Understanding and Analyzing Synchrophasor Data Quality at Scale

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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. Dedicted 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

Introduction

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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

Known Use Cases

"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."

Retrospective

- Operator Training and Event Simulation
- Forensic Event Analysis

Reactive

- Wide Area Situational Awareness
- Oscillation Detection
- Phase Angle Monitoring
- Voltage Stability Monitoring an
Management

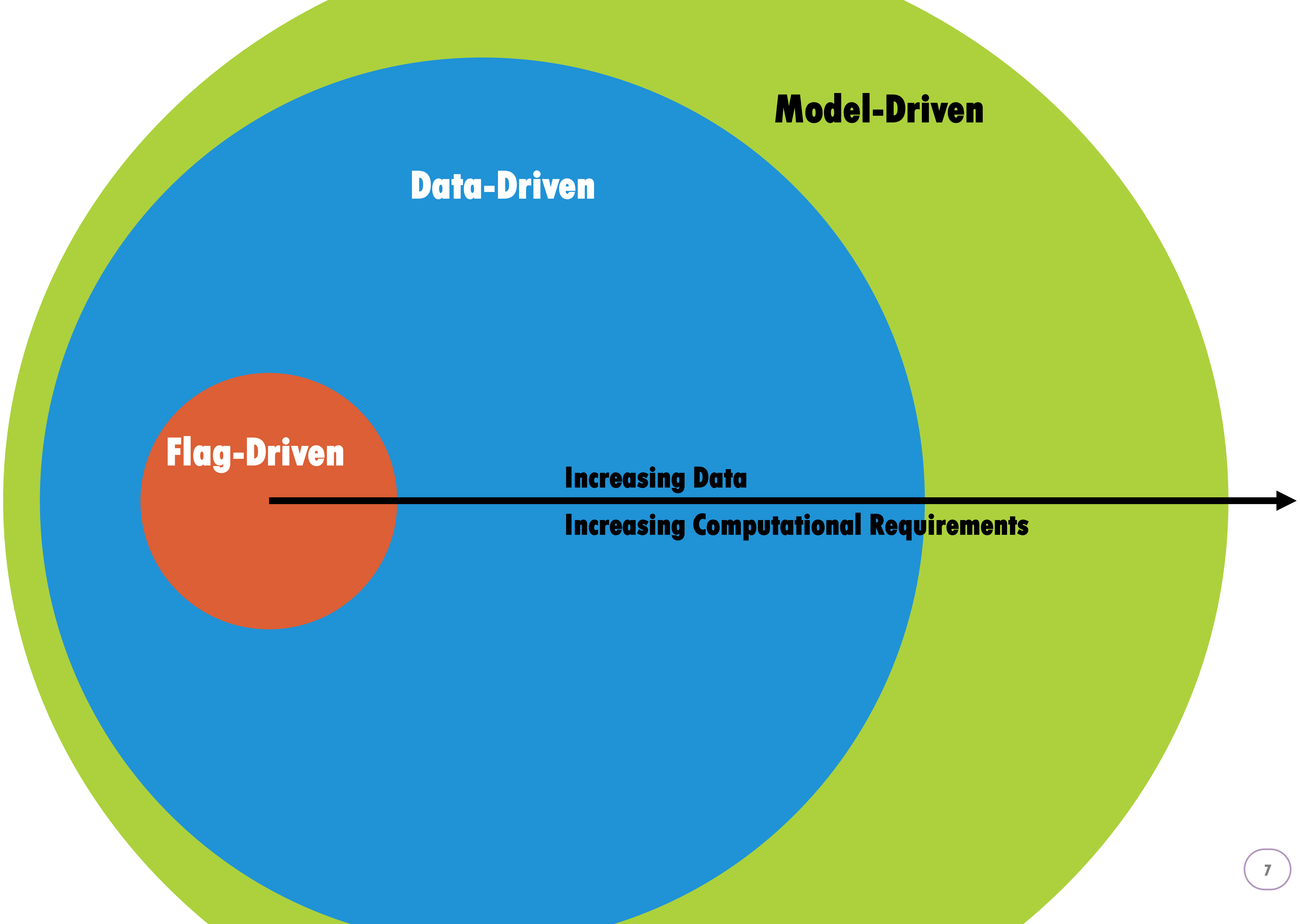
The Value Proposition for Synchrophasor Technology, Itemizing and Calculating the Benefits from Synchrophasor Technology Use, Version 1.0, North American Synchrophasor Initiative NASPI Technical Report, October 2015

Awash in Data

46 TB

Synchrophasor Data Quality

Data Quality



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

CAPABILITY

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 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip

By Gordon E. Moore

Director, Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today.

But the biggest potential lies in the production of large systems. In telephone communications, integrated circuits in digital filters will separate channels on multiplex equipment. Integrated circuits will also switch telephone circuits and perform data processing.

Computers will be more powerful, and will be organized in completely different ways. For example, memories built of integrated electronics may be distributed throughout the

	CPU	RAM	Storage	Software
	Cost per Gigaflop	Cost per Gigabyte	Cost per Gigabyte	Enterprise Data Systems
1995	$42,000	$32,000	$60,000	Million$
2015	$0.03	$5	$0.05	Free, Open source

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 INTEGRITY

Network Communication – Categorizing Solutions

Three PMU communication continuity solutions:

Communication switch port disabled

Firewall rule repairs

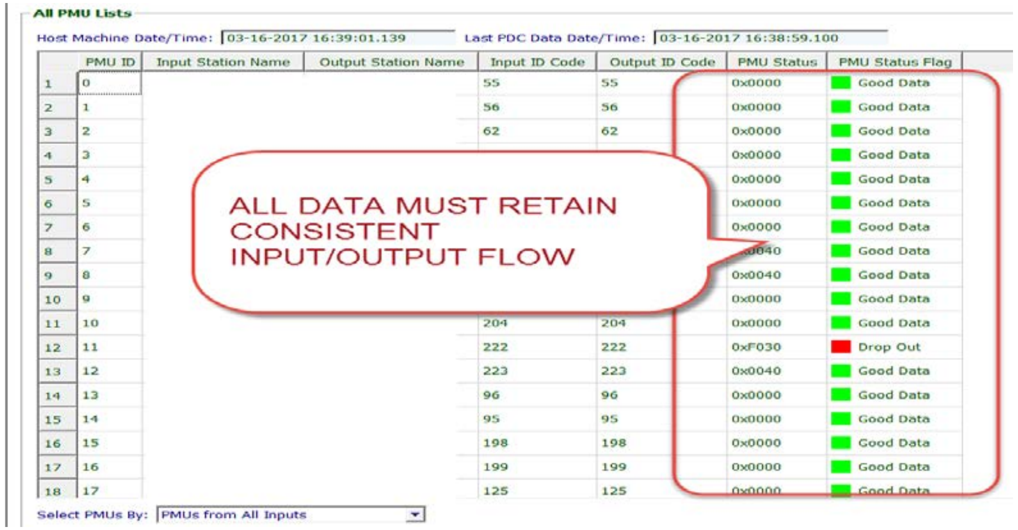
Device setting repairs

PDC Communication – Reliable Gateways

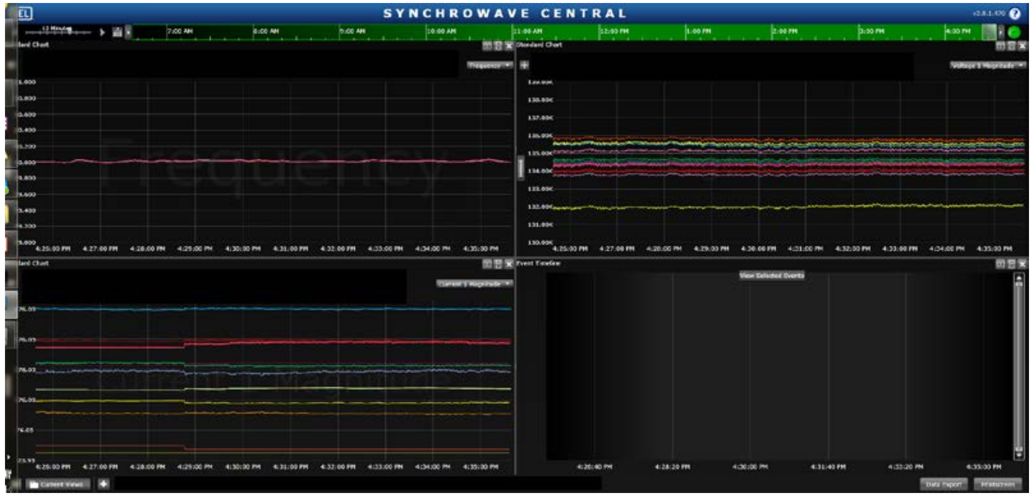
PMU throughput between PDCs must be guaranteed

High quality PMU stream integrity to application

Maintenance: 24/7 service support or PDC failover



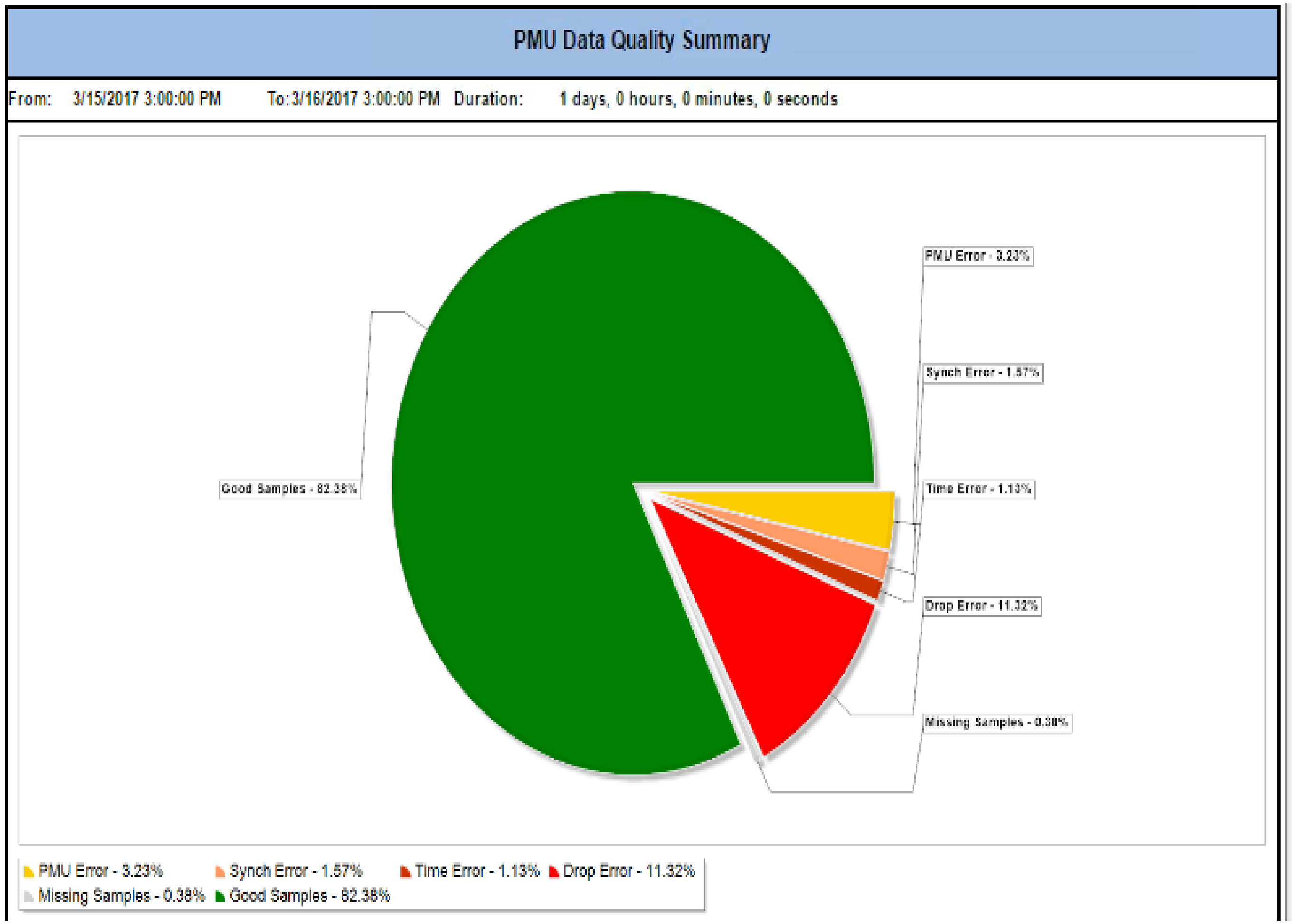
	PMU ID	Input Station Name	Output Station Name	Input ID Code	Output ID Code	PMU Status	PMU Status Flag
1	0			55	55	0x0000	Good Data
2	1			56	56	0x0000	Good Data
3	2			62	62	0x0000	Good Data
4	3					0x0000	Good Data
5	4					0x0000	Good Data
6	5					0x0000	Good Data
7	6					0x0000	Good Data
8	7					[illegible]	Good Data
9	8					0x0040	Good Data
10	9					0x0000	Good Data
11	10			204	204	0x0000	Good Data
12	11			222	222	0xF030	Drop Out
13	12			223	223	0x0040	Good Data
14	13			96	96	0x0000	Good Data
15	14			95	95	0x0000	Good Data
16	15			198	198	0x0000	Good Data
17	16			199	199	0x0000	Good Data
18	17			125	125	0x0000	Good Data



RELIABLE MAINTENANCE METHODS

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

Thank You

Questions?

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