PNNL-SA-121753

PMU Application Requirements Task Force: Update on Data Quality Attributes Document and Methodology for Examining Data Quality Impacts

Pacific Northwest National Laboratory and
National Institute of Standards and Technology
Team

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NASPI North American SynchroPhasor Initiative

Overview

- Phasor Applications Requirements Task Force (PARTF) Background and Expert Team Effort
- Data Quality Definitions and Framework Document Update
- NIST Application Testing

PARTF Charter

- PMU data quality management is challenging
  - Application results incorporate issues related to input accuracies and network delivery problems.
  - The breadth and variety of data quality input issues are not widely recognized today.
  - The impacts of these issues on application results are largely unknown, yet power system standards presume accurate results.
- PARTF objectives –
  - Develop a report that:
    - Clarifies data quality terms to better identify data inaccuracies and data delivery problems
    - Offers a process to understand and identify synchrophasor applications' data quality vulnerabilities
  - Develop an open-source software framework to test PMU Applications to determine their response to Errors in PMU data.
  - Report on some of the findings from using the framework.

The PARTF Vision

- The synchrophasor community begins using **consistent terms** and definitions for data issues, quality and availability.
- We use the **methodology** to develop a clear understanding of how data issues/filters/data flow issues affect each application and algorithm – and determine the priorities for improving PMUs, data networks, and applications.
- This approach can give grid operators and application users **confidence about the quality and trustworthiness** of the guidance coming out of synchrophasor applications.
- These methodologies get **built into applications** (data quality metric in dashboard), improving application performance, transparency and acceptance.

The PARTF Expert Effort

The complex PARTF scope requires a rigorous methodology and consistent approach to be useful. We can help the synchrophasor community and PARTF volunteers by developing a proposal for review, feedback, and improvement.

- PNNL and NIST have contributed expert resources and funds to develop a proposed methodology and definitions framework
  - Alison Silverstein (NASPI) – framework & readability
  - Laurie Miller (PNNL) – power systems & advanced mathematics
  - Dhananjay Anand (NIST) – applied mathematics & control theory
  - Allen Goldstein (NIST) – electrical engineer & digital signal processing
  - Yuri Makarov (PNNL) – power engineering & advanced mathematics
  - Frank Tuffner (PNNL) – power engineering & PMU applications
  - Kevin Jones (Virginia Power) – power engineering & PMU applications
- We still seek your feedback on these recommendations

Methodology - Definitions

- We need agreed-upon terms to talk about fitness-for-use of PMU data by an application.
  - Most terms describing the fitness-for-use of data for a particular task have multiple meanings.
    - There may be subtle differences in usage of terms among standards, guides, application documentation (latency, gap, quality, “good data”, etc.)
  - When examined in context, many terms eventually prove to have multiple attributes that each need their own definition.
- Used related existing definition sets to inform our discussion
  - Information technology, GIS have good overlap with our problem
  - Our definition set is organized for the PMU applications field

The data quality framework

Data attributes differ according to the type and scope of data

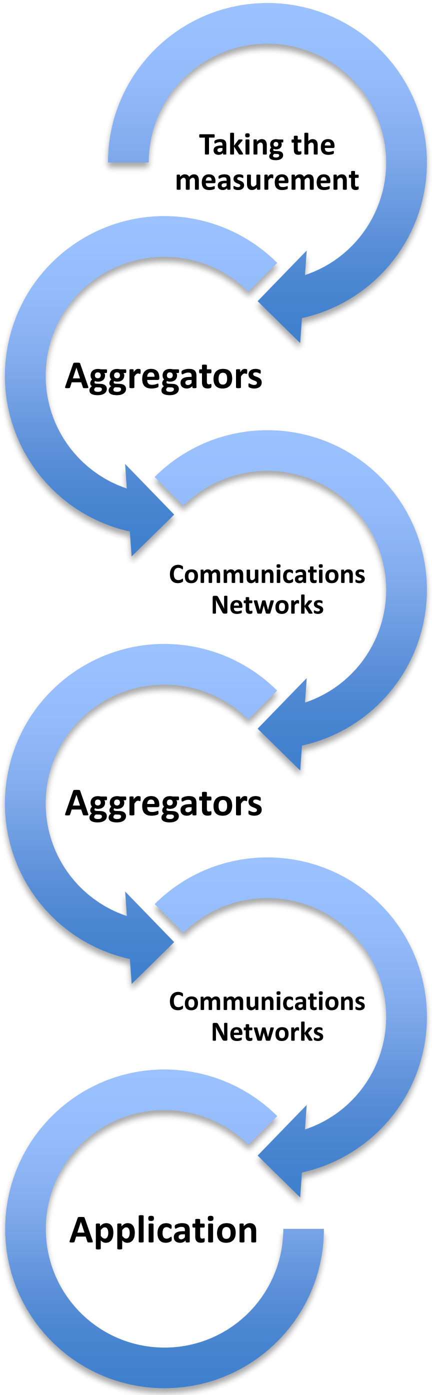
- Data point attributes are mostly about accuracy and metadata
- Data set (a collection of data points) attributes include data coverage (time, topology), consistency (metrology, headers, standards)
- Data stream (a data set in motion) attributes are about the process path and availability

Conceptual Data Process Path

For each of these three categories, data problems can arise in multiple places along the **data process path** from PMU, through aggregators and communications to the final end-use application.

- Measurements are taken at the **PMU** – main point for accuracy
- **Aggregators** refer to any type of historian/database/archive or other storage – affects accuracy and data point availability
- The data usually passes through more than one **communications network** – affects availability and timeliness

Example issue: Leap seconds (June 30, 2015) can lead to misinterpreted timestamps or data misalignment at any aggregator



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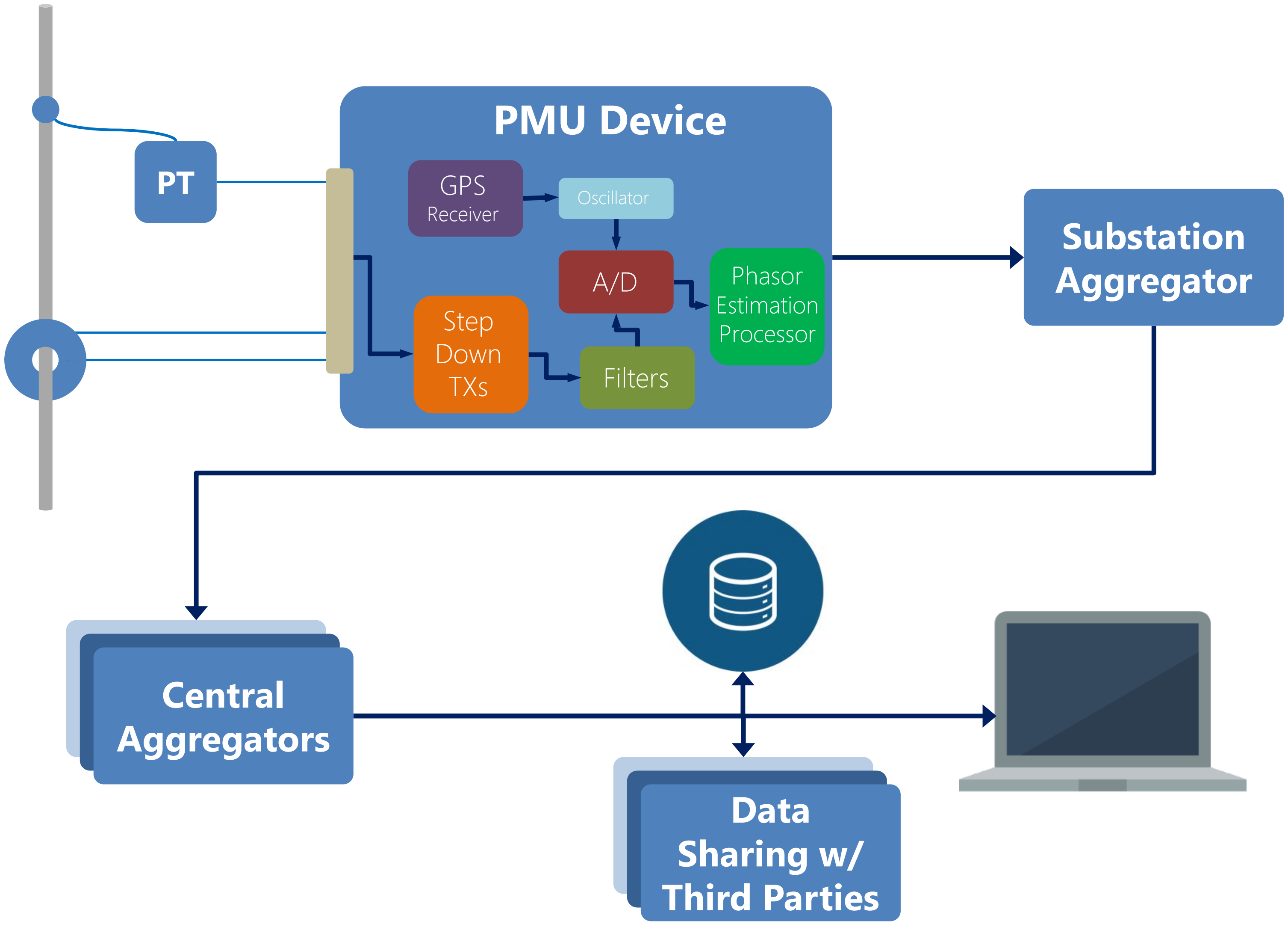
Detailed Data Process Path



PARTF Definitions and Methodology Paper

- Draft copy is still available on the NASPI website, but it is outdated.
- Feedback has been incorporated from the various emails, phone calls, and discussions at the spring NASPI symposium.
- Definitions and examples have been refined to be more clear to the community and users.
- Updated draft to be released soon, followed by a webinar to discuss.

Key Definition Discussion

- Definition for the grid condition or quantity that a measurement will represent
  - ***Realized quantity***?
  - ***Ideal measured value***?
  - ***"Actual" value***?
- Currently using ***"actual" value*** to clarify what is meant to people not familiar with metrology
- Feedback and discussions are welcomed

PARTF Framework

- Framework of stand-alone modules using plug-ins.
  - Most plug-ins today are MATLAB™
    - May use other languages
- Framework ties together the modules and provides state machines guiding communication between modules and Monte-Carlo analysis.
- Other stand-alone applications can register to receive broadcasts from any/all modules.
  - Separate application(s) supporting an application under test
  - Visualization applications

Busses:

As many as the processors and memory can support

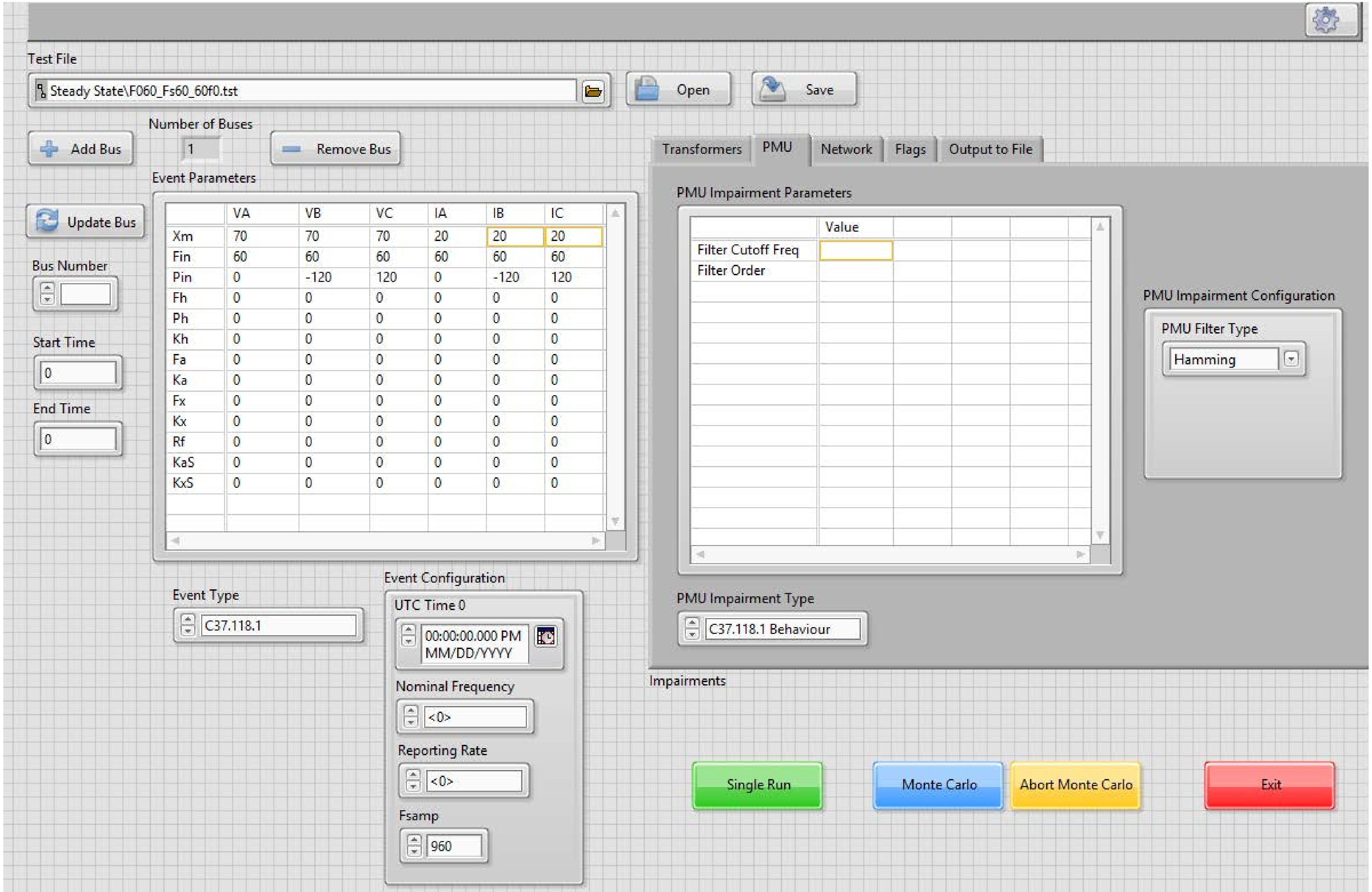
Each Bus:

One event plugin.

One PMU Impairment Plugin

One Network Impairment plugin

One Flag Impairment plugin

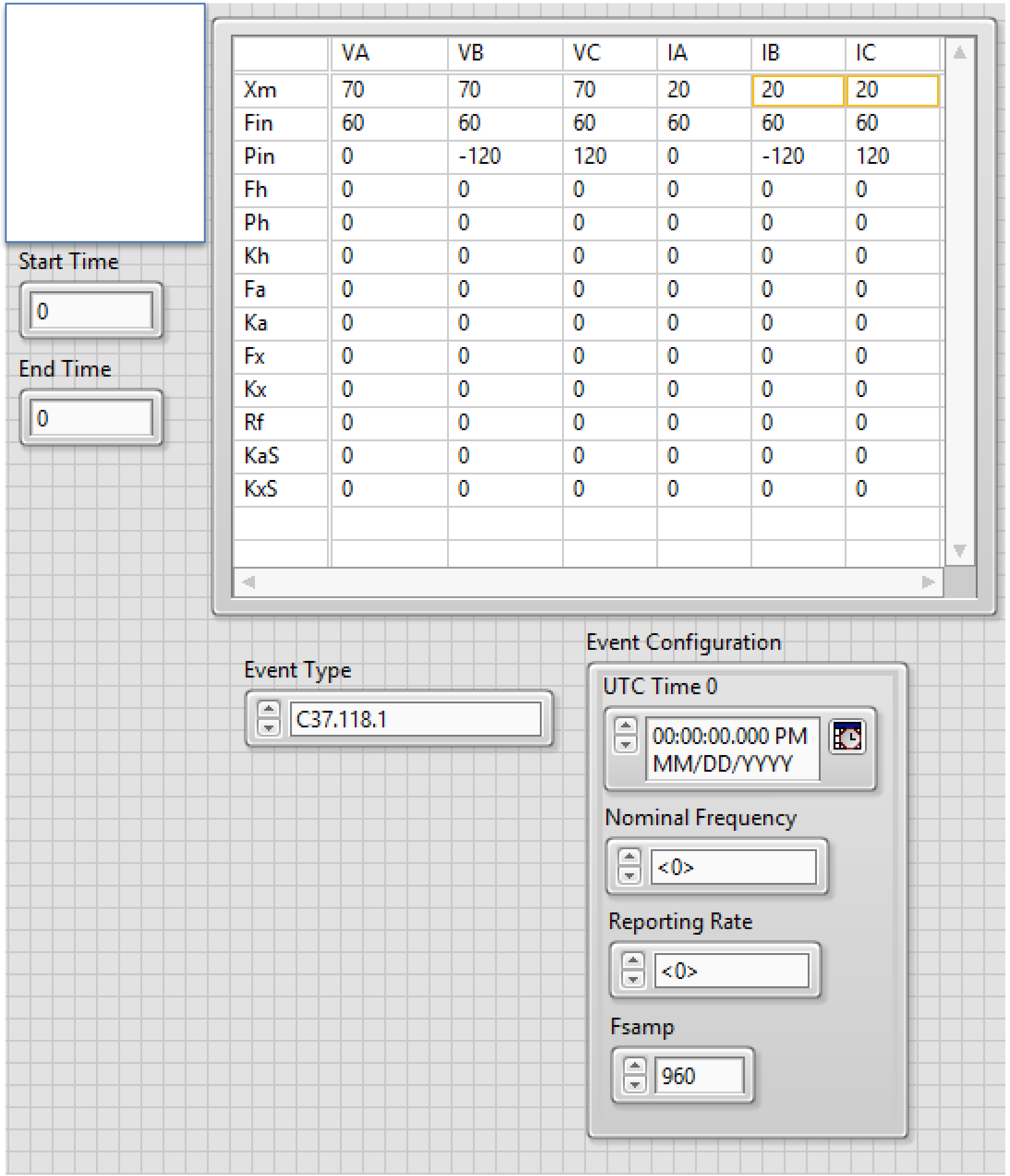


Transformer Impairment plugin TBD

Event types:

- Any event that can be modeled in MATLAB™ can be implemented
- All waveforms required for PMU testing and combinations of them
- Recorded PMU data (COMTRADE format, others to be included later)
- Can create either/both point-on-wave and synchrophasor reports

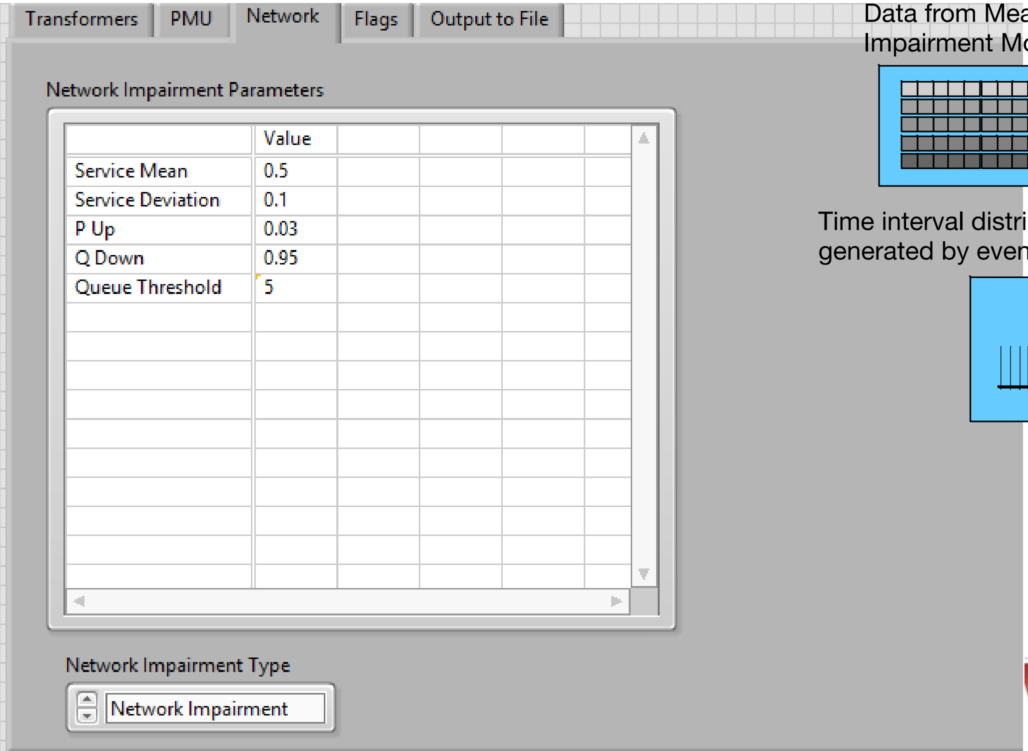
Parameters and their default values are defined for each plugin in an .INI file for each plugin

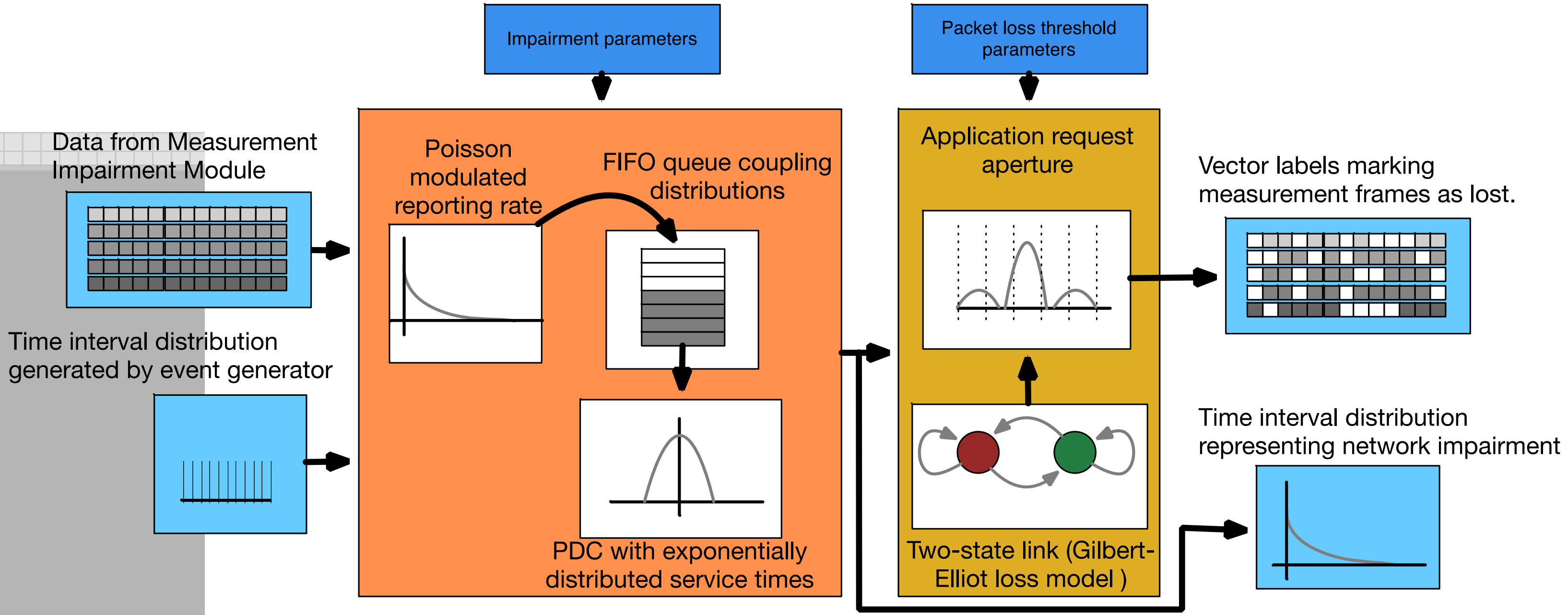


	VA	VB	VC	IA	IB	IC
Xm	70	70	70	20	20	20
Fin	60	60	60	60	60	60
Pin	0	-120	120	0	-120	120
Fh	0	0	0	0	0	0
Ph	0	0	0	0	0	0
Kh	0	0	0	0	0	0
Fa	0	0	0	0	0	0
Ka	0	0	0	0	0	0
Fx	0	0	0	0	0	0
Kx	0	0	0	0	0	0
Rf	0	0	0	0	0	0
KaS	0	0	0	0	0	0
KxS	0	0	0	0	0	0

Network Impairment

- Plugin-based
  - Network errors
    - Missing Packets
    - Packet Delay

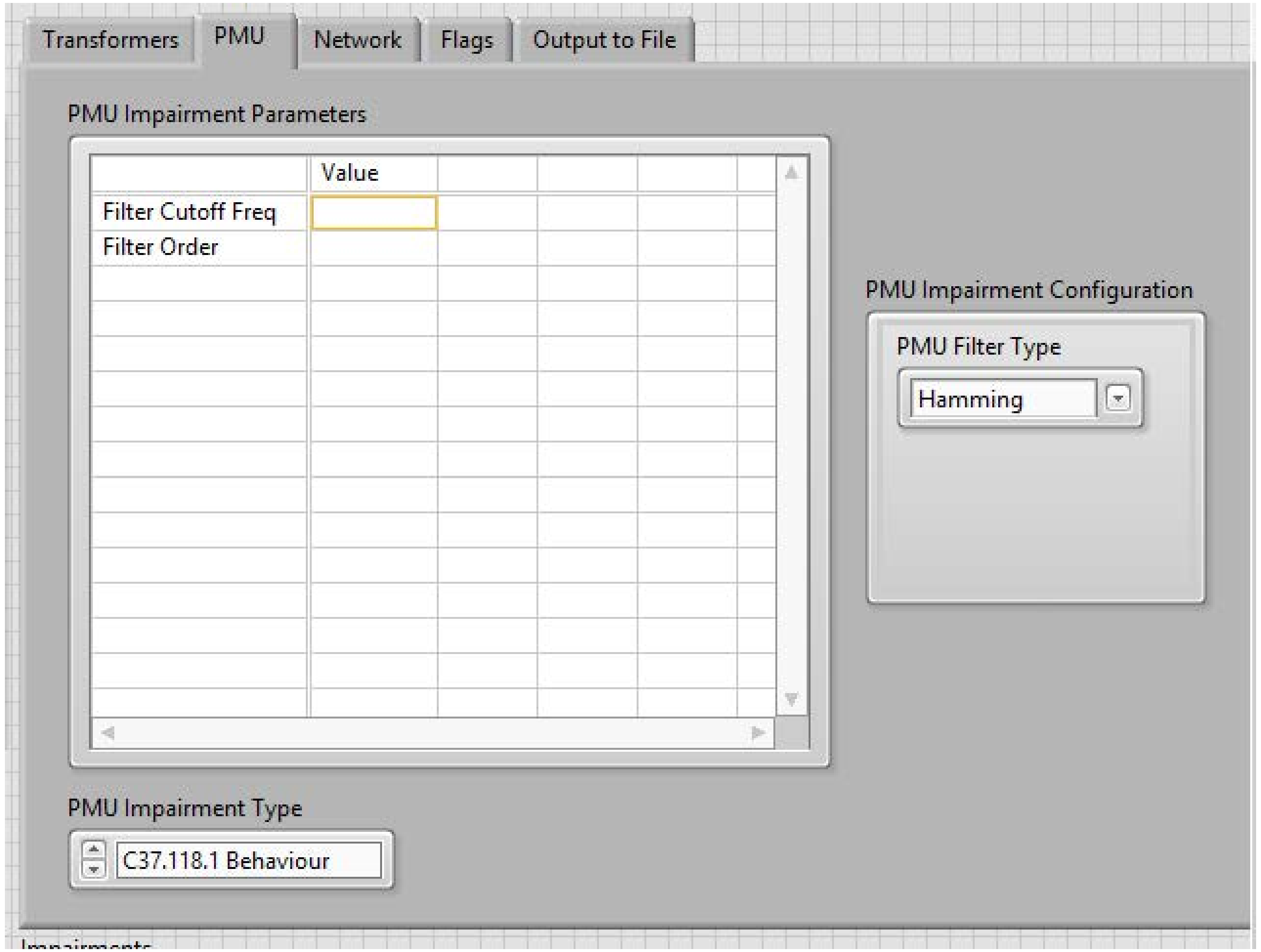




PMU Impairment

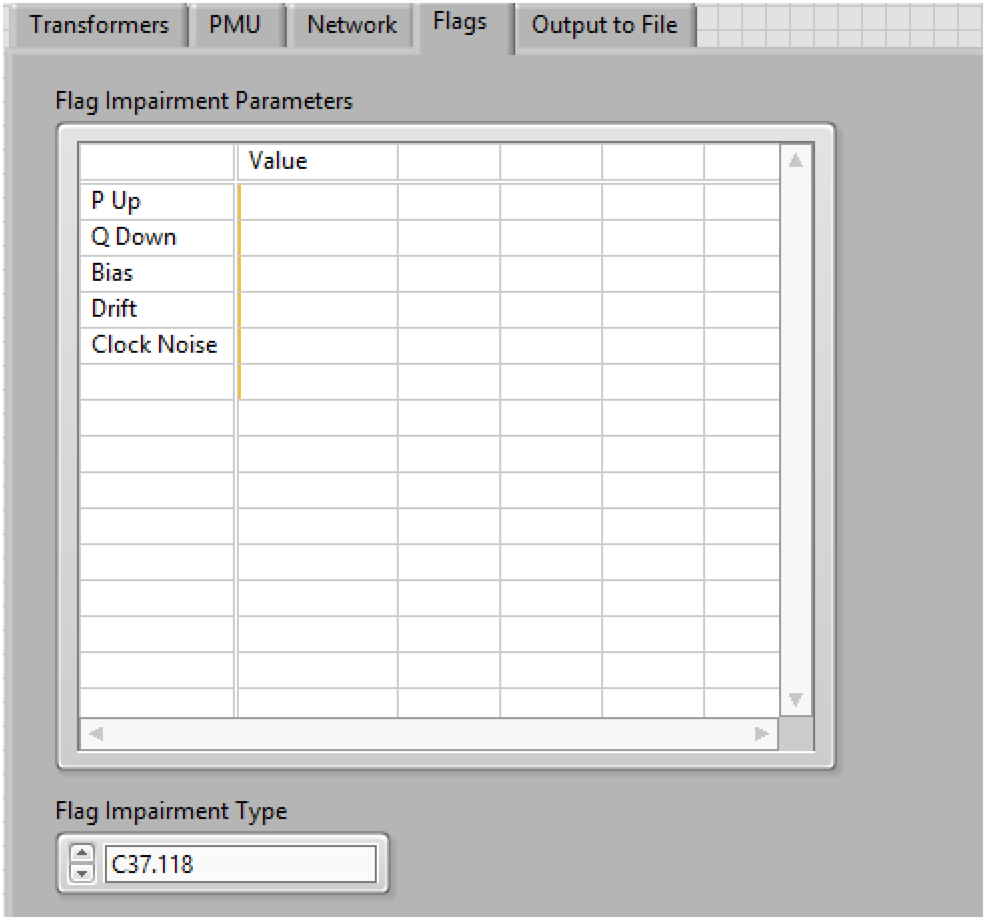
PMU impairments are plugin based:

- C37.118.1 Annex C
- Frequency tracking types
- Full PMU error simulation
- Creates impaired PMU reports from point-on-wave or ideal synchrophasor reports
- Can impair PMU reports well beyond requirements of C37.118 to discover where application output becomes unacceptable



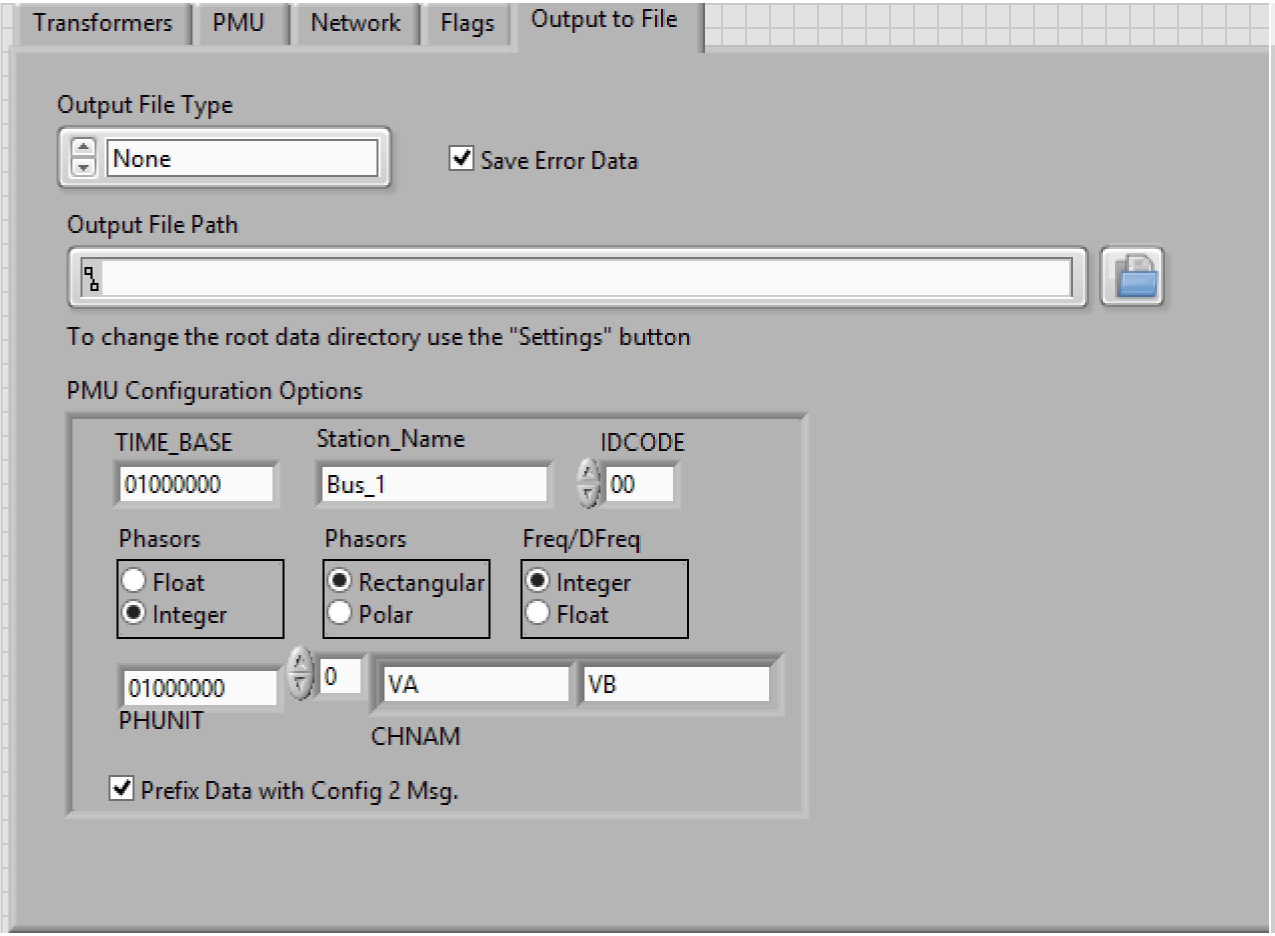
Flag Impairment

- Plug-in based
  - Timing-related flags
  - Other flags to follow.
- Stochastic error generation



Output to File

- Plug-in based
  - Different file definitions based on plug-in
  - COMTRADE will be the first to be implemented
    - Considering using CIM to describe the Bus structure
      - READ/WRITE



Next Steps

- Definitions and methodology document
  - New version by November 4, 2016.
  - Webinar to discuss document and get feedback on December 1, 2016.
  - Incorporate feedback and have finalized version by January 6, 2017.
- PMU Application Test Framework:
  - First beta test will be ringdown (Prony) analysis.
  - Second beta will be Generator Model Validation.
- Open Source software.

QUESTIONS

WATCHING THE UNICODE PEOPLE TRY TO GOVERN THE INFINITE CHAOS OF HUMAN LANGUAGE WITH CONSISTENT TECHNICAL STANDARDS IS LIKE WATCHING HIGHWAY ENGINEERS TRY TO STEER A RIVER USING TRAFFIC SIGNS.

http://xkcd.com/1726/