ADAPTING OMS SYSTEM TO DEAL WITH STORMS DATA IN REAL TIME

André PAULO
EDP Distribuição – Portugal
andre.paulo@edp.pt

Cláudio MESQUITA
EDP Distribuição – Portugal
claudioosorio.mesquita@edp.pt

Luís SANTOS
CGI – Portugal
luis.santos@cgi.com

Nuno SANTOS
CGI - Portugal
nuno.santos@cgi.com

ABSTRACT

Every equipment in EDP Distribuição network is mapped in the SCADA system, whether telemetered or not. The amount of SCADA events generated by changes of network equipment (switching and maneuvers) in heavy storm conditions can be overwhelming. The rate of SCADA events sent to OMS system could reach 10+ times more the capacity of the previous OMS could process. The consequences of this lack of processing capacity should not to be neglected: during storm conditions the OMS data becomes non reliable; after the storm there is the need to clean the system and to restore/sync the operational states of the equipment.

Furthermore, the Regulator and general customers are making pressure to receive real-time information not only in normal state condition as well as in storm conditions.

One of the major objectives of the OMS upgrade Project that is currently taking place at EDP Distribuição is to address this issue, by having simultaneous and complementary approaches: to improve the hardware and software architecture of the current SCADA - OMS interface itself; to reduce the amount of time needed to process every single SCADA event, to improve the effectiveness of having much more SCADA processors and still maintaining the integrity of the processed data, as the SCADA events registered in a given geographic area have to be processed in the right sequence; and finally to develop a "storm mode" tailored to maximize SCADA event throughput and call processing efficiency.

INTRODUCTION

The Number of storms is increasing

Portugal has been witnessing an increase in Extreme Weather Events within the territory.
In the latest years, 5 severe storms were registered: Klaus (January 2009), Xynthia (February 2010), Gong (January 2013), Hercules (January 2014) and Stephanie (February 2014). Although each of them caused severe damages in EDP Distribuição (EDPD) network infrastructures, the largest and most powerful storm registered in Portugal was the Gong storm, in recent years.

EDPD is the concessionaire for the electricity distribution network in Portugal for all high and medium voltage and most of low voltage.

Every storm generates a vast amount of events which has to be processed by EDP's SCADA and OMS systems in almost real-time.

The previous OMS system could handle the normal weather conditions and even a light storm. As the number of big storms is increasing, and having an OMS that couldn't keep up in real time with the network conditions, some non-negligible impacts arise:
The OMS data becomes non reliable, because the information it has may be delayed by hours in terms of the network state (switch states), whether as in terms of Trouble Calls this problem may not happen, hence leading to a situation where the trouble calls are not naturally grouped in ongoing Outages in the OMS system, because these outages which are taking place in the field are not yet registered in the OMS system, due to the SCADA processing delay.

As EDPD believes the frequency of storms is going to increase further, a plan to deal with this problem was put in place in early 2013, with the main objective of upgrading the OMS system.

The problem

EDPD OMS system is based on GE PowerOn system. The previous OMS was based on PowerOn 3.1.2, released in 2005, and the new and improved OMS system is based on PowerOn 4.2.2 released in 2013.
The chronology of both EDP OMS versions and the relation with GE PowerOn version is represented in figure 1.

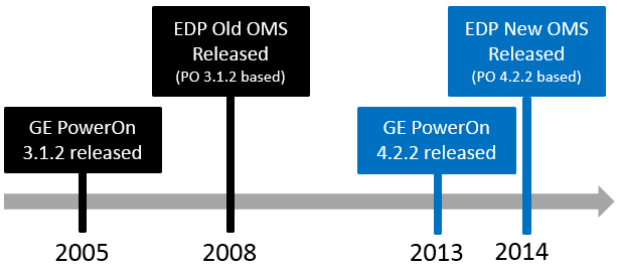

Figure 1 – Chronology of GE PowerOn and EDP OMS versions

Until June 2014, PowerOn Core version only supported one SCADA analyzer, i.e., only one instance to process data received from SCADA.

CGI provides IT outsourcing, systems integration, infrastructure, business process, business consulting and application management services in 40 countries. It acts as EDPD's partner concerning OMS, among other areas.

Soon after the previous OMS rollout in 2008, EDPD felt the need to boost SCADA processing performance. In late 2009, EDPD requested CGI to add the ability to run multiple SCADA analyzers simultaneously, while

ensuring the consistency of event processing. The task was completed in late 2010, when a SCADA multiprocessor solution was delivered to EDPD, based on PowerOn 3.1.2 SCADA Analyzer.

This was a major breakthrough at that time, because it allowed a greater overall system performance – A maneuver of a substation switch located in the North of Portugal could now be processed at the same time as a maneuver of a substation switch from the South of Portugal.

The algorithm challenge lied on identifying which SCADA events were related and had be processed sequentially, and which ones were not related and could be processed as soon as possible, i.e. could be processed without having to wait for the other non-related SCADA processing is concluded.
EDPD soon found that having more than a handful of parallel SCADA analyzers was not effective, because only some of them were actually processing SCADA events. The OMS system ability to scale horizontally (ie, by increasing the number of SCADA analyzers) was found to be very limited and not enough for EDPD when in a storm scenario.

Therefore, even with an improved PowerOn 3.1.2 version, having the ability to process SCADA events with multiple instances, the general performance of the system was not enough to deal with data generated by a heavy storm.

During heavy storm conditions, almost 3000 events per hour can be sent from SCADA to OMS system. Although almost half of them are fast recloses (open followed by a close event), each one of them has to be processed, resulting in a major contribution to total resource and time consumption. The previous OMS system had the ability to process about 300 events per hour, therefore, as time went by during the storm, the SCADA events to be processed started to stack up.
This leads to an inconsistency state of the OMS network state, when compared with the real/field state of the network. Thereby, with the customer trouble calls being received at constant pace and being processed in real-time, the OMS data becomes more of a problem to dispatch operators and may in fact end in not helping their tasks, rather than easing their job.

During the storm, in an attempt to clean the OMS inconsistent data, scripts had to be ran often to clean the inconsistent outages created in the system; to stop the SCADA OMS interface in the hope that after this reset the OMS could keep up with the ongoing SCADA events; to extract from SCADA a list of all equipment states and force a sync to OMS switches and maneuver equipment (sync states between OMS and SCADA).

In the end of each storm EDPD found that there was a lot of information missing or inconsistent, caused by all the attempts to not turning off the SCADA OMS interface during storms.
Consequently, after every storm, an extensive and painful work must be done: dispatch operators have to manually register every outage in OMS. That work usually took weeks.

This performance is not compatible with the recent demands from the Regulator and the general customers' expectations, which demand online information even (and specially) under heavy storm conditions. As the OMS is the system responsible to provide this type of information, in this type of chaotic situations, EDPD had to rely in other systems and non-usual procedures to provide the status reports.

Furthermore, OMS system takes a central place in the EDPD system's environment and EDPD's operation procedures and the delay or the inconsistency of the outages information may impact other department activities such as Quality of Service department, Maintenance department, and Field team's management department. All OMS connections, to and from other systems, are represented in figure 2.

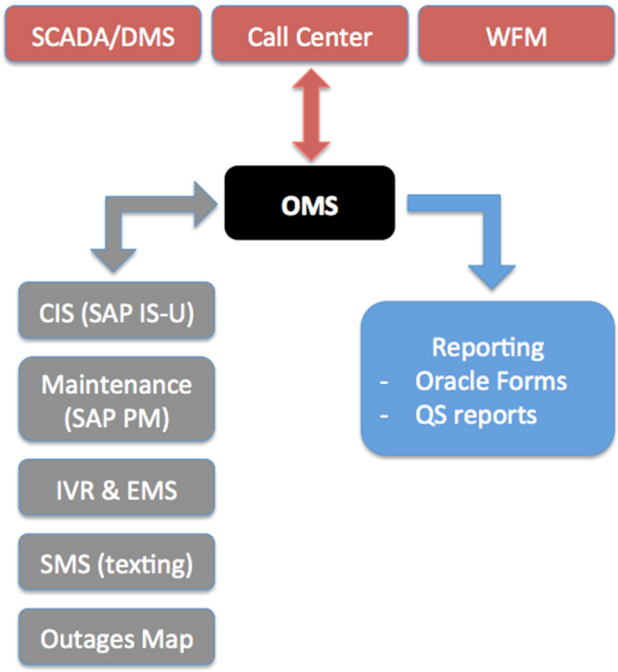

Figure 2 – OMS connections

TACKLING THE ISSUE

The ability to cope with large storms (which Gong is a fine example) was a strong motivation to upgrade the OMS system. However, system reports obtained for the Gong period showed that the OMS system wasn't either CPU or I/O constrained.

By analyzing the cause of the low number of SCADA events processed in storms – out of pace with the rhythm of events imposed by the storm – it became clear that the locking strategy being used to ensure the events were processed in the correct order was way too conservative. As an extreme, but not necessarily rare, example, it was possible that an event in MV network could lock half of all distribution network, concerning the ability to process

SCADA events by the SCADA analyzers.

The clear nature of the cause of the problem showed where the focus should be: find new ways to minimize the amount of network to lock while ensuring that related SCADA events are processed in the correct order.

Indeed, with this in mind, a new locking strategy was devised that normally requires only 2 locks (rarely reaching 4 locks). With the previous approach, between 75 to 100 locks was the norm. Additionally, the concept of strong and soft locks was introduced, with compatibility rules, to further enhance concurrency.

To illustrate the former, it is now possible to process simultaneously events for two MV zones that are feed by the same HV zone. Previously, there was no strong versus soft lock concept (i.e., all locks were strong).

This change in locking strategy has a profound impact in the OMS ability to deal with storms. Previously, adding more SCADA analyzer processes had no impact, as the locking in place limited concurrency severely. This is not the case anymore. In a storm scenario more SCADA analyzers can be added with the corresponding increase in the system's ability to process more events.

During storm simulations, effective use of 18 SCADA analyzers (all that were available) was observed. Actually, at one time it was observed that 80 SCADA events were available for execution, concerning locking, if there were that many available SCADA analyzers.

Changes in other activities during a storm can benefit OMS's ability in terms of SCADA event processing. However, those changes make sense only in a storm scenario. As such, EDPD has now access to an Admin Application where it can set the system in storm mode when required. When in storm mode, the OMS system:

- Saves recloser activity to be played when feasible (as indicated by EDPD through the same admin application).
- Put trouble calls in quarantine.
- Non-critical processes are freezed (i.e., not run) to not put unneeded load in the system.

It was known to EDPD that an important part of open/close activity was actually reclosing (i.e., an open followed by a close event for the same device in a short period). Analysis of the Gong storm confirmed that. The following table reflects the reclosing activity considering different interval durations (values shown for the day with more event activity in the Gong storm; values are similar for the peak hour).

Table 1 – Interval duration vs reclose activity

Interval	% reclose events
3 seconds	21,10%
1 minute	44,33%
3 minutes	55,63%

This observation and the assumption by the business that recloser activity could be processed afterwards, assuming the normal state of the network, could be used to further improve event processing throughput. This is possible because processing recloser activity is a non-critical function in the context of a storm.

Processing a trouble call, even a call from a LV customer, effectively disables any SCADA event processing upstream. Although call processing only locks the part of the network to which the customer is connected, processing an HV operation implies exclusive access to all downstream network.

To limit this impact, trouble calls are put in a quarantine state for a configurable period. On leaving quarantine, if an order exists that affected, or still affects, the customer, the trouble call is associated with that order, bypassing trouble call processing and avoiding any impact in OMS's ability to process SCADA events. However, if no order meets the criteria for trouble call association, then, and as long as SCADA events are being processed in near real time, the trouble call reflects, most likely, an LV outage and is passed to the call processor to be processed.

Further, EDPD can choose what should be active in storm mode (ex: recloser activity shouldn't be processed but trouble calls should always be made available to OMS). Additionally, the storm can cover only part of the country, so the storm mode can be enabled/disabled by area.

PERFORMANCE OF THE IMPROVED OMS

The new OMS system went live in the 1st of July, 2014. Up until January 15, no storm was registered in Portugal and thereby, the new OMS performance during a storm condition is yet to be seen.
Nevertheless, all the stress tests performed during final stages of the upgrade project were made with real data, collected from the recent Gong storm.

Four stress test sessions were made, and each one brought to light some minor problems that certainly would not be detected until a real storm reached Portugal. This fact alone proved the stress tests to be an invaluable exercise, although the main objective was to measure the overall OMS system performance during storm conditions.

The stress tests were a complete success, and the performance of the OMS system was in line with EDPD expectations.
Some relevant numbers from the latest stress tests are

presented in Table 1. The worst three hours of GONG storm were reproduced, which consisted in almost 6000 SCADA events and more that 3000 trouble calls[1].
The system was capable of handling all the above mentioned events and calls in real-time.

Table 2 – Summary of the Stress Test.

Type of evens	Number
SCADA Events	5.921
Trouble Calls	3.158
Quarantined recloses	2.656
Associated Trouble Calls	103
Outages created	3.743
Affected customers	1.482.068
Affected primary and secondary substations	14.492

FUTURE DEVELOPMENTS

The OMS system is a central piece in almost every operation procedure related to the LV, MV and HV networks, hence with the success of the Upgrade Project, OMS data is reliable even in storm conditions. This is the foundation that will allow other new systems to be built upon.
EDPD has always recognized the importance of having updated systems, using the latest technology available.
In this section are presented the ongoing and future developments in order to improve the OMS system, and to make it ready for future challenges.

Dispatch training Center

The Dispatch Training Center (DTC) is a new Project to be put in place in 2015. It consists in developing a full simulated dispatch environment, including OMS, SCADA/DMS, WFM systems, network events, trouble calls, field teams and weather conditions.
Also, the DTC must be able to have different starting scenarios, being the real challenge that each one of the scenarios may produce a different outcome at the end, depending on what choices were made by Dispatch operators during the simulation.
Ideally each scenario will be built with data gathered from real storms.

With the OMS Upgrade Project a significant part of the OMS adaptation work was done, as the simulation tool to send Trouble Calls and SCADA switching events to OMS system was developed and has proven to work really well, as stated in the previous section.

SCADA - OMS Interface improvements

EDPD's SCADA/DMS solution already supports the representation of Generators, Open Points and Jumpers.
The new OMS brought these new features on board to.

In 2015 the SCADA OMS interface will also support the new type of objects, meaning that when a Dispatch operator inserts a Jumper (or other object) in a given network point, whether it may be in the DMS schematic view or geographic view, that same Jumper is send to OMS in the form of a SCADA event, and thereby OMS can processes it and guarantee the network state coherence between both systems.
Nowadays these procedures have to be executed manually by the dispatch operators.

Damage Assessment integration

The E-REDE Project[2] is in the final stages. The Project consisted in the development of a new WebAPP with the schematic and geographic representation of HV, MV and LV networks, with total integration with Google Maps.
The WebAPP will be running in tablets which will the distributed to all the field teams.

This new system will be the starting point of the future EDPD Damage Assessment System (DAM), hence the in near future it is expected that both OMS and DAM can exchange information between them, and some OMS functionalities can even be integrated into DAM.

Improving OMS and Smart Metering integration

As part of the award winning Smarty City EDPD INOVGRID Project, since 2011 EDPD uses AMI information in order to help the outage related operation in real time.
In summary, the OMS system knows if a given customer has a smart meter, and if that's the case, OMS tries to figure out the neighbors' status, as well as the Concentrator status, located in the secondary substations which feeds the circuit, in order to be able to pin point the most probable faulted network equipment location.

EDP AMI platform is evolving, having considering the rollout of 6 more Portuguese cities with smart metering, and the rollout of 10.000 Concentrators in secondary substation all along the Country.

There is a new LV SCADA system being developed which will naturally be integrated in the OMS's workflow.
Having the rollout of thousands of concentrators, and

1 Under normal conditions, OMS receives about 1000 SCADA events and 1000 Trouble Calls daily, in average.

2 Another important EDP Distribuição Project, submitted to CIRED2015 - #0354 Dispatch Web Application for Field Operation Support.

thousands of smart meters, it is expected that the LV SCADA system may have a smart alarms module, capable of filtering all the alarms and find out where actual outages are occurring even before the customers call EDPD to report the problem. The detected outages will be managed in the OMS system hence implying that an integration between OMS and LV SCADA systems will be developed.

CONCLUSIONS

The success of the OMS upgrade Project was directly dependent on the ability to process the amount of events generated by a major storm in near real time.
Although no severe storm has struck Portugal after the new OMS went live (July 2014), the data obtained during and after all the stress Tests conducted allows EDPD to conclude with great confidence that the new OMS will have the capacity to process all the data, in real-time.

This is a major step towards the objective of EDPD to be able to provide relevant information, in almost real-time, to the regulator, municipals, customers and press. That information includes, but is not limited to, customers affected (globally or per area), installations affected, extension of the network affected (in km), by voltage level.

Another positive consequence of having this type of information available in almost real-time are the new possibilities that emerge and naturally depend on this information, such as, a new Outage Map system available to the general public; new services such as sending useful information proactivity to some customers by smartphone push notifications, email or SMS – Estimated Time to Restore, a new channel for customers report new outages, etc.

Also, from the operation point of view the new OMS system resilience brings some major advantages. The Dispatch Operations will be able to operate more efficiently and the information available will greatly help the Dispatch Operation. After the storm, there will be no need for the extra monumental workload related to the cleaning and normalization of the OMS system.

Finally, having in mind the challenges of the future, the upgrade Project successfully managed to launch the pillars and open the way for future integration with other systems like Damage Assessment, SCADA OMS interface and future LV SCADA platform; and new workflows such as the future dispatch training environment.