ABSTRACT

Understanding the quality of data produced by synchrophasors is the crucial first step to leveraging the investment that utilities and governments have made over the last two decades. Key to developing the solutions that the industry needs is an awareness of the existing data reliability and quality challenges faced by utilities and the resulting baseline that this provides. Over the last two years, PingThings has collected numerous, multi-year data sets containing sensor measurements from nearly a thousand synchrophasors across North America, representing terabytes of data.

From the utility perspective, synchrophasor collection networks can be divided into two categories, dedicated and piggy-back networks. Dedicated networks contain network and PMU architecture dedicated solely to synchrophasor data collection and applications. The majority of industry, though, has built synchrophasor networks on existing...
Data is just like crude. It’s valuable, but if unrefined it cannot really be used. It has to be changed into gas, plastic, chemicals, etc. to create a valuable entity that drives profitable activity; so must data be broken down, analyzed for it to have value.

M. Palmer, “Data is the new oil,” http://ana.blogs.com/maestros/2006/11/data_is_the_new.html
3 Components to Unlocking the Value of Data

1. Raw Material
   - Data of known and reasonable quality

2. Motivation
   - Economically-relevant use cases
   - Data liability

3. Capability
   - Requirements for big data and machine learning
   - Moore’s Law and the exponential decrease of cost
   - The state of the possible
"BPA used synchrophasor data to recalibrate the 1,100 MW Columbia Nuclear Generating Station without needing to take the unit off line, providing $100,000 to $700,000 in estimated savings for this type of generator outage."

"ISO-NE event analysis applications automatically collect and analyze synchrophasor data from PMUs all across New England, enabling engineers to quickly identify and analyze disturbances. With the improved efficiency, ISO-NE is able to analyze two or three events per week – up from two events per year – using the same resources."
Awash in Data

46 TB
Synchrophasor Data Quality

- Good: 52%
- Bad: 48%

Data Quality Pie Chart
Data Quality

Flag-Driven

Data-Driven

Model-Driven

Increasing Data

Increasing Computational Requirements
Two Options for Implementation

Historical/Forensic Analysis

**Pros**
- Much easier to do at scale
- A lot of available software frameworks
- Longitudinal perspective can identify unexpected issues and causes

**Cons**
- Data export can be challenging
- Too late to remedy

Real Time Streaming Analysis

**Pros**
- Address data quality problems immediately
- Increase amount of good data
- Inform downstream applications

**Cons**
- Fixed time budget for computations that can limit what is possible
- Algorithms must be amenable to streaming implementations
- More storage required for archiving results along side data
Imminent Scale

500,000 PMUs Deployed Today

Dr. Edmund O. Schweitzer III, President, Chairman of the Board
Schweitzer Engineering Laboratories
History of Big Data from Google

- **2003**: Google File System
  - Distributed file system over commodity hardware.

- **2004**: Map Reduce
  - Distributed processing framework to simplify parallel programming tasks.

- **2006**: Big Table
  - A distributed storage system for structured data.

- **2010**: Pregel
  - A large scale graph processing system.

- **2013**: Spanner
  - Google's globally distributed database.

- **2015**: The Dataflow Model
  - A practical approach to balancing correctness, latency, and cost in massive-scale, unbounded, out-of-order data processing.
Cramming More Components onto Integrated Circuits

The experts look ahead

Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1979 economics may dictate squeezing many as 50,000 components on a single silicon chip

By Gordon E. Moore
President, Research and Development Laboratories, Fairchild Semiconductor, a Division of Fairchild Camera and Instrument Corp.

The trend of integrated electronics is the future of electronics so loud. The advantages of integration will bring many a proliferation of electronics, pushing the consumer far more

costs. Integrated circuits will lead to each nation as home

computers, and in the next generation of electronic

products—automotive, compact for examination, and personal—
predictable computers and equipment. This increase in

will make such a display in the future today.

The RAM required to hold a month’s worth of PMU data for the entire North American continent costs approximately $10K.
Synchrophasor Data and a Utility Perspective

- Utility power delivery is paramount in time and resource allocation – New technology incorporation takes longer
- Synchrophasor integration under this paradigm
  - Incorporated into existing technology - cost savings and limited resources.
  - Invested as research projects – dedicated budgets and resources.
- SRP incorporates synchrophasor technology – Big data challenges
  - Data routing
  - Data quality evaluation and mitigation
  - Solutions with minimal human interaction
- SRP has incorporated as a construction standard with over 300 existing PMUs and 75 annually added.
Data Network Architecture Considerations

• Synchrophasor data networks fall under two categories

  Dedicated Networks:  
  Constructed for the sole use of PMU data communication

  Piggy-Back Networks:  
  Established networks that carry PMU data communication

• Dedicated networks can drive communication architecture whereas Piggy-Back networks must integrate PMUs onto existing communication channels.
Network Communication – Categorizing Solutions

Three PMU communication continuity solutions:

- Communication switch port disabled
- Firewall rule repairs
- Device setting repairs

PDC Communication – Reliable Gateways

- PMU throughput between PDCs must be guaranteed
- High quality PMU stream integrity to application
- Maintenance: 24/7 service support or PDC failover
Number of signals determine whether manual maintenance or a signal quality software is required.

Ensure downstream applications receive reliable and consistent data that conforms to various formats.
SRPs Synchrophasor History and Current Challenges

• SRP Synchrophasor Network timeline
  • Pre-2009 – PMUs added as part of WISP project
  • 2009-2014 – PMUs added as a limited standard in line relaying packages
  • 2014-2016 – PMUs data management structure and process begin
  • 2016-Present – PMU data storage established, data management processes in place
  60% - Big data management solution exploration begins

• SRPs Big Data Challenges
  • Automation of data network streaming with limited personnel – Automation solutions?
  • Ongoing data quality evaluation and mitigation
Questions?

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