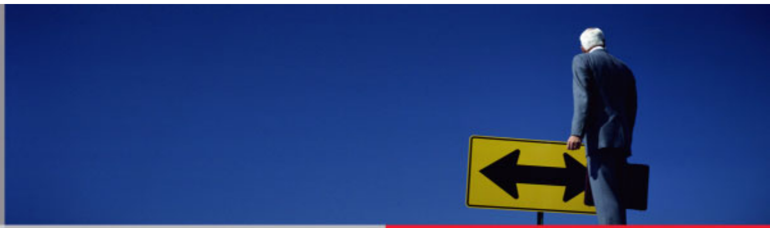
A Framework for Smart Grid Analytics and Sensemaking: The Mehta Value



Redguides
for Business Leaders

Lisa Sokol, Ph.D.
Steve Chan, Ph.D.

- Learn about an analytics-based solution for effective power grid management
- Discover how to improve outage detection and prediction
- Make better, more timely smart grid business decisions using the analytics data

Redbooks

Executive overview

The growing complexity of electric power grids requires innovative solutions to effectively manage power grids and to enhance grid security and stability. Predictive modeling software can use the historical data to discover, among other things, failure order, failure relationships to components, and predictors associated with failures.

This IBM® Redguide™ publication proposes a dedicated *ad hoc synchrophasor network* that is embedded within the smart grid. This synchrophasor is a device that can measure, combine, and analyze the time-stamped measurements from various locations on an electric power grid. The proposed *Smart Grid Analytics and Sensemaking* framework is based upon various devices, data, and analytics.

A smart grid is really an ecosystem of large interconnected nonlinear systems. This proposed solution instance focuses the use of context-awareness analytics to maintain correct values (current and historical) for nodes and edges. Key to the analytics is the use of the *Mehta Value*, which is composed of a base reference, drift, and context-referenced phase angle data. Real-time decisions, such as load shedding or pathway selection, can then be made based upon the combination of contextually correct data and analytics, such as the Mehta Value.[1] The streaming data within the electrical grid can be used automatically by various Smarter Grid Analytics.

Using the Smart Grid Analytics and Sensemaking framework described in this guide, smart grid managers can:

- Provide a context awareness to generate solutions that create an optimal, reliable, and stable network
- Reason and make sense of observations as they present themselves
- Make better, more timely business decisions, while the observations are still occurring
- Use the Mehta Value as a base reference to help make real-time decisions, such as load shedding or pathway selection

[1] The notion of the *Mehta Value* was introduced at the North American Synchrophasor Initiative (NASPI) 22-24 October 2013 meeting in Chicago with Dick Dickens, a Design Engineer at Mehta Tech, and Dr. Steve Chan.

Addressing the growing complexity of electric power grids with innovative contextual solutions

As organizations address the growing complexity of electric power grids, context-referenced data on phasor[2] measurement units (PMUs) is key to any robustly scalable and extensible solution for an electric grid. *Context* is the cumulative history derived from data observations about smart grid entities and their attributes (such as voltage, phase angle). This context is a critical component of the analytic decision process. Without context, grid network stability conclusions and infrastructure modification decisions might be flawed. By using context analytics to take advantage of grid big data, grid managers can discover trends, patterns, and relationships. Sensemaking can use these insights to help energy producers and sellers to make fact-based decisions so as to anticipate and optimally shape business outcomes.

There are more granular real-time streaming data generated by smart sensors and meters along energy production, transmission, and distribution system pathways than ever before. The data can be aggregated around each of the entities types (network segments, current, waves, measuring devices, and source devices) that form an electric grid. This cumulative data can provide what is commonly called *historical context*. Historical data repositories can be used to create an understanding of historical behaviors, inter-dependencies, and outcomes.

There is a critical need for time-synchronized data recorders that can be used to create wide-area visibility and situational awareness to address power grid problems before they propagate. Improved historical analytics can create deep forensic understanding of power grid behaviors and their inter-relationships. Operators and those who broker electric grid output can use the insights gained though forensic analytics to create effective real-time monitoring tools. In essence, forensic insight can be used for predictive insight.

The volume and velocity of electric power grid data certainly places the sector in the realm of big data. The streaming data generated by phasors will be invaluable for utility management. Each and every streaming data element is potentially interesting and should be taken advantage of using context-based smart grid analytics, thereby enabling continuous insight.

Context awareness

Context is the cumulative history derived from data observations about entities and includes several basic building blocks. Context *entities* are generically defined as people, places, and things. For this use case, entities are both the nodes (for example, substations) and edges (for example, transmission lines) in an electric grid. Entities also have *attributes*, such as voltage, wave size, and wave direction, and attributes can have *values*. Context is defined as a better understanding of how entities (for example, nodes and edges within the grid) relate. Cumulative context is the memory of how entities relate over time.

[2] A *phasor* is any type of device that measures the electrical waves on an electrical grid.

The need for accurate context awareness

The electrical utility industry is the predominant provider of electric power within most countries. The electric companies control generation, transmission, and distribution of electric power. An important concern of utilities has been *reliability*. A secure, stable, and reliable uninterrupted supply can be achieved through the use of protective devices and teleprotection systems. These devices and systems prevent damage and preserve the supply systems' stability, so as to avoid failure.

One method to prevent degraded and impeded performance, using teleprotection systems (protective relays in conjunction with telecommunication channels) is to provide the optimal means of selectively isolating faults (on medium/high/super high voltage transmission lines, power transformers, variable shunt reactors, and so on). The teleprotection systems can automatically disconnect the faulted section and transfer command signals reliably using the most optimal pathway. Given appropriate data, the teleprotection systems can quickly engage in tripping (thereby reducing transmission line damage) the faulted section. These systems also attempt to avoid overtripping so as to maintain the stability of the power system. The amalgam of security, dependability, bandwidth (that is, data rate), and transmission time are interrelated and competing conflicting parameters. High security, high dependability, low bandwidth, and low transmission time are competing requirements.

Ideally, the decision to modify a power system should be made on the basis of an assessment of current grid measurements and the time-stamped history of each of these grid measurements. One type of common measurement on the grid is that made by a Synchrophasor. Using a specific Synchrophasor's measurements (current and historical) must include the measurements (current and historical) of nearby Synchrophasors. This combination of current and historical localized grid Synchrophasor data creates a context for the Synchrophasor of interest.

Smart grid analytics can take advantage of contextually correct data and generate solutions that create an optimal, reliable, and stable network. Real-time decisions, for example, load shedding, can then be made based upon the combination of contextually correct data and analytics. The decisions can indicate the need for configuration changes and point out the need for additional data collection. Decision making is optimized when context awareness is provided by a Sensemaking paradigm.

Figure 1 presents a high-level framework for the envisioned Smart Grid Analytics and Sensemaking infrastructure, based upon various algorithms, heuristics, methodologies, tools, and devices.

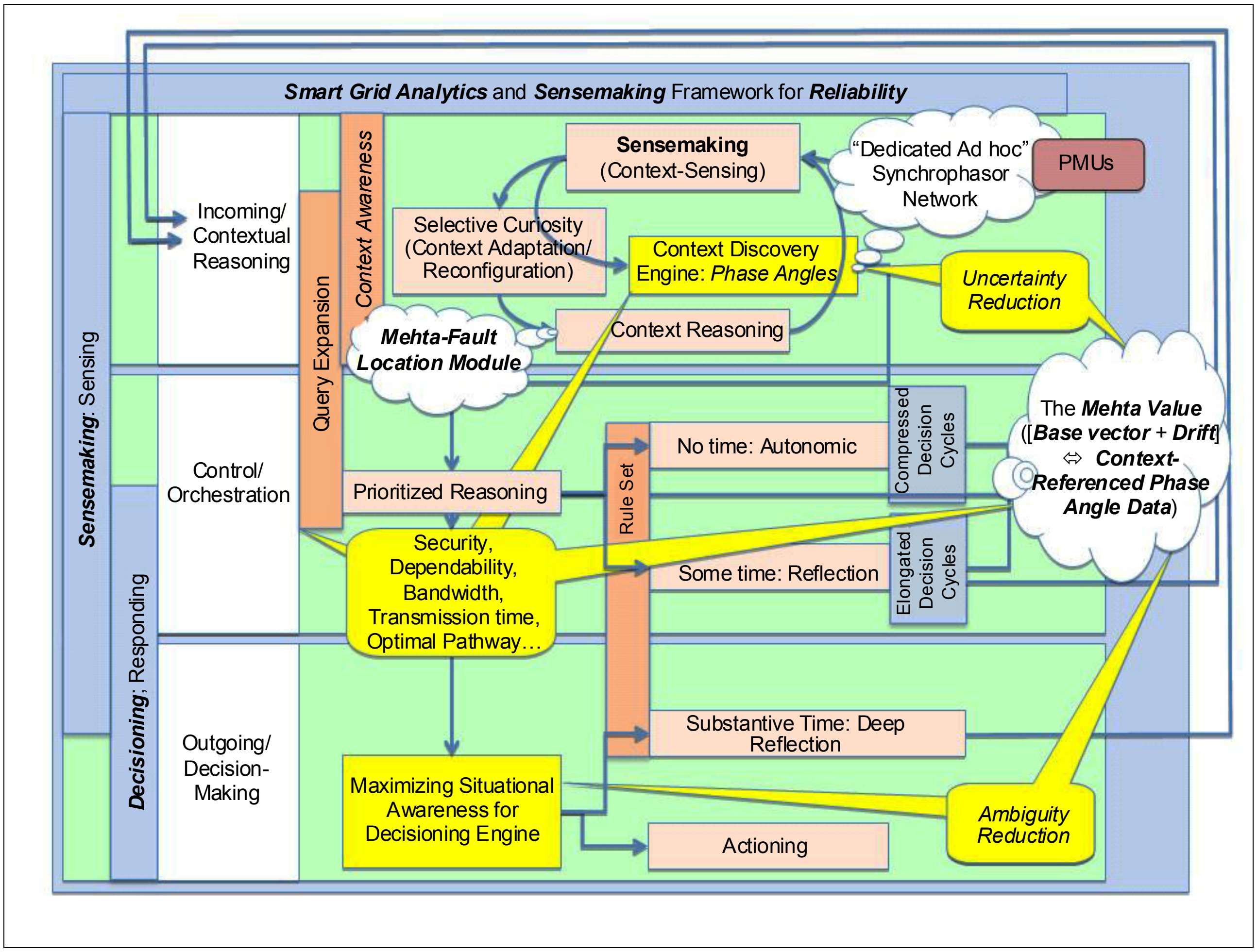


Figure 1 High-level operational concept of a Smart Grid Analytics and Sensemaking framework

Context-awareness is critical to grid and network stability monitoring

Transfers of power across the grid are unpredictable due to market price variations and the increasing role of power brokers. Power brokers can change the terms of a contract in minutes and prices in second. Power brokers are forcing utilities to become more competitive and to increase the reliability of their service through smart grid initiatives. The complexities and the associated unforeseen instabilities stemming from power providers being swapped at a frenetic pace by power brokers can lead to questions of how to maintain the stability of power systems and prevent power system blackouts. To mitigate against these instabilities and to contribute to the overall stability of the grid, power brokers are implementing monitoring systems that can create context-awareness.

The complexity of electrical power grids requires the embedding of innovative systems to achieve more secure and stable grids. One solution instance focuses upon Wide Area Measurement Systems (WAMS) solutions with their associated context-awareness analytics. WAMS and other context-aware solutions, such as IBM InfoSphere® Sensemaking, are dependent upon the ingested data, such as accurately time-stamped PMUs of the electrical waves on an electric grid. PMUs over time can provide real-time insight into electrical grid stability. A synchrophasor device can measure, combine, and analyze the accurately time-stamped measurements from various locations on an electric power grid. The measurement integration can enable the identification of stresses/disturbances on the system. Most utilities are monitoring and collecting information from grids that pertain to network reliability and stability. After all, a collapsing voltage can readily propagate across the electric power grid and can cause the grid to fail. The global assessments can provide insight into the overall network stability.

Grid and network stability is more than just voltage stability. It is also a function of phase angle difference. Phase angle differences across PMUs are indicators of static stress across the grid. Greater phase angle differences imply larger static stress, and greater likelihood of grid instability. Figure 2 shows phase angle difference reflected in electric current measurement. There are strict standards, such as the coordinated universal time, about how to measure the phase angle with respect to the global time reference and how to report this phasor comparison information.

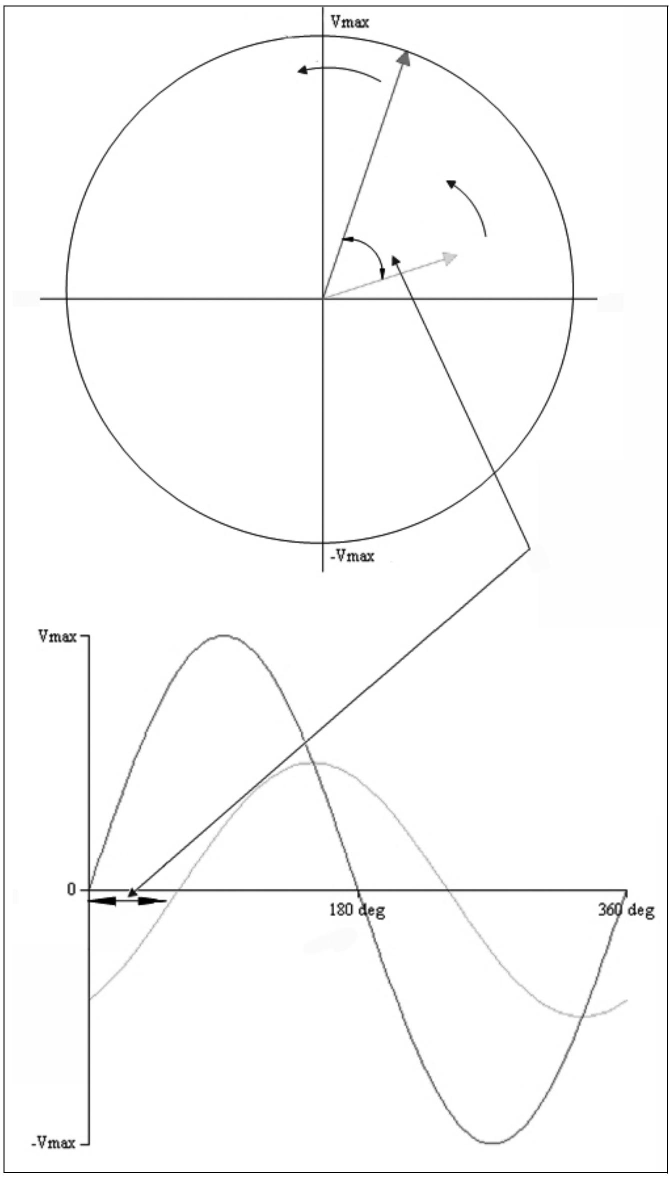


Figure 2 Phase angle difference

Interoperability between different PMUs is determined by a standard called *Total Vector Error*, a measure of compliance levels. The reality is that there are major time-synchronization issues among measurements with the same time-stamps. Even worse, the tools from different vendors create different readings on the same unit. Inaccurate readings and differences between vendors make it challenging for utilities to share the streaming data generated by the PMUs.

Intelligent electronic devices (IEDs), such as PMU, are used to monitor the stability of power systems. PMUs are positioned on the power grid at the substation level. The synchronized sampling and ensuing output of synchronized phasors should support the real time phasor comparison. The real-time output allows power system operators and planners to assess the state of the power system and to manage its stability.

Power system status is a function of rotor angle *and* rotor speed. While rotor speed deviation is used to detect increasing instability, it is the knowledge of rotor angle first swing that is needed for the detection of sudden, dynamic instability. The internal rotor angle is typically not measured directly, and the PMU approximates the internal rotor angle using the generator bus phase angle. When the number of phase angle measurements is increased in each area of interconnect power systems, the accuracy of this base vector computation will be increased. Concurrently, the enhanced base vector inherently provides better context-referenced phase angle data, because both are shaped by the other in a mutually recursive fashion.

The center of inertia (COI) is used to determine the interconnection phase angle and quantify the extent of phase angle variations away from the “system center.” The generated rotor angle estimates are used by the supervisory control and data acquisition/energy management systems (SCADA/EMS). However, the calculation of the online, real-time rotor angle stability COI measures (by WAMS) is computationally challenging, and there is no assurance that the online computational process will be fast enough to produce “real-time” results. As a result, there is a move away from various COI to the notion of a simpler, base reference.

The granularity of a phase angle reference is a more accurate measurement than the common reference. If the number of phase angle measurements in each area of the interconnected power systems is increased, the accuracy of the COI angle reference computation can be increased. The accuracy can be further enhanced if a mapping of the COI over time is made available. This mapping can also account for COI drift over time. More measurements and context allows a better predictor of both the future values for COI and future system instability. The various COI, collectively, represent the base reference.

Reliable, accurate, and seamless exchange of streaming data is critical to the accuracy of continuous insight and the requisite context-awareness for grid and network stability monitoring. Consider the lack of accurate, contextual forensic data, for example the cascading failure of the Northeast Blackout of 2003. Establishing the sequence of events that led up to the cascading failure and determining where the disturbance began was difficult. Although the individual parts that shut down each had data loggers, the clocks on them were not coordinated.

Context analytics: Using the requisite building blocks for gaining insight into network stability

Context-awareness as provided by a Sensemaking paradigm, such as a WAMS, is central to monitoring network stability. Context-awareness analytics can provide increased insight into network stability and reliability. Historical, context rich data can generate forensic lessons learned and predictive models which can estimate future reliability.

Predictive modeling software, such as IBM SPSS® Modeler, can use the synchrophasor historical data to discover, among other things, failure order, failure relationships to components, and predictors associated with failures. Predictive analytics can take advantage of PMU historical data to discover historical patterns, models, predictors, relationships, and trends. The exploration portion of the analytics can focus upon the discovery of relationships between outcomes of interest and data variables and the values of these variables.

The primary output of the predictive analytics will be patterns or models that are relevant to network stability and reliability. These models or patterns can be deployed against real-time PMU data to discover the existence of newly formed patterns. When interesting patterns are detected, this knowledge can be used to guide real-time, mission-critical decisions.

Framework for Smart Grid Analytics and Sensemaking

There are two critical components to the Smart Grid Analytics and Sensemaking framework:

- Sensemaking analytics
- Decision making

The Sensemaking portion denotes the incremental context accumulators. With each new data observation (for example actions, behaviors, locations, activities, or attributes), there is the possibility of a new discovery. The decision making portion of the framework assesses each newly updated entity to determine if something new has been learned *and* whether that new information is important and requires some sort of action, for example network modification or pathway changes. Our Sensemaking approach is divided into three basic components: infrastructure, incoming/contextual reasoning, and decision responding.

Critical infrastructure of a dedicated framework

This proposed framework requires the creation of a dedicated ad hoc synchrophasor network, embedded within the smart grid. Each of these network units, or PMUs, will collect: voltage, phase angle measurements, location, and time stamps. The proposed Sensemaking analytics has the following assumptions:

- There are no time-synchronization issues among measurements with the same time stamps for phasor measurement units (PMUs). Although readings produced by different manufacturers can differ by unacceptable variances, in fact differences ranging up to microseconds in the double digits have been observed.
- The measurements of the rotor angle are correct. All the collected measurements will be forwarded in real time to a context discovery engine.

The analytic portion of the smart grid Sensemaking requires both a layered technology deck and multiple computing infrastructures. Different analytics perform different functions, and the data itself varies in volume, variety, and velocity (data streams where data flows over constantly running queries). The key enabling infrastructures of IBM Apache Hadoop MapReduce and Streams are needed. Within an IBM Hadoop environment, deep analytics can be performed on very large amounts of historical data and data at rest. IBM InfoSphere Streams technology enables the continuous analysis of massive volumes of streaming data with sub-millisecond response times. The volume and velocity of data associated with solutions, such as WAMS, means that real time grid assessment solutions must be instantiated in an infrastructure such as IBM InfoSphere Streams. When these infrastructures are combined with traditional enterprise data marts, analytics can take advantage of the full range of grid data.

Incoming and contextual reasoning support for the Mehta value

Grid systems (a set of elements and relationships) are in the form of networks, which are sets of nodes (also known as *vertices*) joined together in pairs by edges (also known as *links*). A set of binary relations would be used to describe the communication pattern between the nodes. A *network* consists of a set of nodes coupled with a set of binary relations between the nodes, which describe their communication pattern.

Grid networks vary in size (from small to large), density (from sparse to plenteous number of nodes), and topology (from those with highly modular structure to those with highly overlapping structure). The different nodes interact with each other but at different levels of strength. The nodes that are adjacent to a specific node have the most important strength of interaction. Typically, the strength of interaction between a node of interest and other nodes decays the further away a node is. The exact relationship of the strength can be determined by the graph analytics, as strength can change over time.

The analytics portion of the environment updates context, as appropriate, with every new observation. The real-time portion of the smart grid analytics receives the network stream data created by each synchrophasor or collector.

Drift is an important component of the context. If drift is added to the base reference, a more accurate version of a base reference is created. If the base reference is combined with the compensatory drift aspect and context-referenced phase angle data, it is called a *Mehta Value*, as follows:

```
Mehta Value =  base reference + drift + context-referenced phase angle data
```

The Mehta Value can constitute a new de facto currency for utilities.

Decision making and responding

Key to decision making is an understanding of the past. Analytics uses *historical* data about grid edges and nodes to discover historical patterns, models, predictors, relationships, and trends that are associated with outcomes of interest, for example transmission line degradation. These models, patterns, and rules can be compared against a combination of real-time data and contextual history to detect changes in the likelihood of these outcomes or partial matches to patterns. When these changes are detected, management controls can dynamically modify the network and prevent the occurrence of undesirable outcomes.

Control and orchestration

The real-time portion of the analytics environment must reason and make sense of observations as they present themselves. This cumulative, cohesive picture of the nodes and the network enables the analytics to use a combination of internal relevance detection models, rules, and situational assessment algorithms to make sense of and to evaluate different aspects of the smart grid.

The real-time analytics environment can discover whether the cumulative (new streaming data + history) data on that grid location, or Mehta Value, now matches the models and patterns that have been developed in the deep analytics portion of the process. The real-time assessment can determine if an interesting event, such as COI drift, appears to be occurring or if there are interesting changes of parameter values, new evidence for hypothesis confirmation, or surprising and relevant events and insights. The analytics environment can determine if the addition of this new data point changes the existing scores or the likelihood of accuracy for analytics models, trends, behaviors, scenarios, and situations. The analytics also compare the current contextual values to different types of algorithms, such as fault location algorithms, which use both geography (that is, spatial analysis) and time (that is, temporal analysis). Those changes or discoveries deemed relevant and interesting can then be pushed to appropriate users. One type of action is that of continual adaptation or reconfiguration of system aspects to prevent increased system instability.

As the real-time analytics find discoveries that matter, alerts can be sent to users. Alerts can trigger real-time responses or a lengthier replanning event. One type of action is that of system adaptation or reconfiguration to prevent increased system instability. Other grid parameters can be modified, including security settings, bandwidth allocation, pathway selection, and so on. The dynamic modification of these parameters can enhance system reliability and stability.

Outgoing decision making

The primary goal of a smart grid decision making process is to make better, more timely business decisions, while the observations are still occurring. The decision process must enable the achievement of increased reliability, mitigate risk, and recognize opportunity for improvement. The process must improve the detection of outages, determine appropriate instances for load shedding, and create optimal criteria for condition-based maintenance.

The decision criteria are developed off line, using deep reflection analytics. Deep reflection uses predictive analytics to discover how historical data (variables and values) are related to outcomes of interest. The time stamped variables of interest here include: phase angle, voltage, rotor angle, wave size, and wave direction, and so on. The analytics uses historical data to discover historical patterns, models, predictors, relationships, and trends that are related to outcomes of interest, for example drift.

Depending on the size of the historical data, this type of analytics can be performed either in a traditional data warehouse or in a Hadoop based environment. The exploration portion of the analytics typically focuses on the discovery of relationships between outcomes of interest and data variables and the values of these variables. An excellent software platform for the model discovery is SPSS Modeler Premium. It provides a broad set of analytic capabilities, including the following capabilities: visualization and exploration of data, data manipulation, cleaning and transformation of data, and deployment of results.

The primary output of deep reflection analytics is the patterns or models that were discovered within the modeling process. When the enterprise learns from its historical experience, it can take action to apply what it has learned. These models and patterns can be deployed against new incoming (real-time) data in a real-time analytics environment. As the real-time assessment process discovers variable values, patterns, and so on of interest, this information is used to initiate actions or alerts to monitors.

Summary

The complexity of electric power grids requires innovative solutions to effectively manage the power grids and to enhance grid security and stability. Predictive modeling software can use the synchrophasor historical data to discover, among other things, failure order, failure relationships to components, and predictors associated with failures. The proposed dedicated ad hoc synchrophasor network, embedded within the smart grid, focuses the use of context-awareness analytics to maintain correct values (current and historical) for nodes and edges. Key to the analytics is the use of the Mehta Value, composed of a base reference, drift, and context-referenced phase angle data. Real-time decisions, such as load shedding or pathway selection, can then be made based upon the combination of contextually correct data and analytics, such as the Mehta value.

Resources for more information

For more information about the concepts that are highlighted in this guide, see the following resources:

- IBM InfoSphere Sensemaking

  https://www-304.ibm.com/industries/publicsector/fileserve?contentid=235174

- Jeff Jonas, IBM Fellow and Chief Scientist of the IBM Entity Analytics Group, blogs on Sensemaking and Context Analytics

  http://jeffjonas.typepad.com/jeff_jonas/

- *Context-Based Analytics in a Big Data World: Better Decisions*, REDP-4962

  http://www.redbooks.ibm.com/abstracts/redp4962.html?Open

- *Analytics in a Big Data Environment*, REDP-4877

  http://www.redbooks.ibm.com/abstracts/redp4877.html?Open

- IBM Big Data Analytics website

  http://www-01.ibm.com/software/data/infosphere/bigdata-analytics.html

- *Harness the Power of Big Data: The IBM Big Data Platform* (An IBM eBook)

  https://www14.software.ibm.com/webapp/iwm/web/signup.do?source=swinfomgt&S_PKG=ov8257&_TACT=109HF53W&S_CMP=is_bdebook3

- *Turning Big Data into Actionable Information with IBM InfoSphere Streams*, TIPS0948

  http://www.redbooks.ibm.com/abstracts/tips0948.html?Open

- IBM SPSS Modeler

  http://www-01.ibm.com/software/analytics/spss/products/modeler/

Authors

This guide was produced by a team of specialists from around the world working at the International Technical Support Organization (ITSO).

Lisa Sokol, Ph.D. is an Architect within the Office of the CTO, IBM Software Group, US Federal Government Services. Her primary areas of interest are assisting government communities in dealing with the decision overload problem and using analytics to discover actionable information buried within large amounts of data. She has designed several systems that detect and assess threat risk relative to fraud, terrorism, counter intelligence, and criminal activity. She has a doctorate in Operations Research from the University of Massachusetts.

Steve Chan, Ph.D. is the Director of Swansea University's Network/Relationship Science Analytics Program and a Director of the IBM Network Science Research Center (NSRC), focusing upon those Sensemaking methodologies and tools that will facilitate moving from big data to big insights. He is Chairman of the Board for Mehta Tech (an interoperability for smart grid infrastructure firm). He also serves on the Advisory Council for the Network Centric Operations Industry Consortium (NCOIC) and is Chairman for the NCOIC Smart Grid-Sensemaking Workgroup.

Thanks to **Vasfi Gucer** of the ITSO in Austin, TX, for his contributions to this project.

Now you can become a published author, too!

Here's an opportunity to spotlight your skills, grow your career, and become a published author—all at the same time! Join an ITSO residency project and help write a book in your area of expertise, while honing your experience using leading-edge technologies. Your efforts will help to increase product acceptance and customer satisfaction, as you expand your network of technical contacts and relationships. Residencies run from two to six weeks in length, and you can participate either in person or as a remote resident working from your home base.

Find out more about the residency program, browse the residency index, and apply online at:

ibm.com/redbooks/residencies.html

Stay connected to IBM Redbooks publications

- Find us on Facebook:

  http://www.facebook.com/IBMRedbooks

- Follow us on Twitter:

  http://twitter.com/ibmredbooks

- Look for us on LinkedIn:

  http://www.linkedin.com/groups?home=&gid=2130806

- Explore new IBM Redbooks® publications, residencies, and workshops with the IBM Redbooks weekly newsletter:

  https://www.redbooks.ibm.com/Redbooks.nsf/subscribe?OpenForm

- Stay current on recent Redbooks publications with RSS Feeds:

  http://www.redbooks.ibm.com/rss.html

Notices

This information was developed for products and services offered in the U.S.A.

IBM may not offer the products, services, or features discussed in this document in other countries. Consult your local IBM representative for information on the products and services currently available in your area. Any reference to an IBM product, program, or service is not intended to state or imply that only that IBM product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any IBM intellectual property right may be used instead. However, it is the user's responsibility to evaluate and verify the operation of any non-IBM product, program, or service.

IBM may have patents or pending patent applications covering subject matter described in this document. The furnishing of this document does not grant you any license to these patents. You can send license inquiries, in writing, to:
IBM Director of Licensing, IBM Corporation, North Castle Drive, Armonk, NY 10504-1785 U.S.A.

The following paragraph does not apply to the United Kingdom or any other country where such provisions are inconsistent with local law: INTERNATIONAL BUSINESS MACHINES CORPORATION PROVIDES THIS PUBLICATION "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some states do not allow disclaimer of express or implied warranties in certain transactions, therefore, this statement may not apply to you.

This information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. IBM may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

Any references in this information to non-IBM Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this IBM product and use of those Web sites is at your own risk.

IBM may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligation to you.

Any performance data contained herein was determined in a controlled environment. Therefore, the results obtained in other operating environments may vary significantly. Some measurements may have been made on development-level systems and there is no guarantee that these measurements will be the same on generally available systems. Furthermore, some measurements may have been estimated through extrapolation. Actual results may vary. Users of this document should verify the applicable data for their specific environment.

Information concerning non-IBM products was obtained from the suppliers of those products, their published announcements or other publicly available sources. IBM has not tested those products and cannot confirm the accuracy of performance, compatibility or any other claims related to non-IBM products. Questions on the capabilities of non-IBM products should be addressed to the suppliers of those products.

This information contains examples of data and reports used in daily business operations. To illustrate them as completely as possible, the examples include the names of individuals, companies, brands, and products. All of these names are fictitious and any similarity to the names and addresses used by an actual business enterprise is entirely coincidental.

COPYRIGHT LICENSE:

This information contains sample application programs in source language, which illustrate programming techniques on various operating platforms. You may copy, modify, and distribute these sample programs in any form without payment to IBM, for the purposes of developing, using, marketing or distributing application programs conforming to the application programming interface for the operating platform for which the sample programs are written. These examples have not been thoroughly tested under all conditions. IBM, therefore, cannot guarantee or imply reliability, serviceability, or function of these programs.

This document, REDP-5082-00, was created or updated on February 5, 2014.

Trademarks