IoT-based applications in power grids

Analyzing and visualizing data – and using them intelligently

Intelligent components and a wide range of other sensors generate large amounts of data at various points within the power grid. With IoT technologies, these data can now be used with a far greater level of detail than ever before, which in turn makes it possible to meet the increasingly complex requirements for secure grid operation. This can be seen in systems such as the new Grid Diagnostic Suite from Siemens, which contains four cloud-based applications for an extremely wide range of different uses, covering all voltage levels in electrical power distribution.

Fig 1. The Sicam Navigator app makes possible the comprehensive monitoring of secondary substations

Powr grids are subject to major challenges as a result of the energy revolution. At the same time, digitalization is opening up new ways to overcome these challenges. While electrical energy distribution is becoming increasingly complex, the related systems are also becoming more and more intelligent. With the Internet of Things (IoT), cloud-based applications now mean that more data than ever before can be conveniently accessed and then used constructively for a wide range of applications. This also makes it possible to map details right down to bay level and to the level of individual components.

Dipl.-Ing. (Univ.) *Robert Kirkman*, Head of Innovation & Digitalization at the Digital Grid Business Unit, Siemens Smart Infrastructure, Nuremberg, Germany

Control centers are designed for the monitoring and control of the main flows – that is, for use on a large scale for the power-system management. The use of IoT technologies means that these centers now receive a deeper insight into the infrastructure, as well as access to the largely unmonitored medium- and low-voltage range of electrical energy distribution. In fact, it is this area that will probably pose the biggest challenges in the future – for example in relation to decentralized grids.

Siemens has been offering appropriate IoT-based solutions for energy automation since 2018. These tap into the specific potential via simple plug-and-play technology, with no need for any costly engineering. The actual benefits of these solutions can be highlighted with reference to four specific applications: the monitoring of medium- and low-voltage grids, for example in secondary substations; the collection and visualization of operating data from protection devices; quick and efficient fault localization in power lines; and the guaranteeing of power quality in industrial and other grids.

Collection and visualization of operating data from protection devices

Protection devices, such as those used in high- and extra-high-voltage transmission and distribution grids, are of course connected to a control center. If a switch trips, for example due to overloading or a short circuit, the incident is displayed in the control center. From this moment on, every second counts as the fault needs to be rectified as quickly as possible. However, a normal day usually goes as follows: The service technicians must first retrieve the basic information from the control center before traveling to the fault location to find out more details. Only then can they start working on rectifying the fault.

A cloud-based app, on the other hand, creates a parallel transmission path that is independent of the control center and that can be used to transmit not only the actual error message but also all operating data from all connected protection devices. Two specific examples of such data are fault records and malfunction message buffers. The data are transmitted to the cloud, where they

Fig 2. Developed for distribution systems with overhead lines, the Sicam Localizer app provides a clear and transparent display of detailed information regarding the status of individual grid segments

remain available for retrieval. The data can therefore be displayed on any browser, including mobile devices, meaning that technicians have access to extremely detailed information right from the start. Not only does this make day-to-day work significantly easier; in the first place it also leads to quicker fault rectification, and not least to reduced costs.

The corresponding Siemens app Siprotec Dashboard displays the data clearly in the form of a map, station or device view, or as a diagram. The app's intuitive navigation means that it can be used without any specific training. The Siprotec Dashboard also provides additional insights into compact status monitoring parameters, such as thermal energy, due to the connected residual current (I2t) or temperature hotspots on transformers or in switchgear, thereby providing the service technicians with extremely helpful indications for the early assessment of the situation on site. Another benefit of the app is that the user can quickly see whether all the firmware versions of all protection devices within a substation, or even the entire grid, have the same current status.

Monitoring secondary substations and medium- and low-voltage grids

Control-center systems do not record data from secondary substations and wired medium- and low-voltage grids down to the very last detail. The Sicam Navigator app (*Fig. 1*) can contribute here by allowing comprehensive monitoring designed specifically for this area. In this application, IoT technologies help to ensure that faults caused by overloading or short circuits can be rectified as quickly as possible, or even prevented altogether.

The app provides detailed information regarding messages, alarms, and specific grid parameters, making it possible to clearly depict the performance of the power grid. This allows the operating company to assess where the dimensioned outputs of low-voltage grids are reaching their limits as a result of increasing electric mobility, making it possible to schedule appropriate expansion measures in good time. The affected grid section can also be accurately located in the event of a fault.

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Fig 3. The new Grid Diagnostic Suite comprises a total of four different cloud-based applications that are able to use devices already installed in the grid as well as new, intelligent devices to record data and analyze them in the cloud

Further examples

Another Siemens app has been designed specifically to provide quick and efficient fault localization in power lines: developed for power distribution systems with overhead lines, the Sicam Localizer (*Fig. 2*) provides a clear and transparent display of detailed information regarding the status of individual grid segments and any failures that may be present. Individual operating values, such as phase currents, can also be displayed. This means that a service team can be deployed to exactly where the problem has occurred, such as in the case of windthrow in a forest and can quickly restore the normal operating state. Used in conjunction with the Sicam Navigator, the Sicam Localizer helps increase the availability of the power supply, minimize or even prevent power failures, and improve capacity for the scheduling of service work.

Last but not least, the use of the app makes it possible to improve or guarantee the quality of supply or the power quality (PQ). This is of particular importance for operators of industrial electricity grids, where significant damage can be caused by typical issues such as supply voltage deviations, harmonics, voltage dips, or transient disturbances. These issues can be prevented with PQ Advisor Premium, which records grid parameters such as electrical voltage or frequency across geographically dispersed locations every minute without interruption, and then clearly displays them on a dashboard. A traffic light display indicates when tolerance limits have been breached, allowing users to implement the necessary measures in good time in the event of anomalies. PQ Advisor Premium also allows users to analyze energy consumption and to implement appropriate optimization steps.
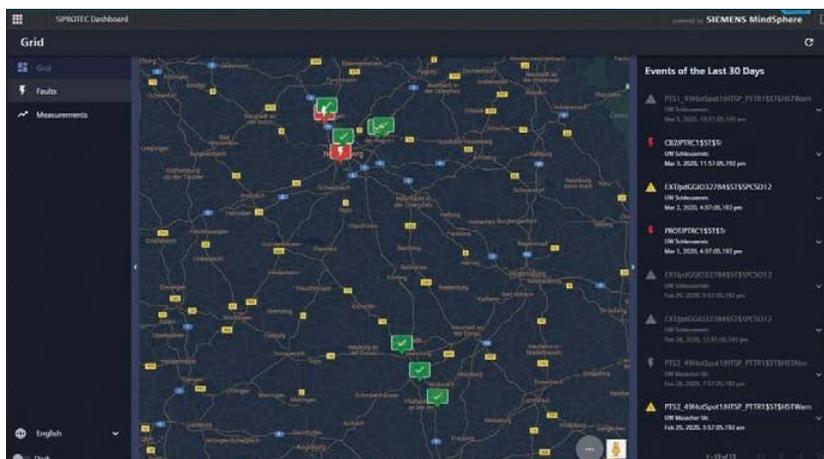

Fig 4. The Siprotec Dashboard gives users a quick and simple overview of the installed protection devices

The new Grid Diagnostic Suite

The new Grid Diagnostic Suite from Siemens comprises the cloud-based applications Siprotec Dashboard, Sicam Navigator, Sicam Localizer, and PQ Advisor Premium (*Fig. 3*). The necessary data are recorded and delivered by intelligent, communication-capable products and solutions from the Siprotec and Sicam portfolio for power system protection, station automation, and power quality and measurement. It is also possible to integrate devices from other manufacturers, provided that these are able to record the relevant data and communicate them in accordance with the applicable standards.

Cloud communication takes place securely to the open Siemens Cloud MindSphere via the standardized protocol OPC UA PubSub (IEC 62541). Once in the cloud, the data are also available for further evaluation and analytics.

With the station-specific application Siprotec Dashboard (*Fig. 4*), device data are transmitted via Sicam Grid Edge, one of the data concentrators and gateways installed in the station. This makes it very easy to ensure the IoT compatibility of existing systems without having to make any changes to the device firmware or configuration.

Sicam Grid Edge also makes possible data transmission in line with the most stringent requirements with respect to grid security, while also allowing for the simple management of certificates and the continual authentication and encryption of data.

Overview of the benefits of the applications:

- Quick overview of the power automation systems for the entire grid
- Increased availability of smart grids and greater cost efficiency
- Preventive maintenance and improved service quality
- Independence from the manufacturer, thanks to IoT standards

robert.kirkman@siemens.com

www.siemens.com/ioe

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