Data Validation & Conditioning Applications

DOE/WECC Projects

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Two Projects Underway

Modeless Data Validation - DOE Project
- Phasor Data Validation and Conditioning (PDVC)
- 6 Modules for Data Validation
- Prototype Completed and Demonstrated
- Error Simulation Utility Utilized for Validation
- Project Nearing Completion

Modeless and LSE Data Validation - WECC Project
- Synchrophasor Data Validation and Conditioning Application (SDVCA)
- Project started in April 2014
- Leverages LSE work done at Dominion and EPG Modeless Data Validation
- User Selection of Validated Data Stream
DoE Project Introduction

- Synchrophasor Data Quality is the Top 10 Issues identified by NASPI
  - Timing source, algorithms, hardware
  - Latency, dropouts, bandwidth, errors

- Need
  - Detect and fix data problems

- DOE Modeless Data Validation and Conditioning Project
  - RFP issued in June 2012 - Awarded to EPG in December 2012
  - Completion by December 2014
Project Plan & Status

PHASE 1
- Survey, Conceptual Design & Prototype Development
  - Review Existing SGIG Systems Completed May 2013
  - Best Practice Recommendations Completed June 2013
  - Research, Design, Develop and Test Prototype Completed March 2014

PHASE 2
- Prototype Demonstration
  - Develop Error Simulation Utility Completion May 2014
  - Data Validation Prototype Demonstration Completion June 2014

PHASE 3
- Functional Specifications of the Data Validation System
  - Document Key Lessons Learned Completion August 2014
  - Functional Specification Completion September 2014
  - Near Completion

Completed
Algorithms Process & Stages – 6 Modules

Module 1 & 2
Communication & Message Format

Module 3
Time & Timing

Module 4 & 5
PMU Status & Data characteristics

Module 6
Measurement Topology

Data Stream

GPS (Optional)

Data validation flag

Combine flag & data
Conditioned data set to NaN for error

Conditioned and/or flagged data

Comm error
Msg size
Chk word
PMU ID
Missing Samples

Msg order & sequence
Time good
Latency ok
Stuttering

H/L limits
Hi Noise
Stale data
Frequency derivation

User defined calculations & logics for topology-based validation

Output Configuration

North American SynchroPhasor Initiative

WECC
Data Quality Flag & Output

- Standard-based Data Quality Flag
  - Flag for each value
    - Phasor magnitude & angle
    - Frequency & ROCOF
  - Can be sent in IEEE 118 stream

- Quality – Good, Bad, Uncertain, Reserved (for future use)

- Sub-status – reason for the quality indication

- Limit – value at H/L limit, cannot move, or ok

- Outputs
  - Raw value
  - Raw value with flag
  - Conditioned with flags (bad and/or uncertain values cleaned)
PDVC Prototype Workflow

- Network Error Detection
- Message Error Detection
- Configure Frame Tracking
- Time & Data Validation
- Notification & Error Indication
- Raw, Flagged or Conditioned Data
- Latency/Out of Sequence Validation
- Time Quality Validation
- PMU Status Validation
- Range Validation
- Stale Validation
- Noisy Validation
- Topology-based Validation

Quality Flag Assigned
Measurement Values

<table>
<thead>
<tr>
<th>No.</th>
<th>Signal Name</th>
<th>Signal Type</th>
<th>Value</th>
<th>Quality C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Status</td>
<td>Status</td>
<td>0x00C0 (Good Data)</td>
<td>Good</td>
</tr>
<tr>
<td>2</td>
<td>V11</td>
<td>Voltage</td>
<td>51.9835 kV / 57.205 V</td>
<td>Uncertain, Topology Validation Failure: Uncertain,</td>
</tr>
<tr>
<td>3</td>
<td>V22</td>
<td>Voltage</td>
<td>536.836 kV / 57.205 V</td>
<td>Uncertain, Engineering Unit Exceeded High Limit:</td>
</tr>
<tr>
<td>4</td>
<td>C11</td>
<td>Current</td>
<td>500 A / -42.9718 Dr.</td>
<td>Uncertain, Topology Validation Failure: Uncertain,</td>
</tr>
<tr>
<td>5</td>
<td>Frequency</td>
<td>Frequency</td>
<td>50 Hz / 0 Hz</td>
<td>0x00-0x04: Good</td>
</tr>
<tr>
<td>6</td>
<td>TeA/Latency</td>
<td>Analog</td>
<td>0.000060304 Seconds</td>
<td>0x00-0x04: Good</td>
</tr>
</tbody>
</table>

Measurement Quality:
Uncertain: Topology Validation Failure
Uncertain: Engineering Unit Exceeded High Limit
Error Simulation Utility

- **Data Source**
  - Recorded real data in CSV file format
  - Real-time simulation

- **Functionality**
  - Replay or Simulate real-time C37.118 stream
  - Inject errors at protocol level, PMU level, and measurement level
  - Manage PMU/Signal and communication options

**Diagram:**
- Record Data File (.CSV)
- PMU Setup File (XML)
- Reader
- Error Injectors
- C37.118 Converter
- C37.118.2 Over network
- PMU Simulator
- PDVC Algorithm Prototype
- User Entry

**Notes:**
- Data Source
  - Recorded real data in CSV file format
  - Real-time simulation
- Functionality
  - Replay or Simulate real-time C37.118 stream
  - Inject errors at protocol level, PMU level, and measurement level
  - Manage PMU/Signal and communication options
DOE Project Current Status

- PDVC and Error Simulation Utility prototype available for download
  https://www.electricpowergroup.net/researchapps/
- Functional Specifications being finalized for delivery to DOE
- EPG planning to release a commercial product that incorporates modeless data validation and additional functionality by 4Q2014
WECC Synchrophasor Data Validation and Conditioning Application (SDVCA)

Data Quality Solution
Validation, Correction, Selection

Model-less Algorithms

Model-Based Techniques
WECC Data Validation & Conditioning Project

Input: Raw C37.118

Model-Less Validation & Conditioning (DoE DV Project)

Model-less conditioned C37.118

Output Selection

Output: Conditioned C37.118

LSE-Based Validation & Conditioning

LSE-conditioned C37.118

Output Selection

Output: Conditioned C37.118

Model-less conditioned C37.118

LSE-conditioned C37.118
SDVCA Data Flow

1. SDVCA Manager

2. Network Model Manager

3. PDVC

4. LSE

5. ICCP Gateway

User data entry

Raw Data Entry in C37.118

Modeless Data Validation & Conditioning

Pre-conditioned data

Post-processing & Result Selection

SDVCA validated & condition data

User configurations

Pre-conditioned data

Breaker Status

Raw Data Entry from EMS

Network Model from EMS

LSE Network Model

LSE conditioned data

Configuration File

North American SynchroPhasor Initiative (NASPI)
WECC Project Status

- Model-less Algorithm Implementation - Completed
- Building upon LSE work at Dominion*. LSE Evaluation and Design - Completed
  - Algorithm Design
  - System Design
  - Detailed Report
- WECC Approved System Design – Completed
  - LSE Network Model Editor
  - LSE Service
  - LSE Integration with Model-less Algorithm
  - LSE Integration with ICCP Gateway for Breaker Status
- Implementation – Ongoing (Targeting Feb. 2015)
- Testing & Installation – Planned (Targeting March/April 2015)

*LSE code developed by Kevin Jones, Dominion: providing consulting support to EPG
Thank You

Any Questions?

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