[Industry Solution]

Real-time Historian for Synchrophasor Data Management

Wonderware® by Schneider Electric

During the widespread Northeast blackout of August 2003 millions of people from Ohio, to Ontario, Canada and east to New York City were left without power for anywhere from several hours to almost four days (Hoffman, 2013)[1]. The catastrophic loss of power cost the United States economy an estimated $4 to $10 billion (Final Report, 2004)[2]. The event exposed vulnerabilities of the electric power grid and highlighted the need for increased wide-area visibility and situational awareness among electric power providers.

With power outages costing the U.S. economy between $18 and $33 billion a year, it is critical for electric utilities to take every action to deter avoidable outages and ensure that an event like the blackout of 2003 does not occur again (Economic Benefits, 2013)[1]. In the 11 years following the blackout, much has changed. New regulations, including the Energy Policy Act of 2005 and the Energy Infrastructure Security Act of 2007, were enacted to increase compliance with reliability standards while increasing power grid resiliency (Hoffman, 2013)[1]. Endless reports detailing the causes and total impact of the blackout were published alongside recommendations for industry improvements.

Significant grid modernization investments continue to be made in an effort to avoid similar large scale blackouts; power companies are adopting new technologies that streamline processes, automate actions, analyze data streams and enable smarter decisions in real time. Utilities are gaining more insight on grid conditions that is leading to better management of T&D assets and systems. Transmission efficiency is improving through increased situational awareness and ultimately, customer service is being improved through the avoidance of outages.

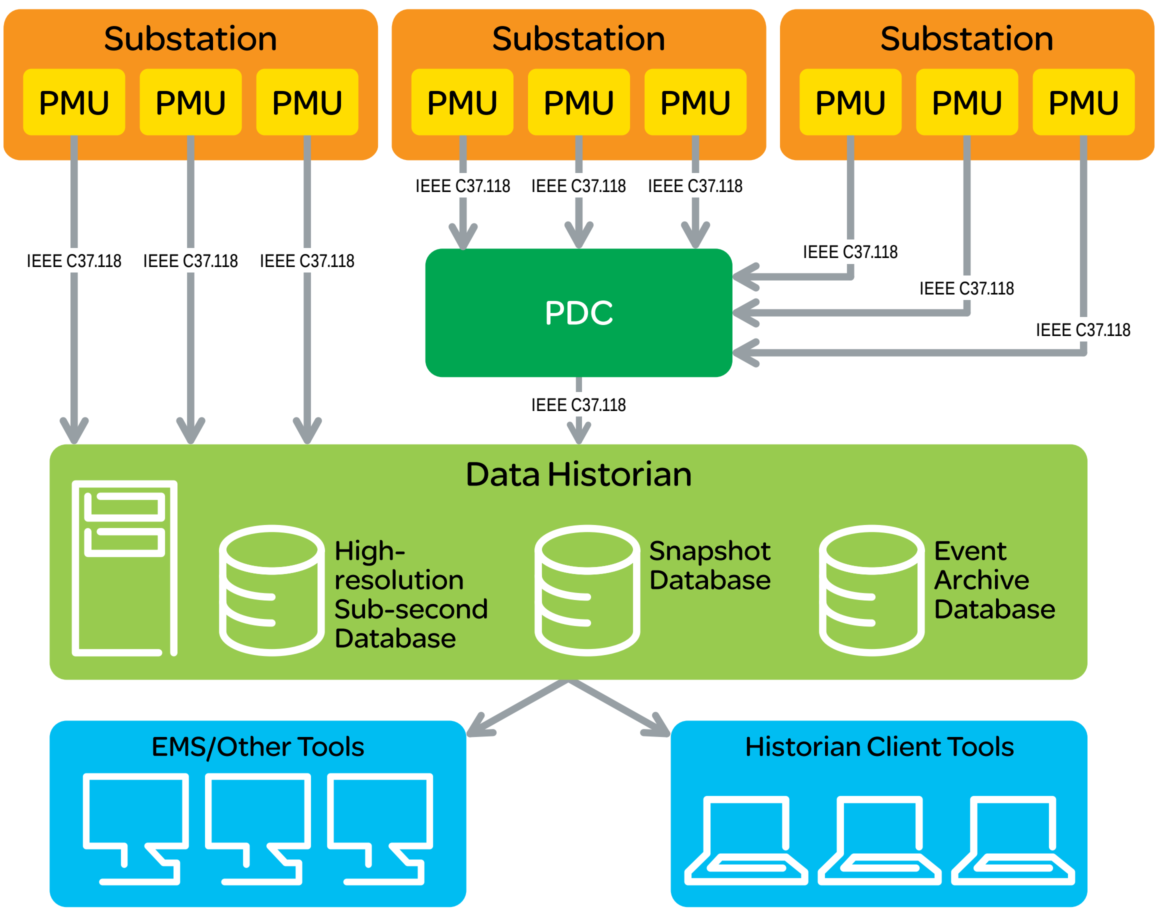
Wide-Area Measurement System Components

One investment creating significant advancement in the modernization of the power grid centers on the deployment of wide-area measurements systems (WAMS). WAMS improve grid performance and help deter major transmission issues that can disrupt service by providing increased system observability and situational awareness. WAMS are becoming more important today because of the growing diversity of power sources and lower predictability levels of renewable sources (Rhodes, 2013)[3].

WAMS are comprised of phasor measurement units (PMUs), phasor data concentrators (PDCs), communication networks, and centralized data collection and analytic systems (real-time historians). The components work together to provide grid operators with real-time insight on grid conditions. A PMU is a piece of hardware installed at a substation that is responsible for gathering data about voltage, current and magnitude of electrical waves on the transmission grid. The IEEE C37.118 standard allows sampling rates from 10 to 120 per second. Grid operators and engineers use this data for a number of online and offline applications related to grid visibility, stability, resiliency, transmission and forensic analysis, among others.

Once the data has been collected, it is transferred to a PDC and is aggregated into a single data stream for use by power companies across geographic areas. The data is time-coordinated through a GPS time stamp and becomes known as a "synchrophasor," detailing the magnitude and angle of the phase vector, the time of the sample and the accuracy of the time stamp. The time stamp is used to calculate energy flow and assess "grid health" and also allows utilities across and within regions to correlate and share information, giving them wide-area visibility of grid conditions (Rhodes, 2013). Once aggregated in the PDC, real-time historian software collects and archives the data while making it available for advanced analytics and visualization to improve situational awareness. A historian can also interface directly with PMUs and archive data from other systems, including Supervisory Control and Data Acquisition (SCADA) and Energy Management Systems (EMS), to provide additional measurements and insight into how the grid is performing.

Synchrophasor measurements were developed in the late 1980s, however, the technology adoption rate has been slow until recently. With an increasing interest in diversifying energy sources, reducing outages and building a more resilient and reliable grid, synchrophasor projects are being funded by the U.S. government and are becoming more widely implemented. According to the Department of Energy, the number of installed PMUs has grown from less than 200 in 2009 to more than 1,700 today (Hoffman, 2014)[4].



Synchrophasors Require Massive Data Storage Capabilities

The magnitude and velocity of synchrophasor data can easily become overwhelming to even the most experienced grid operators. A SCADA system is not equipped to handle synchrophasor data because of the sheer velocity of sampling and recording required to identify subtle grid oscillations. Rather, centralized real-time historian software is needed to manage the volume and velocity of data generated from WAMS. Real-time historian software is preferred for WAMS data because of its abilities in data storage, short and long-term archiving, time-series data aggregation, reporting capabilities and analysis functions (Rhodes, 2013)[3].

In order to keep analytical systems and computer networks from becoming too stressed, best practices suggest storing raw synchrophasor data online for a period of about three months. However, time-aligned "snapshot" data and event/disturbance data requires less storage and is typically kept in an online archive for many years. The primary reason to maintain different archives is because the use of the information varies. For example, when a disturbance occurs engineers will typically want to view the trends leading up to the disturbance and overlay multiple disturbance events on the trend.

Wonderware eDNA Real-time Historian

Wonderware® offers the eDNA real-time data historian for synchrophasor data capture, storage and analysis from PMUs. The high-speed eDNA synchrophasor data collection service archives up to 100 samples per second per data stream via the IEEE C37.118 protocol. Each high-speed collection node gathers data from PMUs and PDCs and is designed for efficient archival and fast data retrieval. As an enterprise historian, eDNA also securely integrates with numerous critical control, monitoring and smart devices in addition to other business systems.

Features and Benefits

- Scalable architecture that aggregates operational and business data through standard interfaces for a comprehensive, enterprise-wide view
- Collection and management of high-speed synchrophasor data to increase situational awareness and grid observability
- Highly available, fully redundant architecture and lossless data compression for a continuous flow of data
- Configurable archives for full-resolution, snapshot and event data for efficient storage and quick retrieval
- Advanced user applications for organization, analysis, visualization and reporting of data to increase awareness of grid conditions and identify subtle grid oscillations
- Real-time event capture based on phasor alarms, user-configurable calculations and manual triggers for notification of instabilities and analysis of the sequence of events leading to the fault

Historian for Synchrophasor Data Management

Real-time historian software is an essential application to a successful WAMS project, providing power transmission companies with the tools required to gain the highest return on synchrophasor data. When implementing a WAMS, it is important that the utility selects a real-time historian that has a proven capability to manage synchrophasor data. Utilities should ensure that the historian of choice uses highly secure data storage and archiving techniques while meeting NERC CIP requirements in addition to transferring information through the standard synchrophasor protocol IEEE C37.118. Scalable real-time historian software with low latency, high-availability and redundant configurations minimizes data collection, storage and retrieval challenges while creating opportunities for new applications and uses of the data through advanced client tools.

Real-time historians simplify the data collection process by gathering multiple streams of data into one centralized system. Without a real-time historian, engineers would have to analyze synchrophasor data from multiple different files and sources, all of which would be uniquely formatted and could require significant exporting, file parsing and time alignment. It could take days for an engineer to compile such information for analysis. Instead, a historian is able to interface directly to the PMUs and/ or PDCs to efficiently and accurately collect the synchrophasor data.

Utilities require different resolutions of synchrophasor data for various use cases including real-time operations, root cause studies and event analysis (phase angle separation, frequency excursions, etc.). Special database provisioning is needed in order to achieve rapid retrieval from historical archives, in addition to real-time services. Real-time historian software is equipped with advanced archiving capabilities to handle the specific data storage and retrieval requirements of WAMS. For example, a historian can be configured to easily retrieve, display and trend raw data, snapshot data and event data.

Visualization and Alert Notifications

Organizations gain additional value by using the enterprise real-time historian to display synchrophasor data in view screens, trends and reports that grid operators can easily understand. With access to the synchrophasor data through a historian, users are able to react to disturbances quickly and with more information to avoid potential service outages. Some visualization methods include phase-angle compass charts, trend plots and geospatial contour maps. These visualization and analytic tools are designed to identify grid stress points in real time, allowing for quick and informed decision-making by grid operators and engineers. In addition, the historian software makes this information available to all authorized personnel within the enterprise.

Historians can also provide alerts to grid operators when an issue occurs, enabling immediate responses to maintain grid stability and to avoid further problems. A data point stored in the historian not only has a value, a timestamp and a status, but also contains a range of values that will notify a user if the point is reaching alarm status, currently in alarm or exiting alarm status. If a value exceeds a specified threshold, an alarm in the form of an email, a sound or a visual alert, will be sent to the appropriate personnel. Alerts can also be created with an expression, wherein an alert would be triggered if two or more data points reach specified thresholds. Alerts are characterized by the value's deviation from its normal operating range, with high values referring to a value that is above the normal range. One way of characterizing an alert is as follows: High Out-of-Range, High Alarm, High Warning, Low Warning, Low Alarm, and Low Out-of-Range. Configuration difficulty and customization capabilities vary depending on the historian software being used.

After an issue has been identified by the data historian, operator reactions are determined by the plant's protocol. However, alarm notification emails can be configured to include reports, trends and any other information necessary for determining the correct action. For example, the customizable email could include a list of steps to be taken should a value reach a certain threshold. Some systems work with a remedial action scheme that details appropriate actions.

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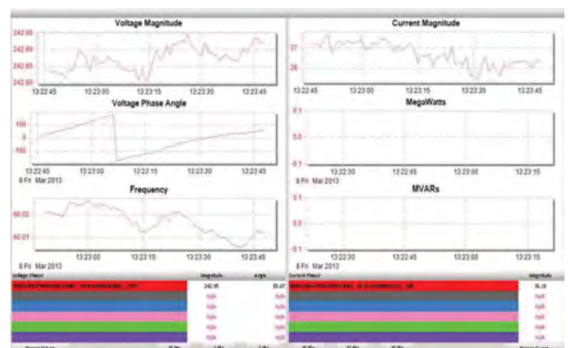
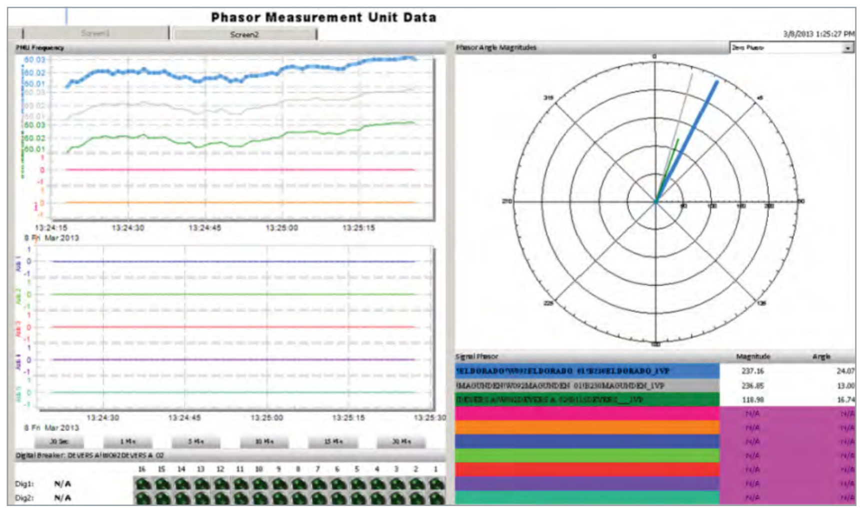


For example, engineers can use real-time historian software to create view screens that display frequency and rate of change of frequency, magnitude and angle of a phasor in real time. Appropriate personnel are immediately notified when collected measurements begin to diverge or deviate from normal conditions. Grid operators can then take action to correct grid oscillations or other problems that could lead to service interruptions. The engineers and operators are also able to use real-time historical data trending capabilities for further analysis to prevent similar issues in the future.

When dealing with real-time monitoring and alarming, PDC latency can be of concern and varies with the communication network. PDC latency of a few seconds is acceptable. However if the latency is any longer, all data for the station would be marked unreliable until new data is retrieved. The operator monitoring the system would be immediately notified of the latency.

Real-time enterprise historians provide hundreds of interfaces, many of which are based on industry standard protocols, which ensure that investments in smart grid technologies are maximized and can be integrated with other operational and business systems.



Flexible and Scalable Integration

As with all T&D technologies, the ability to interface with new and legacy systems is critical. All hardware and software must continue to be compatible as new technologies are introduced and adopted. A challenge with managing synchrophasor data in SCADA is that it does not easily translate the information to other applications. WAMS real-time data and disturbance events must also be analyzed by planning, operations, maintenance, trading and management, all of which have different needs to make decisions and a real-time enterprise historian has the most comprehensive suite to communicate to these groups and systems.

These can include SCADA and substation automation systems, state estimation and load forecasting systems, analytics, power purchasing systems, and others to provide measurements and insight into how the grid is performing holistically. For instance, one clear benefit is that the state estimators can leverage state measurement values from the historian to provide more accurate forecasts in any section of the grid. With this improvement, market operations can be more confident in the delivery and purchase of power.

Case Study

One leading U.S. transmission and distribution utility has expanded the use of its eDNA real-time historian software to manage its synchrophasor project data and make the information available company-wide. This phasor project involves the deployment of PMU devices in 500 kV and 230 kV substations throughout the utility's network. The utility obtains underlying grid conditions from the PMUs through the IEEE C37.118 protocol at a minimum sampling rate of 30 samples per second and collects the data into eDNA using lossless data compression.

The synchrophasor data is archived in eDNA in its raw collected form with high-resolution and is stored for up to 90 days. One second snapshot data is stored for as long as 10 years. The PDC/historian interface can also detect disturbance events and store the data in the event historian with the event record so users can query the database for post-event analysis.

Once the information is collected and stored in eDNA, grid operators and engineers can query the system for synchrophasor data analysis and reporting to help increase visibility into operations. eDNA historian software provides high-availability as it is configured with symmetric redundancy, meaning there could be multiple points of failure but the data would remain available.

In addition, eDNA accommodates information from other sources such as energy management systems and non-electrical system data (weather, traffic, fire, earthquake, etc.). This system provides the grid operators with visibility into power system dynamics and a real-time wide area view of the grid.

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Conclusion

The U.S. power industry has made significant strides since the Northeast blackout of August 2003 that impacted approximately 50 million people in North America. As WAMS projects are being deployed, the demand for advanced, secure technology solutions is continuing to grow. Because of the high-velocity data streams associated with synchrophasor projects, highly reliable and scalable enterprise real-time historian software is required for effective data management including collection, storage, visualization, analysis and reporting. Successful management of the data allows grid operators and engineers to make quick and informed decisions that solve grid transmission problems and help prevent the occurrence of disturbances and wide-spread blackouts.

Common benefits from synchrophasor data management projects include increased situational awareness, improved observability and identification of transmission issues and instabilities. Because of improved situational awareness and observability, transmission capacity can be determined in real time and energy loss can be minimized as transmission lines can be ran at optimal levels. Synchrophasor technology identifies grid issues and immediately alerts grid operators of any disruptions, leading to a better service experience for consumers. Users can also determine the cause of faults and their sequence of events by analyzing the high-fidelity, time-stamped synchrophasor data. Engineers and operators can review reports and trends over time to ensure that grid events are not repeated. Operations and maintenance costs are reduced through grid reliability and efficiency improvements. Ultimately, synchrophasor technology is only as useful as the resulting actionable insights.

References

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