SMART ALARM PROCESSING

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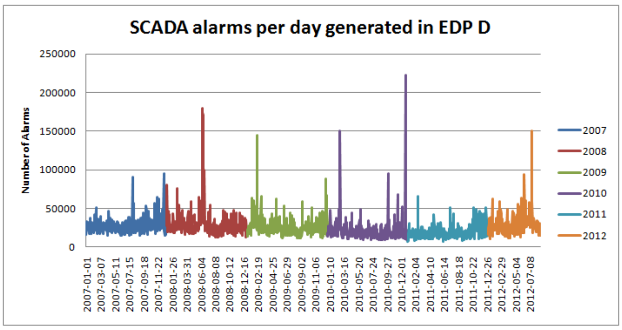
ABSTRACT

The paper presents a smart processing tool for helping the SCADA dispatchers to obtain the necessary and helpful information from the alarms generated as a consequence of a fault in the electric network. This tool uses rules to correlate the SCADA information in real time identifying scenarios and presenting them as a single composite alarm.

INTRODUCTION

EDP Distribuição (EDP Group), Portugal, Distribution System Operator (DSO), with more than 6 million customers, over 400 HV/MV Substations, 60 thousand MV/LV Substations, 80 thousand km Network (HV/MV) and a LV Network about 140 thousand km, has a SCADA system with more than 500,000 data points, overseeing the distribution network.

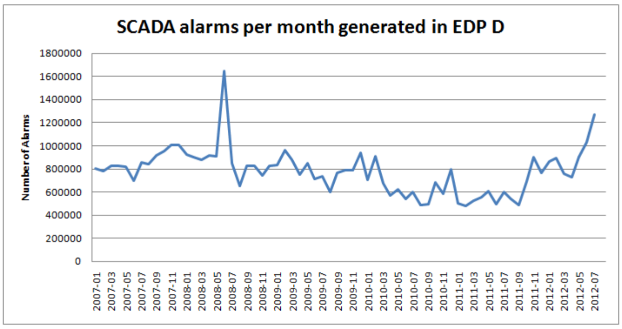
When faults in the electric network occur, several alarms are generated by the SCADA system. For example, a single fault in a MV line generates 24 alarms in a few minutes, during the self-healing cycle performed by the substations automation program. This cascading effect of alarms means that sometimes the SCADA dispatchers receive bursts of alarms that can reach values as high as 300 per minute, 200,000 per day or 1.6M per month.



Picture 1 – Evolution of the SCADA alarms per day

Although the number of alarms decreased from 2008 to 2010 (one reason was the tuning of alarm parameters of many SCADA points), since 2011 the number of alarms has been increasing again (in part due to the increase of remote controlled circuit breakers in overhead MV lines and MV substations). As it was, the current number of alarms during an emergency could quickly reach values that could not be adequately processed by human dispatchers.

When we consider the limitations of the human working memory [1, 2], clearly it is essential to explore and promote new ways to present this same information to the operators.



Picture 2 – Evolution of the SCADA alarms per month

The final aim must be to avoid the situation where operators have so many alarms in front of them they are tempted to simply accept large quantities of alarms.

Since 2006, the EDP D Network Analysis Department has been studying the recognition of outages by extracting information of the SCADA history data base, creating an off line algorithm that is used to produce reports of the performance of the protection systems.

METHODS

This paper discusses the creation of a real-time process of alarm correlation, continuing on from off line studies over the event archive for the system.

We built a system that correlates and summarizes in real-time many related raw events into a much smaller number of composite alarms, the aim being to avoid presenting all the raw alarms to the SCADA dispatchers.

The raw distribution network events are published by the GENESys SCADA/DMS from EFACEC in use at EDP D. The events are then received and correlated by the FeedZai Pulse data processing engine. FeedZai Pulse performs real-time correlation of the events using rules proposed by an earlier off-line study. Raw alarms are generated by the opening of circuit breakers. The rules executed within Pulse parse those alarms or events and recognise certain groups of events as a given composite alarm. The composite alarms are then identified and are also grouped by substation and area.

The final step is to present the composite alarms to the operator. The user interface shows both the composite alarms and their geographic distribution.

DEVELOPMENT PROCESS

The initial steps (after the previous offline study and other work aimed at classifying and normalizing all the SCADA data received) were to identify those most meaningful signals to be considered in the first stages.

At a laboratory stage the rules were tested running the previously studied historical data through the FeedZai Pulse engine, delivered as if it was occurring in real-time.

The development of the final user interface, including the support of persistence and logging functions and the integration into the software Bus that forms the base of the GENESys architecture completes this stage of the project.

RUNTIME PROCESS

The GENESys system publishes on the software Bus mentioned earlier all the live data in the system.

The FeedZai Pulse engine has an adaptor to collect the necessary information from this Bus. Each event is pre-identified by substation, bay, equipment and signal type (e.g. switch state, specific over current protection, etc.).

Using predefined rules, including time distance between events and relationships based on the information above, the motor will recognise composite alarms and place them into its store. These are currently reclose cycles, definitive trips, and device problems. For example, with the trip of a transformer breaker the failure to trip of the out feed breaker between the transformer and the fault may also be identified.

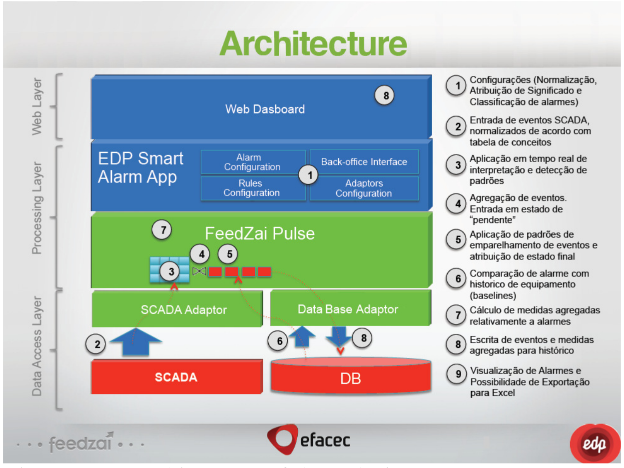
Within the FeedZai Pulse engine, these composite alarms are grouped by bay and substation. Using the EDP D operating area structure, also published on the Bus, the composite alarms are further grouped and counted into operating areas.

Each composite alarm contains the information of all the raw events which gave rise to this composite alarm, including: date with millisecond resolution, substations and panel where the outage occurred, time of the outage, substations automation programs and manual controls involved, type of fault that originate the outage, success or not of the actions taken. At any moment, the dispatchers can drill-down from the composite alarms into the associated raw events collected from the field by the SCADA/DMS system.

The user interface is thus able to offer a dashboard style summary of the number of problems and their location, a list of current situations, composite alarms, requiring the users attention and the details that were recognised and 'included' in the composite alarm.

Architecture

The solution based on FeedZai Pulse processes data with high performance and is scalable. It is non intrusive to the SCADA system and features business intelligence in real-time.



Picture 3 – Architecture of the solution

As shown on stage 1 of Picture 3, the system has a back-office interface and supports configuration of alarms (normalization, definition and classification), configuration of rules to be applied, configuration of the SCADA adaptor and configuration of the Data Base adaptor. The SCADA publishes alarm events, on stage 2, normalized according to concept tables, and an adapter using TCP/IP feeds Pulse. Taking into account the defined rules, on stage 3, a real-time interpretation tool detects patterns and selects events, which on stage 4 are aggregate and stay in a pending state. Then, on stage 5, pairing patterns are applied to the aggregate alarms and the final state is set. After this, on stage 6, the system makes a comparison of the aggregate alarms with the history of their equipment (baselines) stored in the Data Base. Calculations are made, on stage 7, to set aggregate measures and classification of the aggregate alarms, and this information is stored in the historical Data Base, on stage 8, and displayed to the users, on stage 9, using web dashboards, supporting data search and drill-down to the original events.

DISCUSSION

The system will decrease the cognitive load, alarm fatigue and general stress currently imposed on SCADA dispatchers and is expected to reduce outage time and increase quality of service level.

In the short term, SCADA alarms for events identified and included in a composite alarm by the smart tool should be suppressed, greatly reducing the number of alarms presented to the dispatcher. This reduction amounts to not presenting in the alarm list those alarms caused by those events 'included' within a composite alarm, such alarms being considered acknowledged along with the composite alarm.

However, a definitive trip continues to represent both a fault situation to be resolved by alternative feeding and fault location and an abnormal switch position. As with the normal SCADA alarms, we can expect different opinions on what should happen after the event. Should the individual SF6 alarm that has been included in a composite alarm be maintained in the alarm list until the SF6 condition is restored? Should this be the original SCADA alarm or the composite alarm? Are there other more appropriate lists in the system?

As the operators confidence grows in the composite alarms presented their opinion will change, thus both the new composite alarms and the original alarm lists can be expected to change over time.

One of the most important factors mentioned above is the operator confidence. Previous attempts at 'Intelligent Alarms' have often failed to achieve the necessary confidence level. To this end we have to both admit that the failure to identify a composite alarm needs to be balanced against the presentation of an incorrect composite alarm. Due to the very nature of SCADA systems data does not always arrive 'on time' or in the correct order, thus Pulse may eventually be allowed and expected change its mind after having presented a composite event. This is only fair, it is how humans would react in the same situation, however such occurrences will not help in the confidence building stage. The creation of a confidence factor that can be presented as part of the composite alarm is expected to help here, the rules thus recognising that certain sequences or scenarios offer a lower probability than others. This may eventually allow indications like 'substation door open' to be used to assume telemetry testing without the correct tagging whenever the telemetry recovered is clearly inconsistent.

CONCLUSIONS

We are able to present to the operators composite alarms and, depending on company policies, hide some or all of the individual alarms that would have otherwise been presented to and processed by the operator.

We should be able to build on this to generate the all important operator confidence, working to a situation where the alarm list, including both simple and composite alarms, becomes a useful tool.

We note that this needs to be done in the context of a continually developing SCADA / DMS system. Existing tools, such as the abnormal switching list and fault location, have their duties and the responsibilities of this new alarm list must be defined taking these and the evolving smart grid orientation into account. It is a long time since leaving old alarms in the alarm list was the only way to have a tabular list of the important aspects of the power network state.

REFERENCES

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[2] Kaufman, E.L., Lord, M.W., Reese, T.W., & Volkmann, J. (1949). "The discrimination of visual number". *American Journal of Psychology (The American Journal of Psychology) 62 (4): 498–525. doi:10.2307/1418556*