Thought leadership
White paper

Smart grid management with CEP

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Executive summary

Swipe your credit card in a place you've never visited before and you might get a call from your bank. That's because financial institutions use Continuous Event Processing (CEP) to spot unusual transactions. Despite processing billions of transactions every day, with CEP they can identify those which may indicate fraudulent activity. Now researchers at Eaton are applying those same "Big Data" techniques to power distribution in the modern smart grid.

Putting data to work

Power outages are hugely disruptive. Consumers are inconvenienced, businesses suffer, and accidents can happen. They send utility companies scrambling to isolate the fault, send out repair crews and return the distribution system to normal operation. It's a costly and reactive approach to system maintenance.

In a concerted effort to raise resource utilization efficiency and improve overall grid performance, utilities have invested heavily in data acquisition technologies. Sensors and Intelligent Electrical Devices, (IEDs) placed at strategic locations throughout the distribution system operate continuously, sending data on a range of operating parameters back to a central location.

Data analysis after an event in the grid often reveals telltale clues of an impending problem. Had they been spotted earlier, preventive work could have been planned and undertaken before failure occurred.

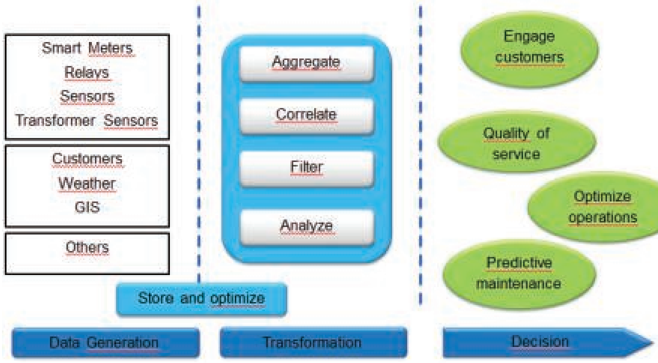
It's impractical to manually scrutinize data from IEDs. There's too much and it would take too long. But what if monitoring techniques used by credit card companies could be applied? That's the thinking behind Eaton's adoption of Continuous Event Processing (CEP). CEP is a powerful tool for enhancing a utility company's preventive and predictive capabilities.

This White Paper discusses how CEP builds on the massive investment already made in data capture. It explains how utilities can better utilize scarce and expensive resources with CEP and highlights opportunities to improve ROI from "smart" devices

Big data and Smart Grid

The modern electric grid is large and complex encompassing generation, transmission, distribution and consumption. (The IEC Smart Grid Standards Map provides a useful reference.) Demands and flows vary rapidly and sometimes unpredictably. Utility companies have invested heavily in a new generation of devices as a means of getting more and higher quality data about what's happening in this system at any given moment. For example, a power line-mounted IED can transmit a range of current and voltage data along with information on its own status. Depending on the data density sought, this can happen hourly or even every minute.

Powering Business Worldwide



Digital transformation in smart grid

This operational data, along with a range of non-operational data, is concentrated and directed to real-time data acquisition systems such as Distribution Management System (DMS), Supervisory Control and Data Acquisition (SCADA) to name a few. These systems channel the data into databases employing classic query languages (such as SQL) for interrogation.

While sufficient for relatively static situations, these databases are inadequate for the dynamism of the modern grid. More specifically, search inquiries are too slow for real-time detection of abnormal or "interesting" situations.

This is a classic "Big Data" problem. How to identify the interesting signals signifying a deviation from normal operations among a torrent of routine data that merely confirms normal operation is being maintained?

IBM defines Big Data as that which, "... cannot be captured, managed and/or processed using traditional data management components and techniques." (The Oxford English Dictionary uses something very similar.) Many computer scientists take a broader definition, asserting that Big Data is that which has volume, velocity, variety, and veracity.

"Volume" refers to having terabytes or more of data available for analysis. "Velocity" references the rate at which new or additional data is being received, and "Variety" means that it takes many forms, both structured and unstructured. Many authorities add a fourth "V" – "Veracity," meaning there may be uncertainty about data completeness or consistency.

In the case of modern grid systems, data comes from many sources and amply meets the four "V's" definition. In addition to the multiple devices deployed through the "smart" grid, data comes from Geographic Information Systems, (GIS,) weather services and also customers who phone, email or text reports.

Continuous Event Processing (CEP)

In such a dynamic environment, the challenge is transforming this data into actionable information. This is the role of Event Processing.

An event is, quite simply, something that happens. According to CIRED white paper presented at the workshop, from a strictly academic perspective, events have temporal properties in that occurrence and detection normally occur separately. However, in this paper, they are considered as simultaneous.

An event is an occurrence that changes the state of something. In power distribution, it could be that current stopped flowing, a relay opened or that a device battery reached a critical level of discharge. Events have both temporal and spatial characteristics, (they happen at a time and place). Data about events splits into three types: operational, non-operational, and event messages.

Example of event in the grid generated by a fault current indicator

Going further, a complex event is one that can only happen if other events preceded it. It follows an "if – then" relationship. To use a simplistic example, if a high wind blows, then a tree falls. If a tree falls on a power line, then an outage occurs. Thus, the actual outage is a complex event.

In complex systems like power grids, events are occurring all the time. However, they usually conform to a predictable pattern. Event data is fed via real-time data acquisition systems into searchable databases. Once stored, the database may be queried to identify deviations from these typical patterns. Clearly though, such analysis is after the fact and so too late for preventative action.

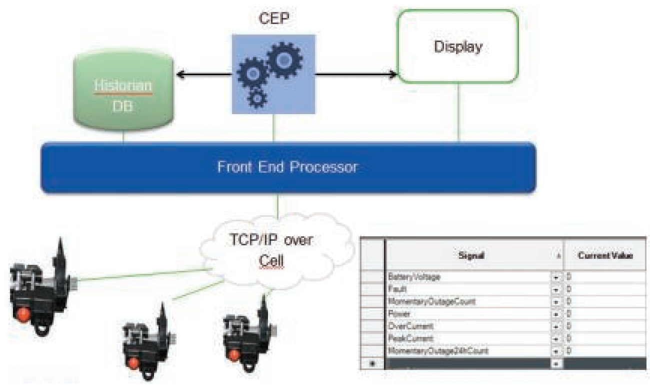
CEP turns the concept of a database system on its head. Rather than storing data to allow searches for patterns, CEP performs the pattern searching as data is received. Data storage becomes the secondary activity rather than the primary.

CEP arose out of research at Stanford University in the late 1990s and was first put to work in the finance industry. In this classic Big Data environment, there was a need to identify the occasional incorrect or fraudulent transaction among billions taking place each day. CEP was later taken up by the credit card industry who use it to detect deviations in the normal patterns of card usage.

CEP architecture

In CEP there are event producers, an event processing engine, and event consumers. In power distribution, event producers are IED's and the other sources identified above. These supply time-stamped information to the event processing engine. Event consumers are those needing information about where changes are occurring that require a response. (Where changes conform to a normal pattern of events there is no need to react.)

The event processing engine sits between producers and consumers and continuously queries the incoming data stream. Using temporal and logical operators as well as causal relationships, it correlates events and recognizes deviations from normal patterns



General architecture of a CEP

Real-world impacts

In power distribution grids, CEP takes data from the many "smart" devices already deployed and creates a "smart" grid. This enables a proactive response at the first indication of problems, rather than rushing to locate and respond to faults after they have occurred.

To give an example, while trialing CEP a utility company identified a particular transformer that was overloaded before it failed. Replacement was scheduled and carried out with no interruption to the supply. In this scenario, CEP was integral to expressing failure patterns and detecting them in real time. Without it, the transformer would only have been replaced after failing.

Other observed gains included a dramatic reduction in customer complaints about voltage surges and drops and neighborhood outage detection 30 minutes before the first resident called the utility.

For utility businesses, such capabilities have a huge payoff. Fault location becomes faster and more precise, reducing response time. Maintenance and repair activities are scheduled for normal working hours and when weather allows, rather than being carried out in adverse conditions and at premium rates. Customers may view the utility more favorably than before, perhaps reducing the extent of regulatory oversight and possible intrusion. Most importantly, the business starts to proactively utilize data from the many IED's installed, rather than just gaining a better understanding of why a problem occurred.

CEP: The missing piece?

In recent years, electricity utilities have invested heavily in data acquisition technologies, expecting them to raise resource utilization efficiency and improve overall grid performance. Today, large numbers of IEDs transmit valuable data to real time data acquisition systems. However, analysis depends on retrieving this data from relational databases, and so it is inevitably too late for a planned, proactive response.

Implementing CEP gives utility businesses the ability to detect changes in the patterns of naturally occurring events throughout the grid. "If-then" correlation identifies when problems are likely, enabling appropriate actions in a controlled and measured way. As discussed, benefits include improved resource utilization, better grid performance, and increased ROI from the IEDs.

About the author

Foued Barouni is a Product Manager at Eaton in Quebec City, Canada and he is involved in sales and marketing projects of grid automation solutions. His work experience includes design and engineering of communication and data acquisition systems for distribution, transmission and generation assets. He has special interests in IIOT, substation automation, Big Data and Analytics. Foued Barouni is a graduate of Computer Science Engineering from the INSAT Institute of Tunisia (Bachelor) and Laval University of Québec, Canada (PhD). He is also IEC TC57 Technical Expert.

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