NEAR REAL-TIME OUTAGE DETECTION WITH SPATIO-TEMPORAL EVENT CORRELATION

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ABSTRACT

This paper presents an innovative approach to outage detection and management using a big data stream processing system. The system, SINAPSE, enables customers to send power-related events in electricity-powered assets over the internet, correlates such events in space and time to detect grid outages, and provides real-time feedback to customers on known outages.

INTRODUCTION

In conventional low-voltage (LV) distribution grids, outage time is prolonged by the need for human intervention in the detection of outages. Incoming calls to the DSO call center, allowing for outage identification, depend on customers' initiative, which introduces inefficiency in their detection and consequent resolution. This negatively impacts reliability indicators such as SAIDI and SAIFI.

Many industrial customers, however, have vast networks of electricity-powered devices with network connectivity that are remotely monitored (referred to as the Industrial Internet of Things – IIoT – or Industrial Internet [1]). For example, telecom operators have signal amplifiers and optical nodes fed in LV, and often monitor the power status of customers' TV set-top boxes and internet routers. Mobile telecoms' radio stations are also mostly fed in LV and monitored in real-time. Security firms provide alarm services with real-time monitoring, including power outage alerts via email/SMS. All this information is valuable for the DSO as, if received timely and processed effectively, it may provide actionable insight over the status of the distribution grid and allow quick response to restore normal operation.

With the objective of partnering with other service providers to share information and bilaterally improve operations, EDP Distribuição (EDPD) built SINAPSE, a system that offers an open, internet-based communication channel, for customers to easily send energy-related events from their operational control centers to EDPD, and receive automated feedback regarding known incidents in EDPD's network that may affect their operations.

METHODS

SINAPSE implements a set of web services that are available for registered partners to use, enabling them to:
a) Communicate georeferenced power on/off events;
b) Request the status of previously communicated events, namely confirmation on whether they are related to an ongoing network incident, and if so, what is the estimated repair time.
SINAPSE also implements a call-back function that can invoke an external web service when an event status changes, avoiding the need for partners to poll the system to inquire for event status updates.

The incoming stream of georeferenced events is processed in real-time, through an event correlation engine using a sliding window [2] that clusters together events occurring within a given time window (currently 15 minutes) and contained in a predefined geographical radius (presently set at 1 Km). Depending on the diversity of customers communicating these events, the rule-based engine determines whether the clustered set of events configures a probable outage situation.

SINAPSE processes power off/on events from multiple types of partner devices. When events are triggered by a single device that corresponds to an installation ID known to EDPD, that ID is used to identify the geographic location of the event – this is the case with mobile telecom radio towers or broadband optical nodes. In case events are triggered by multiple devices unknown to EDPD, such as set-top boxes in customers' homes, these are identified by their installation postal code. In order to filter out false positives and eliminate privacy concerns, a power off event triggered by customer's devices is only generated when a significant number of devices in the same postal code report loss of power. Note: postal codes in Portugal allow for significant accuracy in geographic locations, typically representing a segment of a street in urban areas.

Information also flows from EDPD back to the customers. For each incoming event, SINAPSE looks for an associated grid incident in EDP's outage management system. If an active incident exists affecting the same geographical area, the incident is acknowledged and an estimated repair time is provided to the customer over the same internet-based communication channel, either on demand (using SINAPSE's web services) or proactively, depending on whether the customer provides EDP with a call-back web service to receive information regarding communicated events.

SINAPSE was implemented by CGI, with an architecture built mostly in open-source platforms and tools: RESTful web services for data communication, MongoDB for big data storage, ESPER for streaming data processing and Node.JS for the presentation layer. Integration with EDPD's outage management system is also implemented via web services for retrieval of known incidents and estimated repair times. Information is compiled and presented in a web-based interface that is available to EDPD dispatchers (figures 1 and 2), providing visibility of LV grid status and incoming events at all times.

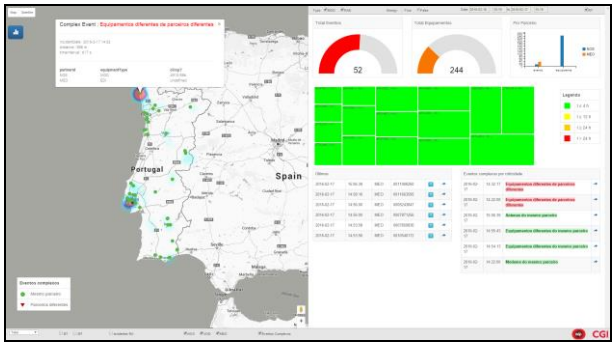

Figure 1 - SINAPSE interface (general view)

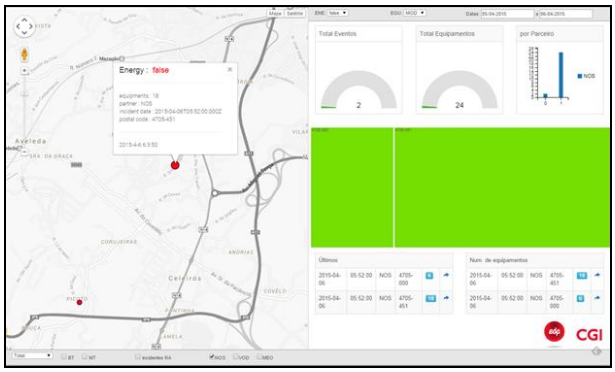

Figure 2 - SINAPSE interface (detail view)

CONCLUSIONS

SINAPSE is in pilot phase with the three major telecom operators in Portugal (Meo, NOS and Vodafone), which currently represent about 1.9 million connected sensors generating events that can be sent to EDPD via SINAPSE.

An initial assessment of SINAPSE events performed using the DBSCAN algorithm [3] indicated promising results, showing clear correlation both in volume and location of events processed in SINAPSE and actual grid incidents registered in EDPD's outage management systems (figures 3 and 4).

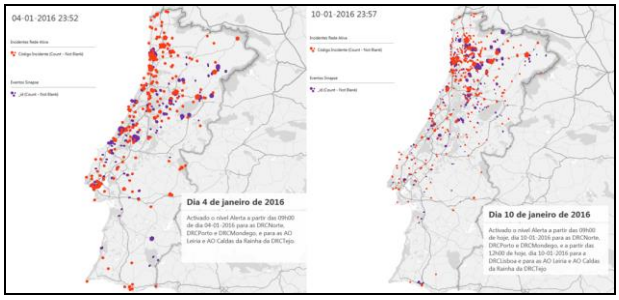

Figure 3 - Geographical distribution of SINAPSE events (blue dots) and grid incidents (red dots) during storms in 4 and 10 of January 2016

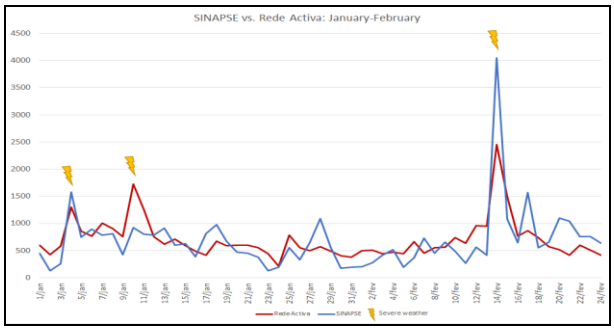

Figure 4 - Comparison of SINAPSE events (blue line) and grid incidents (red line) over time in Jan-Feb 2016

Currently, SINAPSE serves as an additional source of situational awareness for EDPD's dispatchers, who inspect probable outage situations signalled by SINAPSE and decide whether to take action in creating an incident in the outage management system. Conversely, when power on events are reported, operators can decide to close incidents that are still active in the outage management system.

EDPD's future-state vision is that SINAPSE, if proven significantly accurate and reliable during the pilot phase, could be an important source of information in a wider situational awareness platform, eventually generating and closing incidents automatically.

When launched in production, SINAPSE is expected to generate multiple benefits for EDPD:
- Reduction of outage times;
- Reduction of losses associated to regulatory penalties and complaint compensation;
- Optimization of call center operations through the integration of information collected from external sources;
- Improvement in workforce management by near real-time mapping of outage areas based in georeferenced data;
- Improvement in the overall customer satisfaction.

Similar benefits can be expected for partner service providers, who will free up resources by automating processes currently dependent on human intervention, such as monitoring and communication of power outages.

REFERENCES

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[3] H. Tork, 2011, "Spatio-temporal clustering methods classification", *Doctoral Symposium in Informatics Engineering 2012 - Faculdade de Engenharia da Universidade do Porto*, 5-7