

NASPI WG meeting
Data & Network Management Task Team



Efficient PMU Data Analysis through High Performance Data Management Platform

10/14/2015

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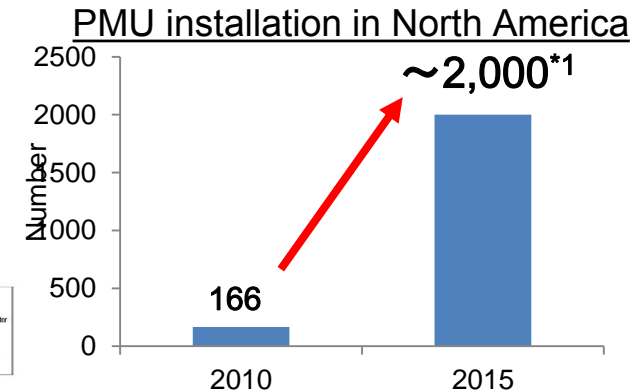
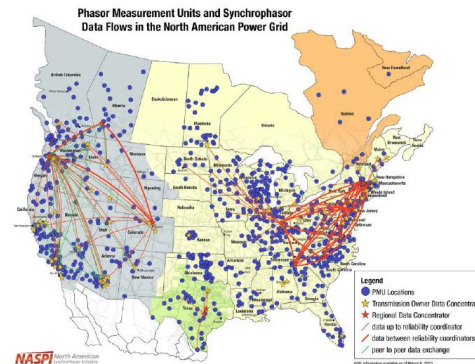
Big Data Research Laboratory
Hitachi America Ltd.

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Background

- PMUs have become increasingly popular in North America
- Many PMU data analysis tools have been developed
 - Grid dynamics monitoring
 - Oscillation detection
 - Model validation



*1: Silverstein, A. May 2015. NERC Board of Trustees Meeting, May 5, 2015, "An Update on the North American SynchroPhasor Initiative"

Challenges

Increasing PMU data size requires;

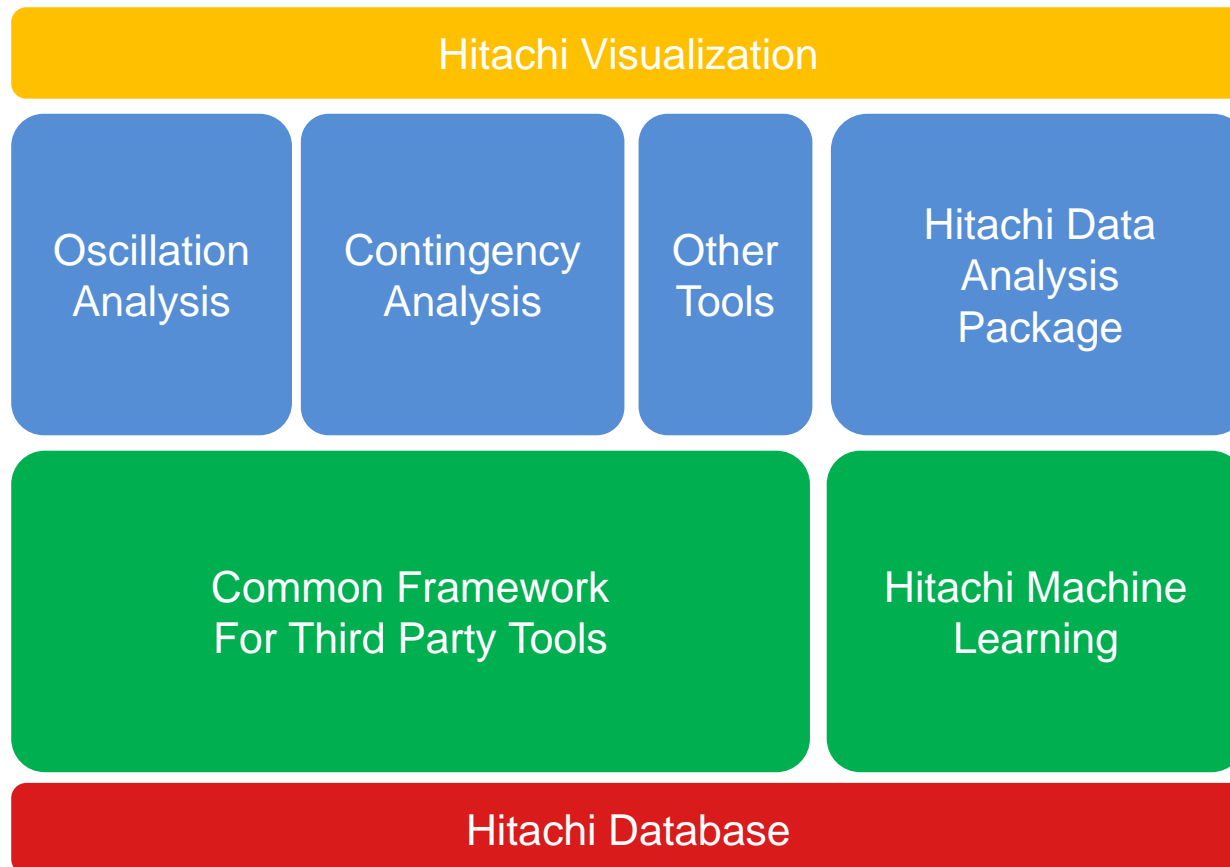
- Fast loading of historical data (Hundreds of TB/year)
- Efficient data cleansing against missing and bad data
- Effective data analysis

To accelerate integrated online/offline analysis fully utilizing every PMU data into grid operation

1-1. Platform Architecture

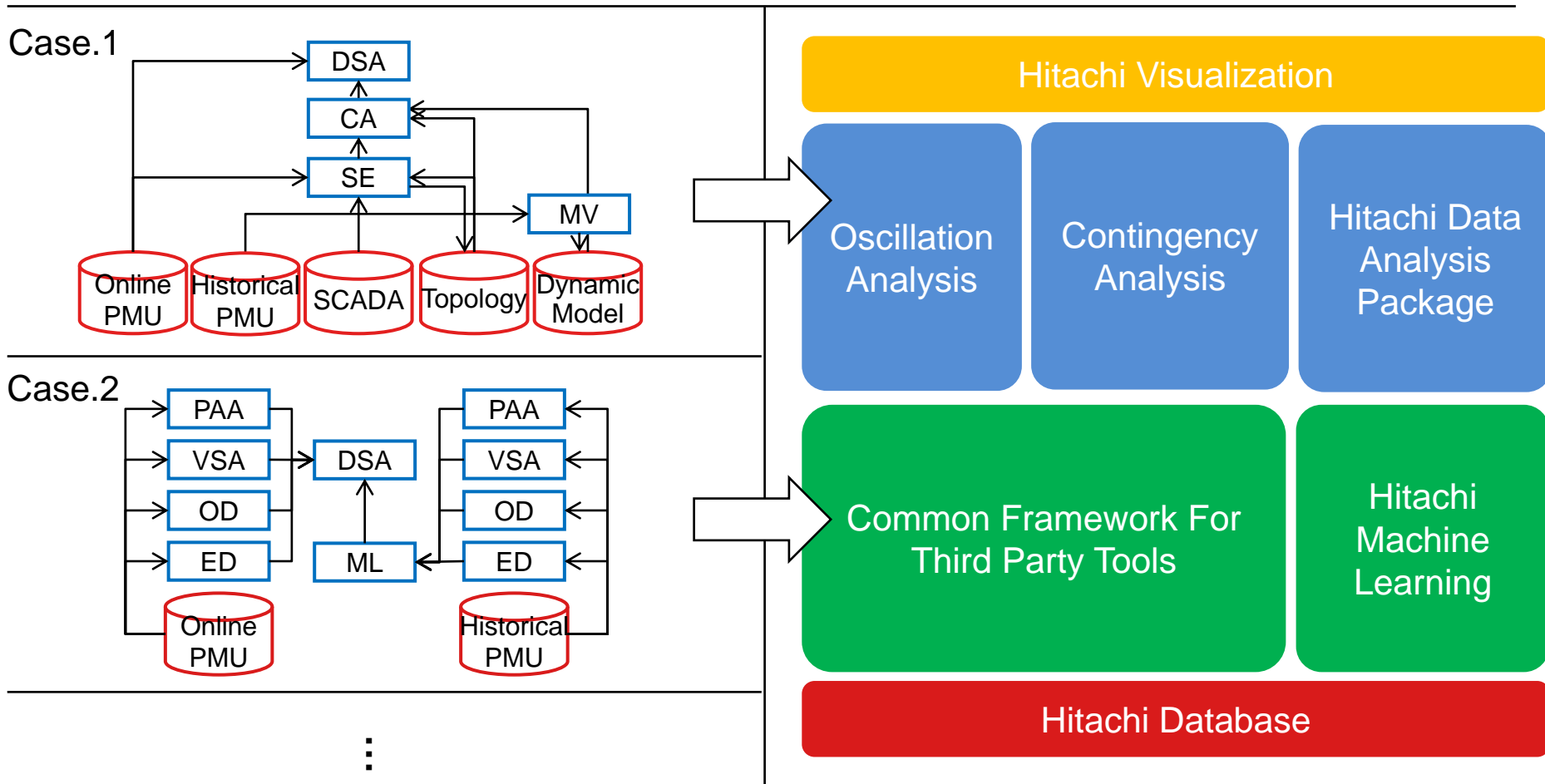
High performance data management platform for PMU data apps

- High speed database engine
- Integrated PMU applications
- Visualizations



1-2. Platform Architecture

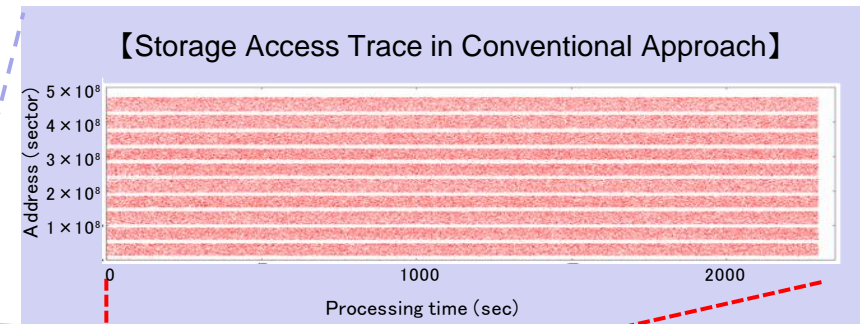
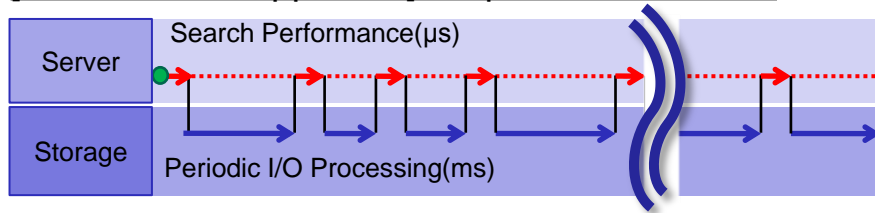
- Total integration from fast data acquisition to various applications and effective visualization



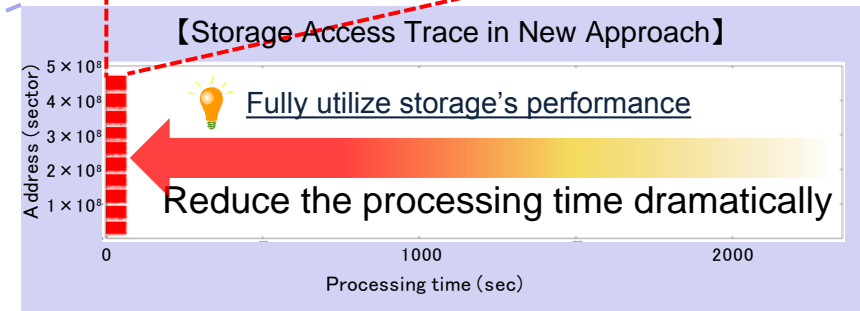
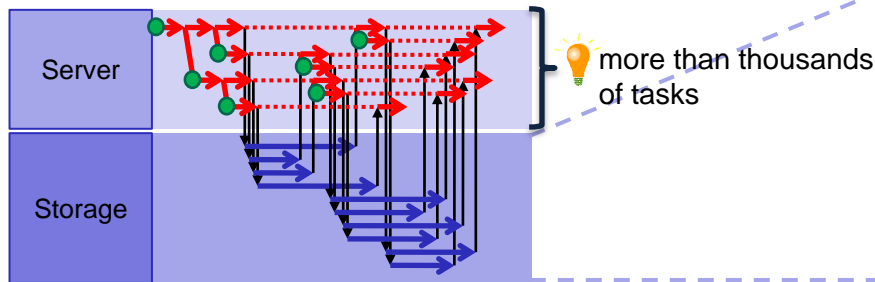
2-1. Hitachi database technology

- Fully utilizes the hardware (server, storage) resources
- SQL processing for DB search is automatically divided and executed with a high degree of parallelism

◆ [Conventional Approach] Sequential Execution



◆ [New Approach] Out-of-Order Execution Principle*1



● Task Allocation → Search Processing I/O Wait → Disk I/O

Application of the outcome of "Development of the fastest database engine for the era of very large database, and Experiment and evaluation of strategic social services enabled by the database engine" project (Principle Investigator: Prof. Masaru Kitsuregawa, University of Tokyo and also Director-General, National Institute of Informatics), supported by the Japanese Cabinet Office's FIRST Program (Funding Program for World-Leading Innovative R&D on Science and Technology).

*1 A new principle invented by Professor Kitsuregawa and Project Associate Professor Goda (The University of Tokyo).

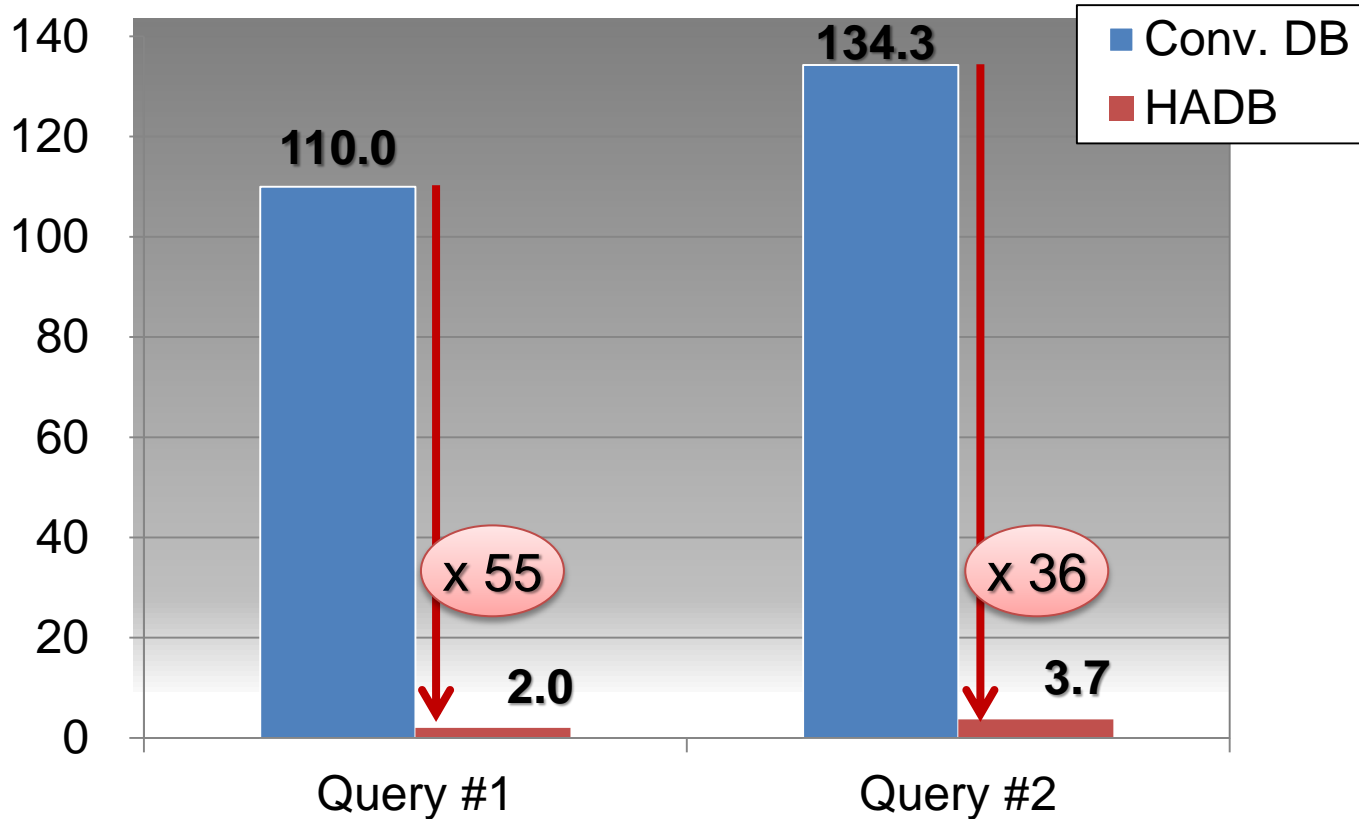
2-2. Performance evaluation

Query #1

Time series Trend Search
10 minutes, 4 PMU

Query #2

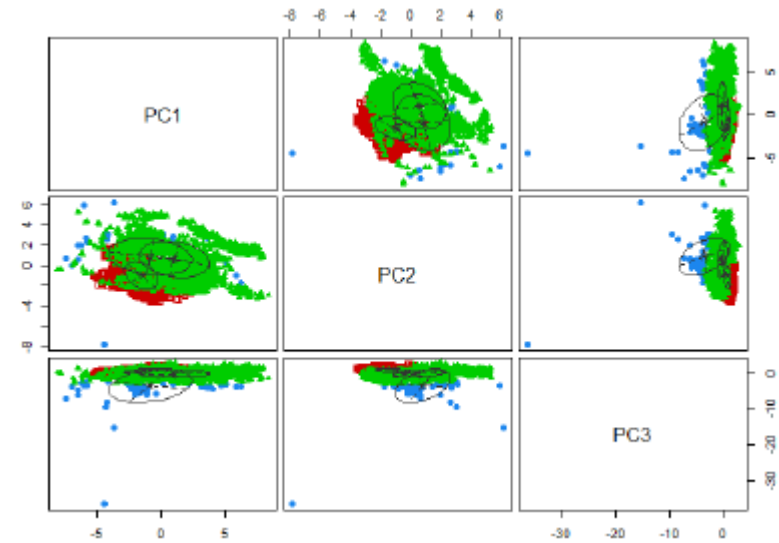
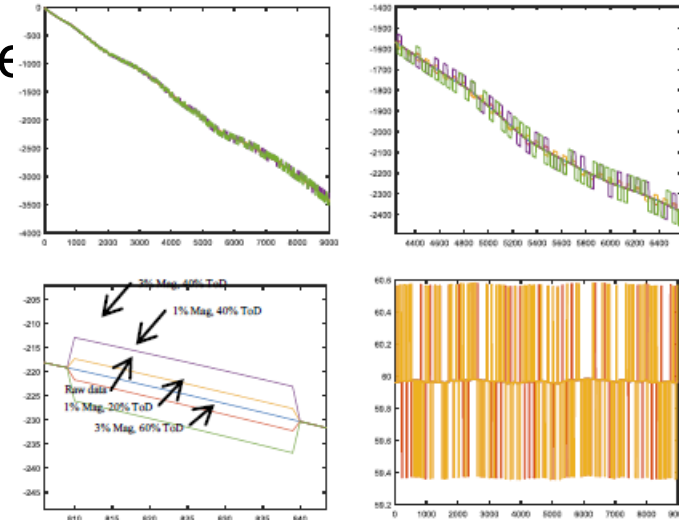
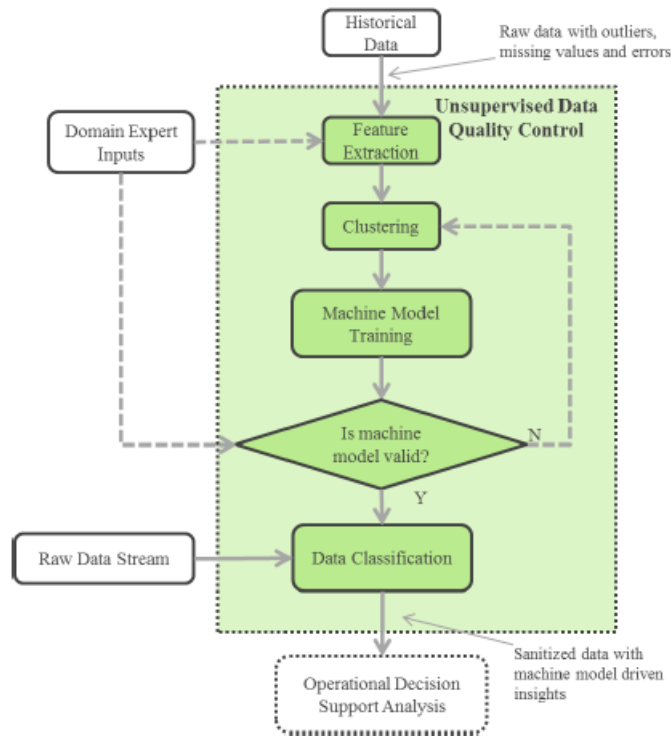
Snapshot Trend Search
5 snapshots, 500 PMU



3-1. Integrated PMU applications

Unsupervised data cleansing

- Outlier detection without domain knowledge
- Noise reduction based on data correlation
- Unsupervised, scalable solution



3-2. Integrated PMU applications

Automatic abnormality event detection

- Online detection of grid events with measurement-based method
- Historical data mining for similar events
- Updating detection rules from stored historical event data

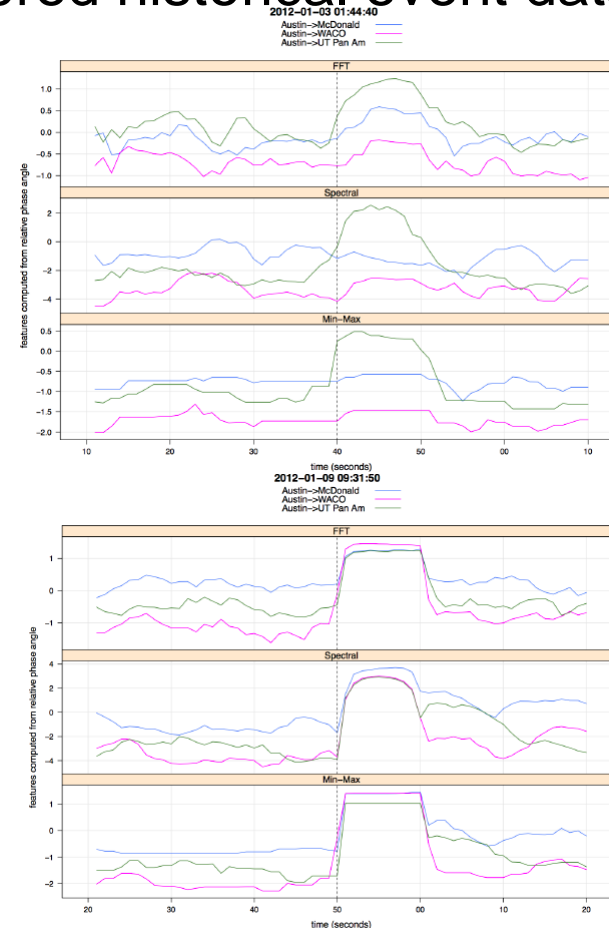
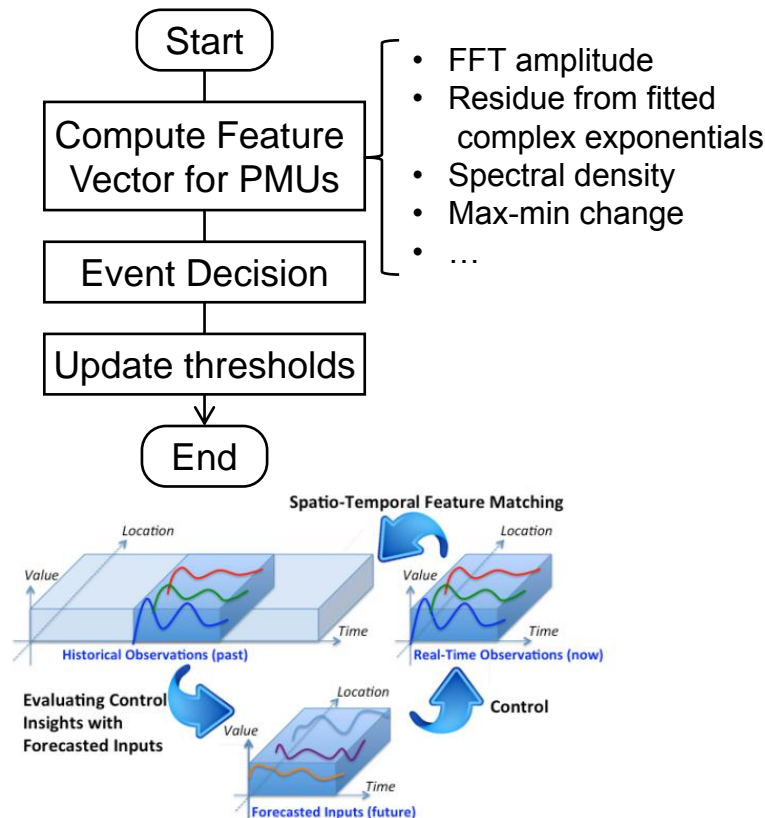
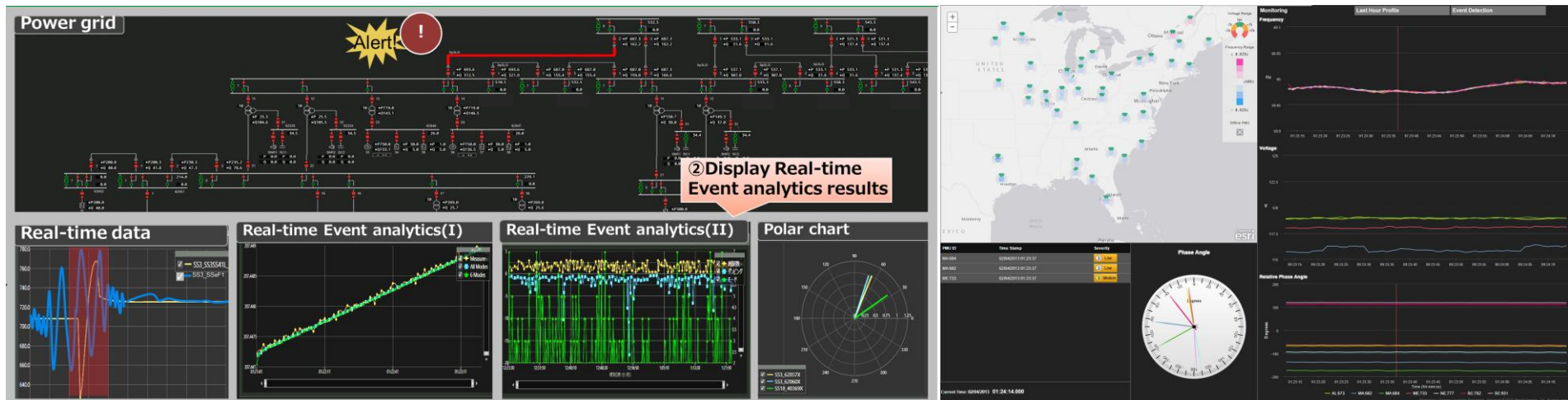


Figure 1 Illustration of spatio-temporal matching for real-time complex system control

4. Visualization

Visualization of various applications

- Coordination of information derived from heterogeneous data
- Intuitive display and operator support



Conclusion

To utilize both online and historical PMU data for operation...

- Fast DB for acceleration and better efficiency of analysis tasks
- Coordination of various power apps for comprehensive analysis
- Visualization for intuitive awareness with heterogeneous information

Future Plan

- Performance evaluation tests are ongoing on every layers; Database, Applications, and Visualization
- Integration of third party analysis tools to be tested
- Evaluation with real grid data will be planned

END



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