Public Repository of PMU Data for Oscillatory Events

Slava Maslennikov

Why?

- IEEE PES/PSDP/PSSC Task Force on Oscillation Source Location was formed in 2016 with the objective to facilitate the development of PMU-based methods/tools for locating the source of sustained oscillations (both Forced and poorly damped Natural oscillations)
- Work plan includes the creation of the Test Case Library of sustained oscillations by using simulated and actual oscillatory events
- Publicly available test cases (http://curent.utk.edu/research/test-cases/)
  - **27 Simulated oscillation cases** on a WECC 179-bus system model in PSS/E V30
  - **5 Actual oscillatory events** recorded by PMUs on multiple locations in ISO-NE http://web.eecs.utk.edu/~kaisun/Oscillation/actualcases.html
  - 4000+ visits in past two years

- This presentation describes ISO-NE experience in publicly sharing PMU data

Major Factors in PMU Data Sharing

- Data confidentiality
- There is no universal PMU data format and naming convention
  - ✓ Which format to be used for PMU sharing?
- Significant efforts are required from utility in a manual process
  - ✓ Need in an automated procedure to extract data, remove confidential information and save it in desired format
- How to provide mapping between measurement and location?
  - ✓ PMU application can require a mapping of a measurement point with the location in power system
- There is no obligation or incentive for utilities to share PMU data as a public information
- All above factors discourage utilities from sharing PMU data

Data Confidentiality

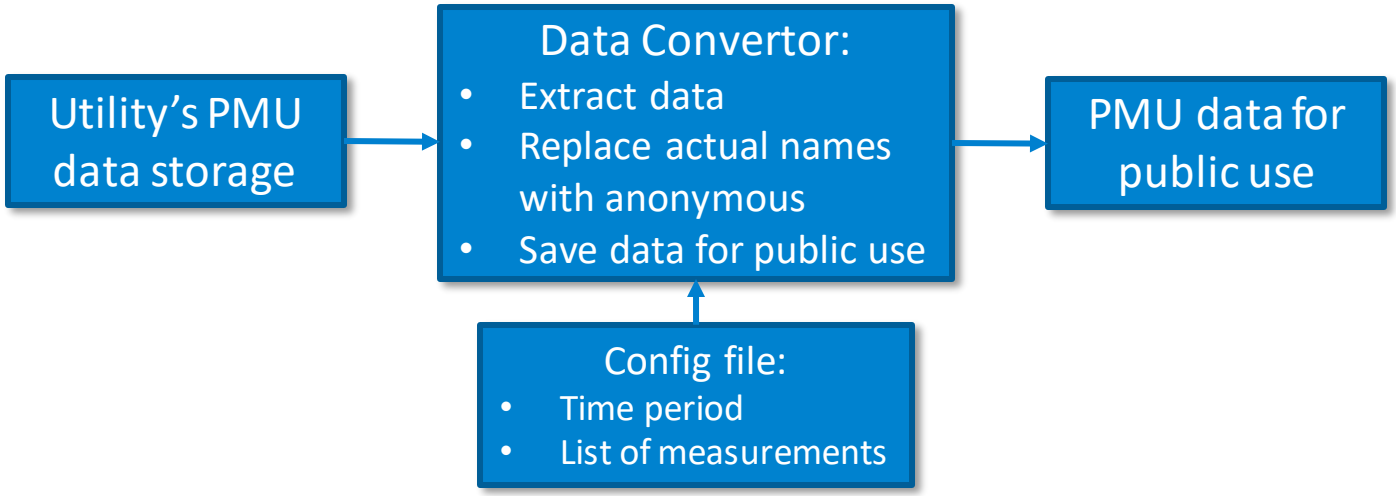
- Confidential information cannot be publicly shared. Confidential components:
  - ✓ PMU names listing specific locations and types of equipment
  - ✓ PMU data itself linked to a specific location and particularly for very recent time period
- Ways to overcome the hurdle
  - ✓ Replace actual PMU names with anonymous but preserving the naming convention which can be important for an application

    <Substation name><Transmission element><Type of measurement>
  - ✓ Anonymous names should make difficult the reverse engineering to discover actual names
  - ✓ PMU data should preferably be related to “old” events; at least few weeks old

PMU Naming Convention and Data Format

- There is no commonly used universal PMU naming convention and data format. PMU data set for public use should be
  - ✓ Convenient for viewing, writing and reading. Text-based, not binary
  - ✓ Flexible to accommodate all types of measurements. Different applications can require different sets of measurements
  - ✓ A comprehensive format and naming convention description must exist. Good example for WECC naming convention is here: https://www.wecc.biz/Reliability/WISP%20PMU%20Identification%20and%20%20Signal%20Naming.pdf
- Today, there is no standard PMU naming convention across utilities. Utilities use different naming convention for internal use. Examples:
  BPA: BLSN 500 A1 SA.B500WEST____1VC.VM
  ISO-NE: i_east_medway_446_22003_be_emedway_1_t345_t345a_is_30
- Some of available formats and naming conventions
  - ✓ "WISP 2015", "WECC 2012" naming conventions
  - ✓ "WECC .pdat", "NERC SMS .csv", "IEEE .csv" formats
- Each utility need to have a data convertor from internal format to public format
  - ✓ Who can help to develop such convertors?
- Main components in naming convention <Substation>, <Transmission element>, <PMU ID>, <Type of measurement> should be preferable preserved but made anonymous.
  - ✓ Different types of PMU-based applications may require all these components

Data Conversion from Internal to Public



- Universal data convertors do not exist
- It makes sense to develop such an automated data convertor for each utility
  - ✓ One-time efforts for the development and practically no efforts for the creation of a public data set
  - ✓ Elimination of human errors at semi-manual data conversion

Mapping PMU measurements and Locations

- PMU application may require to know the location of measurements in the power system
- Mapping options:
  - ✓ One-line diagram
    - Would be a good option but difficult to prevent back engineering and revealing CEII information
  - ✓ Approximate, schematic diagram
    - Preserve relative geographical relation between locations
    - Anonymous names consistent with PMU naming
    - Partial set of locations and measurements not allowing back engineering

Practical steps for sharing ISO-NE PMU data

- Developed PMU data requirements and "IEEE .csv" format for public use
  SustainedOscillations_Requirements_PMUdata_2018-03-12.docx at http://web.eecs.utk.edu/~kaisun/Oscillation/actualcases.html
- Developed a Matlab code facilitating the verification of the consistency of PMU data set with the "IEEE .csv" format requirements

  Read_AnalysisPMU_IEEEformat_v1.m at http://web.eecs.utk.edu/~kaisun/Oscillation/actualcases.html
- Developed an automated Data Convertor (Matlab) to extract PMU data from Phasorpoint historian, make naming anonymous and save data in "IEEE .csv" format
- Developed a schematic "PMU map" for selected PMU measurements across ISO-NE system
- Results of Data Convertor with anonymous names and "PMU Map" were approved by ISO-NE legal for public release
- Created five sets of PMU measurements for actual events of sustained oscillations
  - ✓ Raw PMU data, no any treatment
  - ✓ Missed samples replaced by NaN

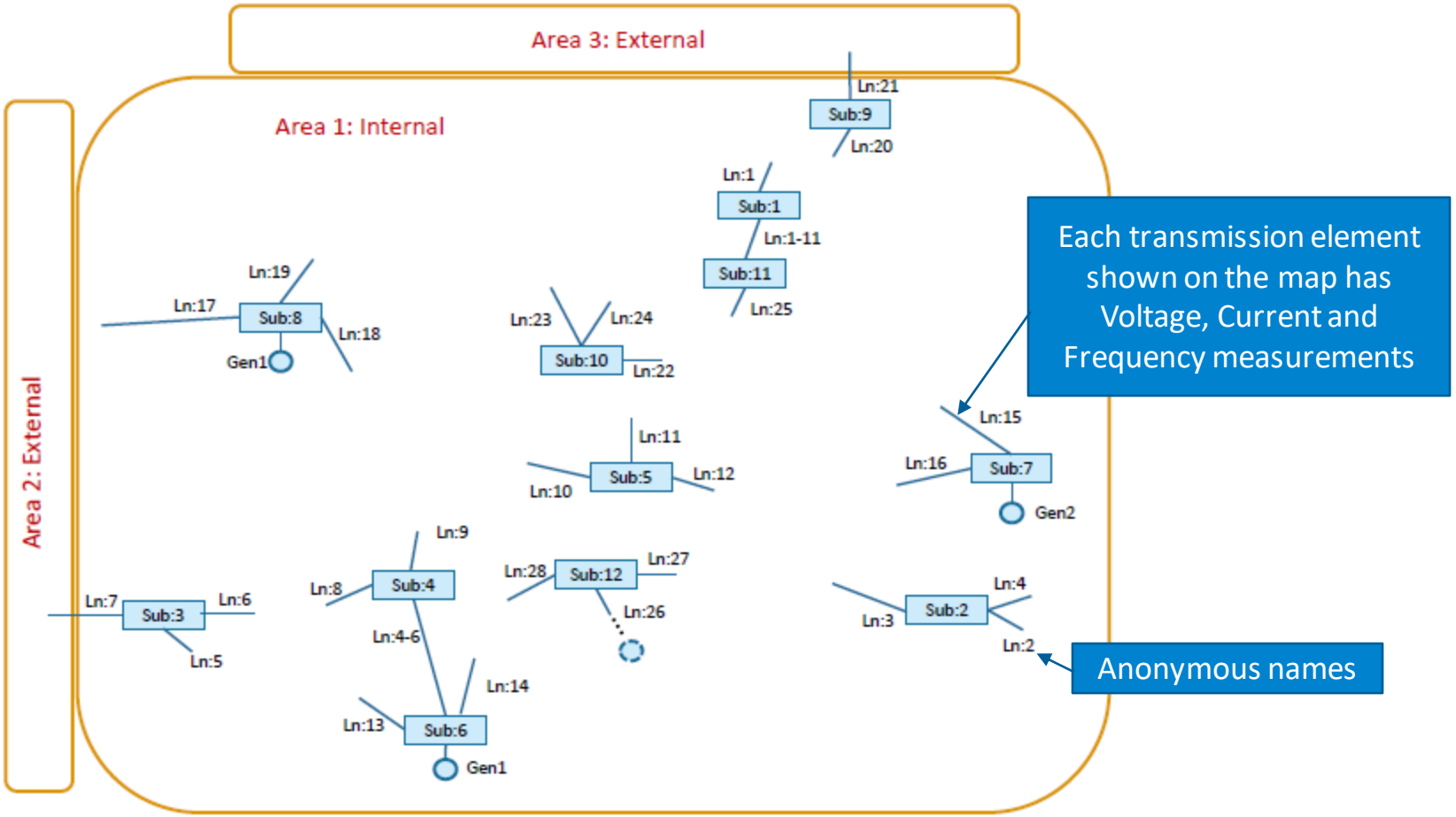
Actual Oscillatory Events

- Each data set contains PMU measurements from 12 substations of ISO-NE

Cases #	Case name	Data of event	Power system - source of PMU	Type of oscillations	Frequency/Hz	Peak to peak magnitude	Source and location	Confidence level on the source location	Duration of sample set	Comments
1	ISO-NE case 1	Jun.17, 2016	ISO-NE	System-wide mode	0.27	Up to 27 MW	Generator outside of ISO-NE in Area 2.	100%	3 min	Near-resonance conditions with system-wide natural oscillatory mode caused by a large generator located in Area 2. Area map: ISO-NE_map.pdf.
2	ISO-NE case 2	Oct.3, 2017	ISO-NE	Multi-frequency, wide-spread	Dominant modes: 0.08 0.15 0.31	Up to 130 MW	Generator outside of ISO-NE in Area 3.	100%	6 min	Multi-frequency process with growing magnitude caused by a generator located outside of ISO-NE in Area 3. Oscillations with significat MW magnitude were observed in multiple locations. Area map: ISO-NE_map.pdf.
3	ISO-NE case 3	Jul.20, 2017	ISO-NE	Regional	1.13	Up to 115 MW	Generator located East from Sub:2. Lines Ln:2 and Ln:4 lead to the area, where the source generator resides.	100%	3 min	Equipment issue in a large generator has created 1.13Hz oscillations with growing magnitude during 40 seconds.
4	ISO-NE case 4	Feb.14, 2018	ISO-NE	Wide-spread	0.25	Up to 10 MW	Presumably outside of ISO-NE.	Low	5 min	Sustained oscillations with variable magnitude and observed in multiple locations.
5	ISO-NE case 5	Jan.29, 2018	ISO-NE	Local	1.57	Up to 15 MW	Generator Gen2 at Sub:7.	100%	4 min	Local oscillations caused by a large generator. Area map: ISO-NE_map.pdf.

Schematic map of PMU locations

- Each data set contains PMU measurements from 12 substations of ISO-NE



Example of data: ISO-NE_case1

- File ISO-NE_case1.csv opened in Excel
- PMU naming: **Sub:<substation number>:<type>:<component number>**

	A	B	C	D	E	F	G	H	I
1	Time	Sub:1:Ln:1	Sub:1:Ln:1	Sub:1:Ln:1	Sub:1:Ln:1	Sub:1:Ln:1	Sub:1:Ln:1-11	Sub:1:Ln:1-11	Sub:1:Ln:1-11
2	T	F	VM	VA	IM	IA	F	VM	VA
3	sec	HZ	KV	DEG	AMP	DEG	HZ	KV	DEG
4	1/1/1900 0:00	Ln:1	Ln:1	Ln:1	Ln:1	Ln:1	Ln:1-11	Ln:1-11	Ln:1-11
5	0	60.0300	205.1355	113.4106	246.0403	-52.9467	60.0300	205.3336	113.4995
6	0.033	60.0300	205.1342	113.7659	245.7559	-52.562	60.0300	205.3297	113.8538
7	0.067	60.0300	205.1389	114.1301	245.8354	-52.2041	60.0300	205.3306	114.2182
8	0.1	60.0300	205.1375	114.4889	245.6425	-51.7842	60.0300	205.3313	114.5755
9	0.133	60.0300	205.1443	114.8603	245.7712	-51.389	60.0300	205.3402	114.9466
10	0.167	60.0300	205.1332	115.229	245.2883	-51.1699	60.0300	205.329	115.3159
11	0.2	60.0300	205.1407	115.5872	245.6588	-50.8372	60.0310	205.3332	115.6738

Questions