of SCADA events per day over the past 2 years.

Being SCADA at the core of any smart grid decision making, in which real-time analysis of that stream of data is fundamental for any automatic or manual decision process, EDPD started to develop big data handling algorithms and homemade tools to transform this huge amount of data into relevant information to the dispatch engineers and maintenance teams. These algorithms aim to transform the dozens of events generated on SCADA in just one High Voltage (HV), or Medium Voltage (MV), line outage into relevant and simple information, easy to read, understand and relevant for the grid operation and maintenance process.

Aware of the potential to enhance the smart event analysis tools EDPD started also to introduce data from sources other than SCADA in their algorithms. The cross reference of the output of the smart event analysis algorithms with information from other sources, as will be described in this paper, is proving to bring major benefits grid operation as they help to assess the reliability of the protection systems, identify trends and to estimate the root causes of faults.

SMART SCADA DATA ANALYSIS

Since 2006 the Protection and Automation Systems Department of EDPD has been testing and developing

smart event analysis tools focused on SCADA data analysis. As this tools proved to be very useful to assess some protection system behaviours, explore trends and estimate the root causes of faults an effort was made to upgrade the developed algorithms.

Over the past two years the smart event analysis tool developed at the Protection and Automation Systems Department of EDPD was redesign and suffered major upgrades after a long process of classification and normalization of all SCADA data. This process was essential due to the much different technologies and philosophies scattered across the Portuguese Distribution Network. Then new features were added by extending the SCADA data usage.

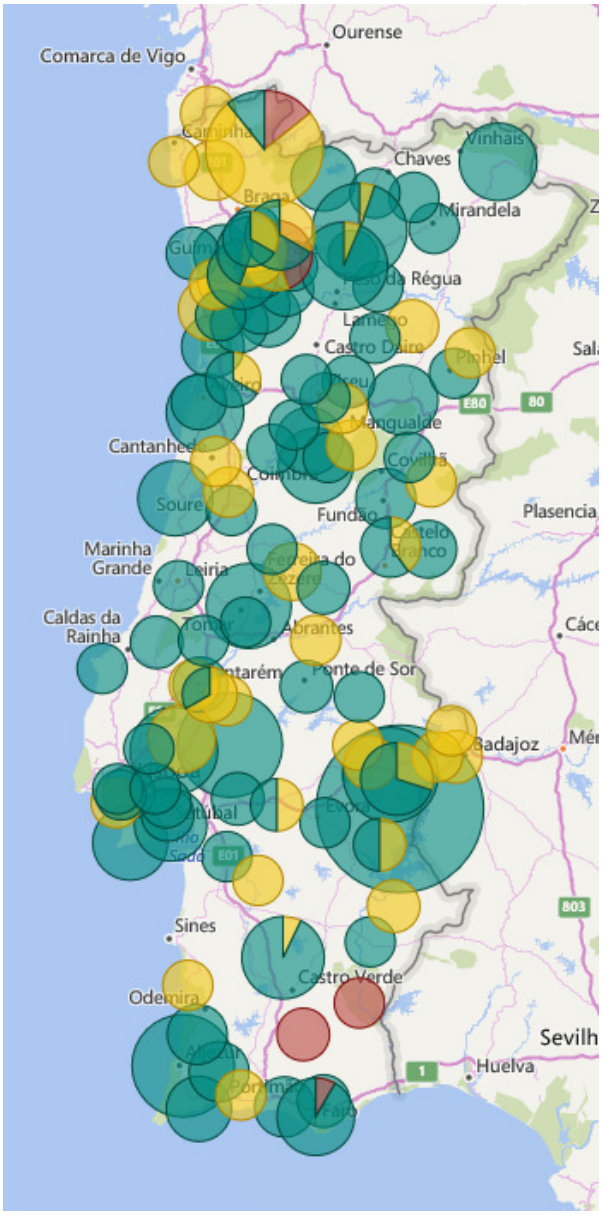

Figure 2 – Geographical distribution of phase-to-phase (yellow) and phase-to-ground (green) faults in Portugal for day with adverse climate conditions.

The smart event analysis tool developed uses algorithms that, for each line outage, identifies, aggregates and analyses all the SCADA events from relays pickups, trips and other sensors and generates an output. That output gives the user two events, one containing the information about the trip (substation, panel, function tripped, type of fault, duration of fault and circuit breaker opening time) and other containing the reclosing information (outage duration, and indication if the reclosing was automatic or manual). These algorithms aim to reduce the dozens of events generated on SCADA for just one line outage into two relevant and simple lines, easy to read and readily understandable by the dispatch engineers.

Sometimes the developed algorithm fails to assess the fault type for lack of information about witch protection function trips and what backup function starts. This cases are marked as unknown and as shown in Figure 2 are marked in red.

Relay trips from scheduled maintenance actions and commissioning are also received in SCADA, therefore the smart event analysis tool must identify which relay trips should be ignored and disregard for further analyses. To do it so it uses a parameter available at EDPD's SCADA that is used to mark equipment that is under maintenance and commissioning.

After the two events output, described above, is generated for all line outage, the smart event analysis tool carries out second stage analysis by making more complex correlations between SCADA data and the information previous processed. This analysis primarily aims to identify some unusual faults root causes like cross-country faults, circuit breakers failures, protection relays malfunctions and incorrect relays settings. This second stage algorithms combined with the two based events generated by the described tool prove to be very useful for the outage management process carried out in the dispatch centres.

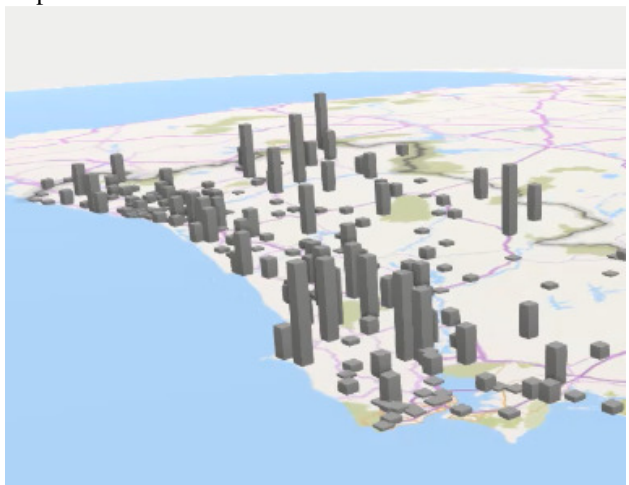

Figure 3 – Geographical distribution of cross-country faults identified in one year by the smart event analysis tool.

All this information exported from the smart event analysis tool is then used for further evaluation of time and geographical trends and patterns.

Smart SCADA data algorithms are also used for subsequent assessment of grid automatisms behaviour, like auto reclosing cycles efficiency and load shedding by under voltage or under frequency relay trips.

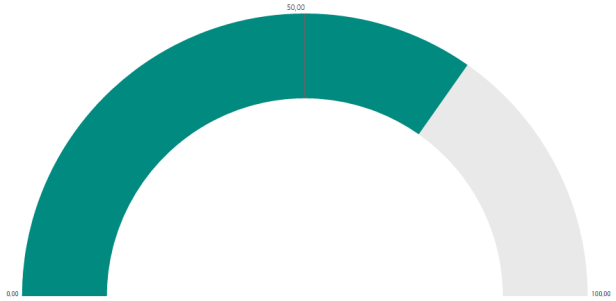

Figure 4 – Fast auto reclose efficiency in fault elimination over 6 months of 2016 (success rate in green).

In the developed tool a feature dedicated to circuit breakers performance was also included. This feature contains, for each circuit breaker, information about the latest circuit breaks opening manoeuvres by relay trip and manual command. High opening times and operating time degradation over the latest manoeuvres is then automatic detected by this feature and presented to the user (Figure 5). This information also come in handy to identify low usage circuit breakers that are likely to fail. Such type of information has proven to be extremely useful for maintenance teams as a way to evaluate their assets condition.

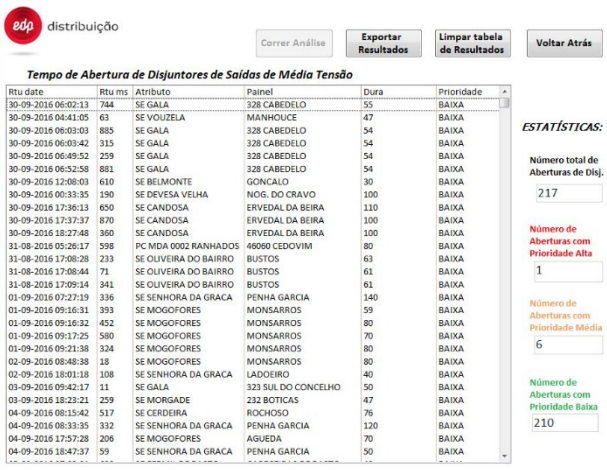

Figure 5 – Data output for one moth of circuit breakers operating time analysis.

SCADA DATA IMPROVEMENT THROUGH ALTERNATIVE DATA SOURCES

Cleary aware of the potential to enhance the smart event analysis tools with data from other sources EDPD's Protection and Automation Systems Department started to cross reference the output of the smart event analysis algorithms described above with information from other sources.

As all the features that will be described below are not yet fully integrated in just one tool. The development of the algorithms was carried out as prove of concept of data correlation potential.

Outage Management System (OMS)

The first step to improve the smart SCADA data analysis tools was the inclusion of the linkage between the smart event analysis program output and the OMS events. Thus helping fast and automatic incident report as some fault root causes identification.

As the base algorithm are tuned and their results confidence increases this feature could be seen as a useful way to accelerate the process of understanding an outage event and therefore decreasing the response and consequently the outage time.

Voltage Dips Correlation

Presently the output of the smart event analysis algorithm is being cross referenced with the voltage dips information (magnitude and duration) acquired from the voltage quality monitoring equipment scattered across EDPD's HV and MV network. This feature aims to identify the voltage dip origin correlating it with the type and location of the fault that caused it.

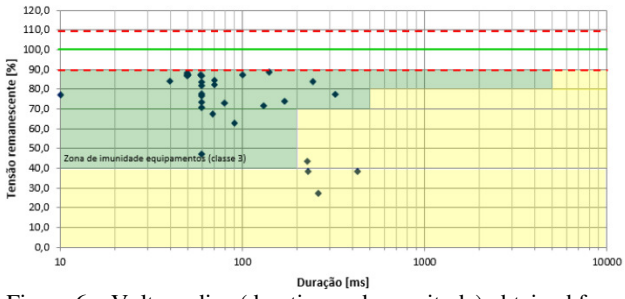

Figure 6 – Voltage dips (duration and magnitude) obtained from one quality monitoring equipment over one year.

When the voltage dip duration is greater than expected the smart event analysis tool proves helpful to assess if it is due to the protection relay malfunction or incorrect settings or due to high circuit breaker operating time.

During the past two years, EDPD carried out an exhaustive revision program of all MV protections functions for the entire mainland Portugal distribution grid. As the results of this work have been fully implemented in the field, the smart event analysis algorithms described in this paper are being used to assess the improvements on voltage dip durations, on the number of short interruptions and on the elimination of unintended interruptions in the public service power grid.

Wild Fire Stricken Areas and Weather Forecast Data Correlation

In the Summer, overhead lines located nearby forest fires outbreaks are covered with thin layers of ash. Afterwards, when the first rains come, these ashes mix with water, forming a thick ash-paste that sometimes leads to insulation failures.

To prove this hypothesis, using the smart event analysis tool capabilities, correlations between overhead line outage caused by fire outbreak and outages occurred on the next rainy day were made (like show in Figure 7).

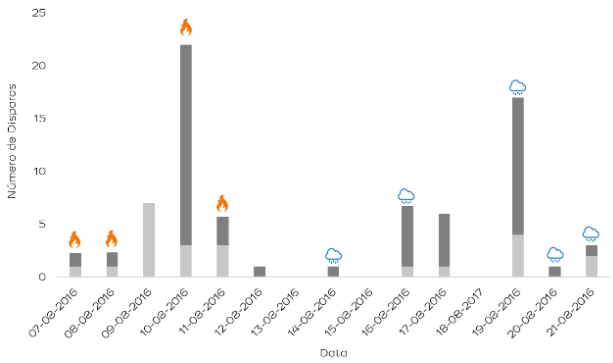

Figure 7 –Outages distribution for one primary substation feeders over one month (to show correlation between the outages caused by fire outbreak and the ones occurred on rainy days)

The previous results met the expectations, so, a feature was then added to the smart event analysis tool where beyond SCADA data, burned areas, weather forecast and overhead lines geographical information was also included.

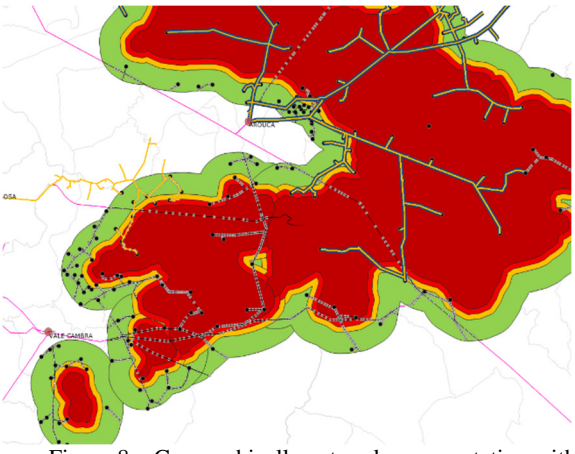

Figure 8 – Geographically network representation with estimated ashes dispersion layer due to a single forest fire.

With all the acquired data the developed tool is able to infer which lines are probably affected with ashes, and then suggest maintenance cleaning operations since ash should be removed before the first rains to minimize insulations failures. As it has weather forecast information smart event analysis tool can schedule each maintenance operation to happen before it rains.

Lightning Strikes Correlation

Atmospheric discharges location is one other useful information that helps to find out outages root causes. Presently at EDPD this information is only being used in HV outages.

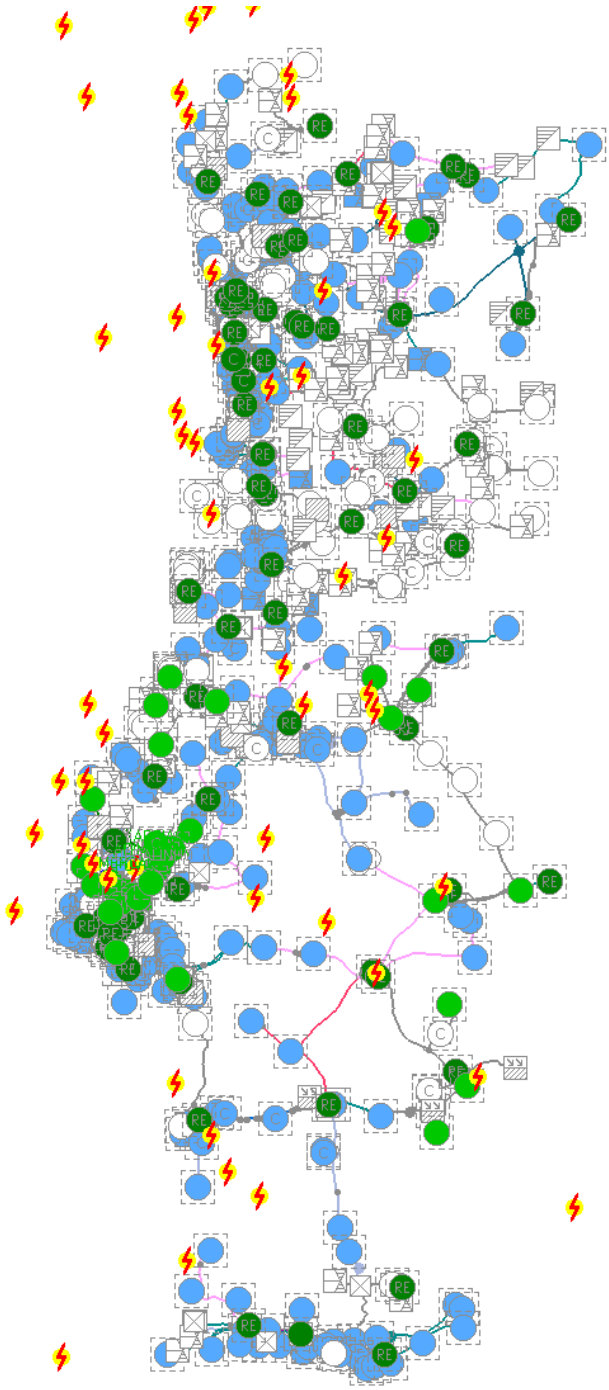

Figure 9 – Geographical distribution of lightning strikes over one week on Spring overlap with the HV network representation.

Every time lightning strikes data information reaches our systems it is overlapped on EDPD's HV network to check if there is a positive relationship between these evets and HV outages occurred (time and coordinates with an error margin). If there is a positive match, then the probable fault cause is assigned and registered on the smart event analysis tool.

CONCLUSIONS

The continuous increase rate of information, due to smart grids proliferation, that reaches the dispatches centres set a series of challenges to the DSO as they slow down the decision making process. Real time smart SCADA analysis tools, as described in this paper, are part of the solution as they reduce by several of times the number of events received by the dispatch engineers, giving them only the relevant and helpful information. This filter aims to reduce alarm fatigue and general stress hence is expected the reduction of the outage time and therefore increase the service quality level.

This paper also sets to prove that Smart SCADA data analysis tools are as important for real time grid operation as they are for offline assets performance evaluation and to access time and geographical trends and patterns. Analysis of automatisms behaviour, protection relays performance and circuit breakers operational condition are just a small part of all the possible benefits of this types of tools for the grid operation and maintenance process.

SCADA data in only a small part of all the information that can be used for grid operation optimization. Although real time process of alternative data sources is not yet still fully implemented, the algorithms developed, shown in this paper, serve as proof of concept of the capabilities of SCADA data enhancement.

As data correlation produced widely accepted and outstanding results, the development of a real-time full integrated tool becomes mission-critical to a continuous improvement of the grid operation and maintenance.

REFERENCES

[1] F. Mendonça, A. Neves, G. Alves, 2014, "Grid Operation and Congestion Management", Cired 2014 Workshop, paper 60