Applications on openPDC platform at Washington State University

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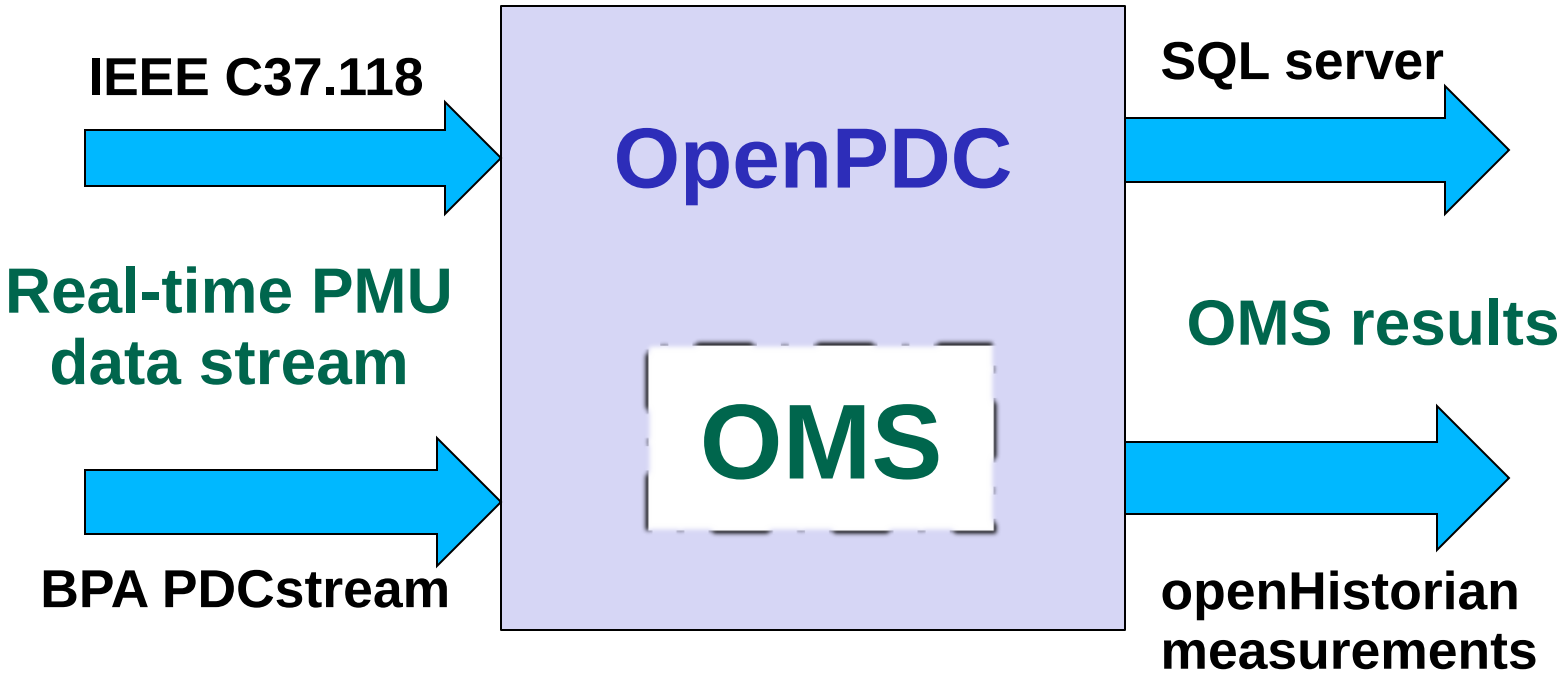
WSU projects

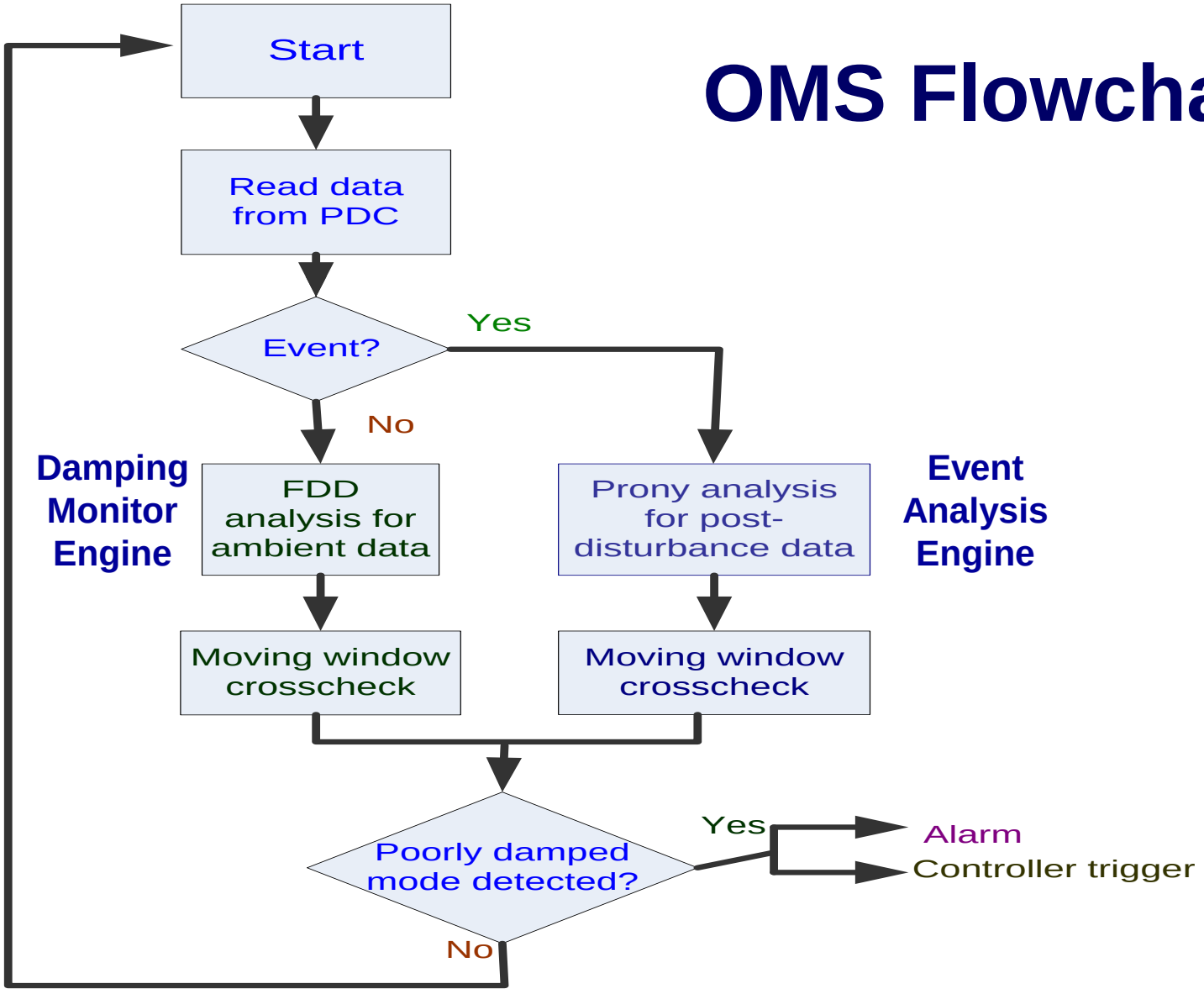
- **OMS** - Oscillation Monitoring System
  - Stand-alone system for oscillation detection and analysis using wide-area PMUs
- **VSMS** - Voltage Stability Monitoring System
  - Stand-alone system for voltage stability stress indicator using wide-area PMUs
- **GridSim** – Large-scale real-time power grid simulator
- **SLVC** – Substation voltage controller

Oscillation Monitoring System



OMS action adapter built into OpenPDC 64 bit version 1.5

OMS Flowchart



Complementary Engines

- **Event Analysis Engine**
  - Four algorithms: Prony, Matrix Pencil, Hankel Total Least Square and ERA.
  - Aimed at events resulting in sudden changes in damping
- **Damping Monitor Engine**
  - Ambient noise based. Continuous.
  - Frequency Domain Decomposition
  - Provides early warning on poorly damped modes

OMS Engines

- Event Monitor Engine
  - Automated Prony type analysis of oscillatory ringdown responses
  - *Five seconds* of PMU data analyzed every *one second*
- Damping Monitor Engine
  - Automated analysis of ambient noise data
  - *Four minutes* of PMU data analyzed every *ten seconds*

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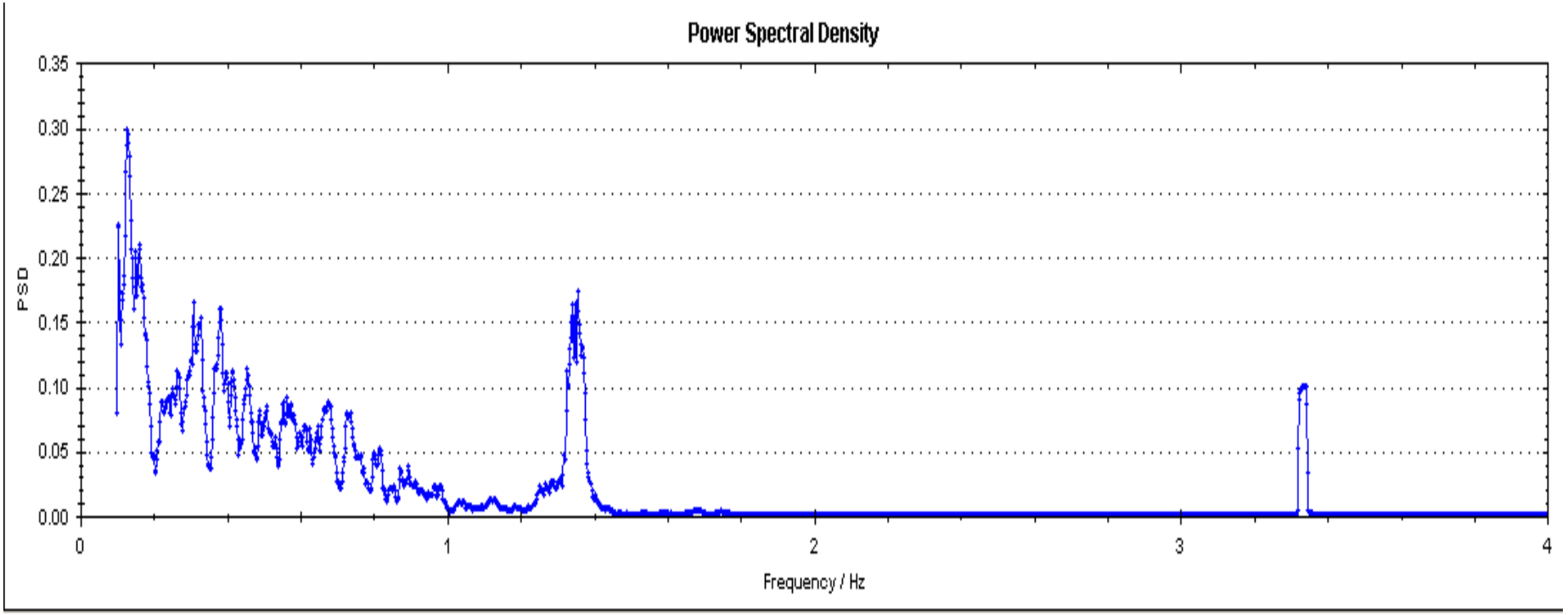
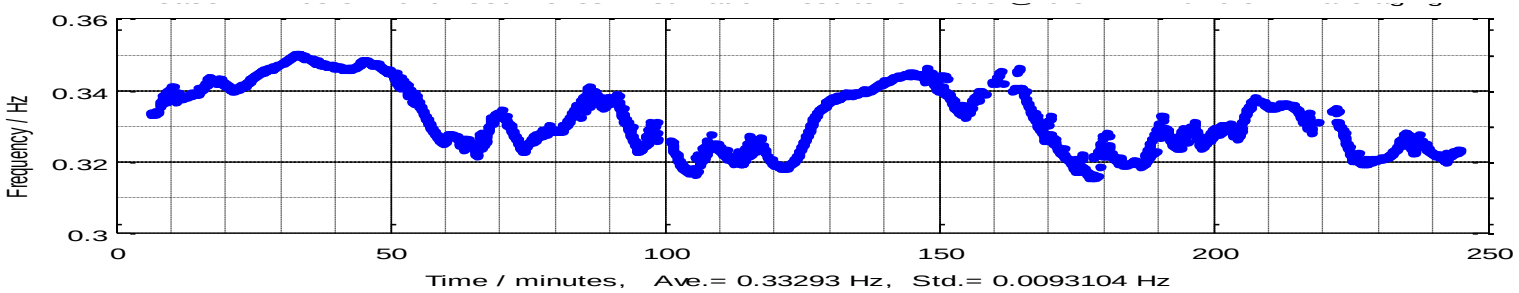
Different modes in a real system



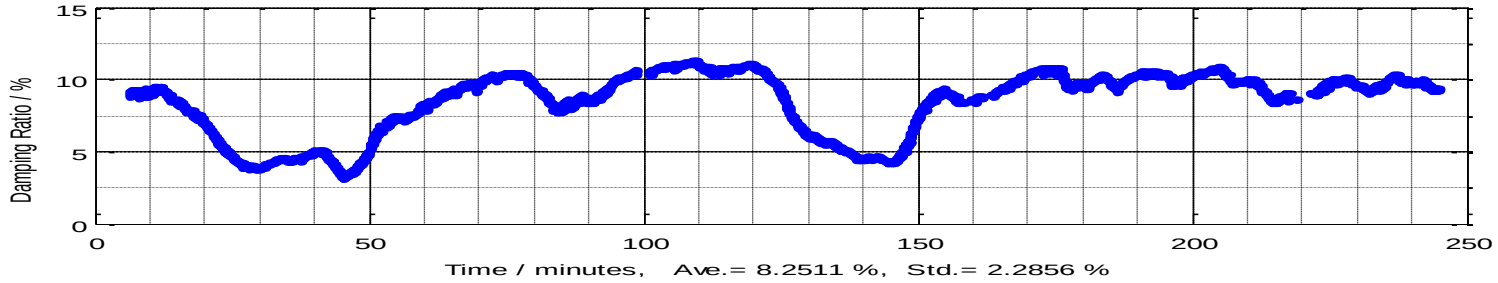
Poorly damped local mode at 1.3 Hz

Zero damping mode at 3.3 Hz

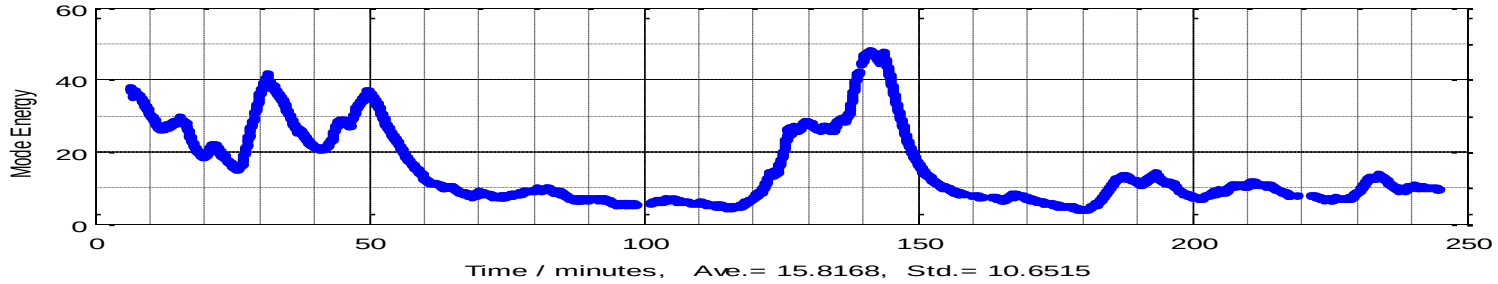
Western Data Analysis



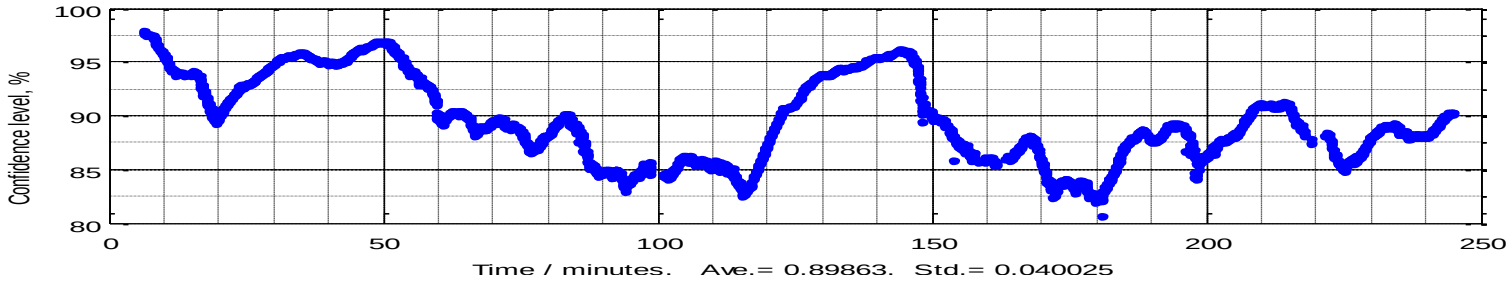
Mode Frequency



Damping Ratio

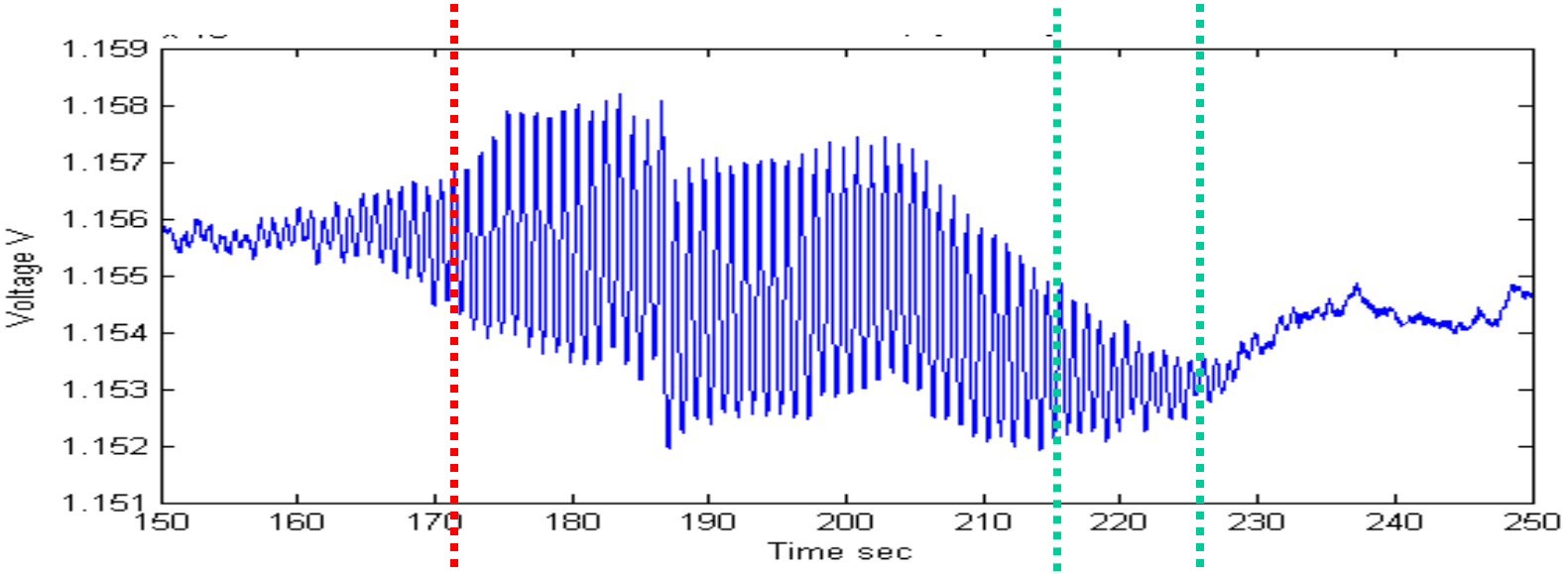


Energy Estimate



Estimate Confidence

Case Study – Western Event

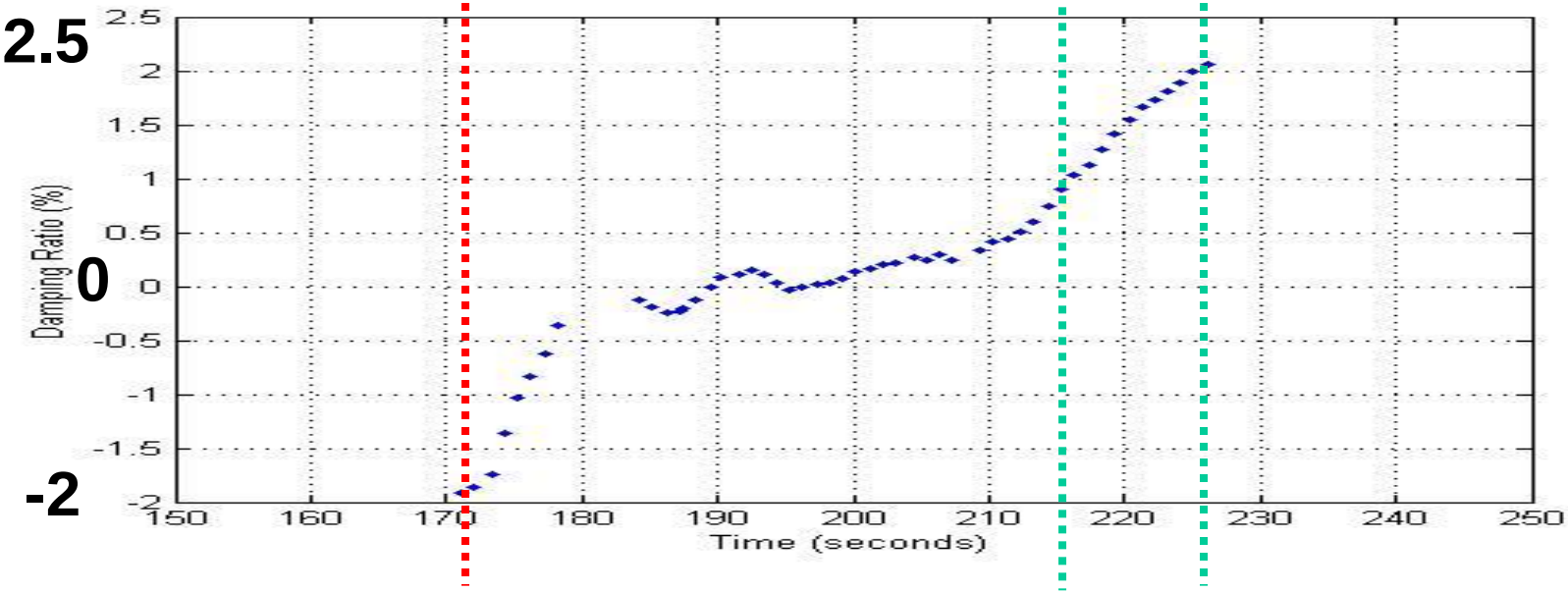


PMU Bus Voltage

2.5

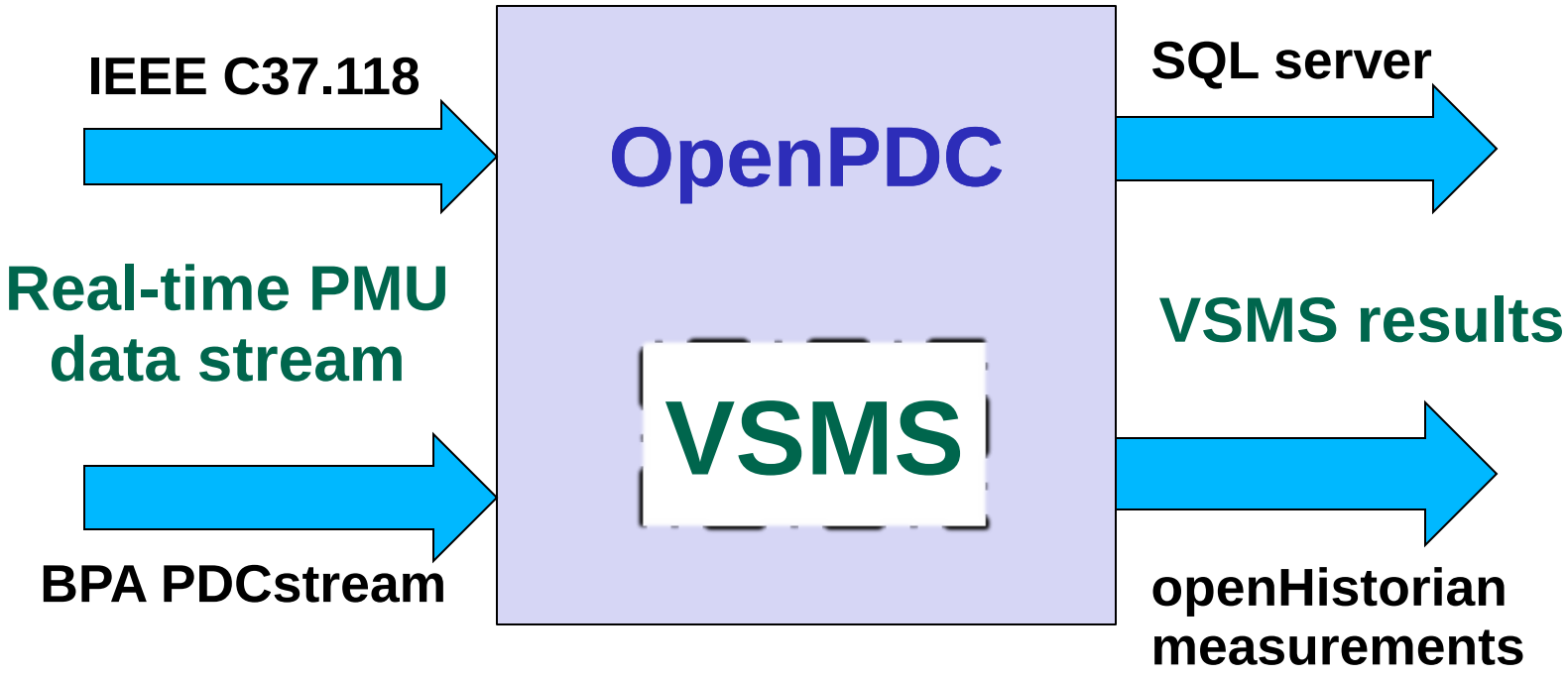
0

-2

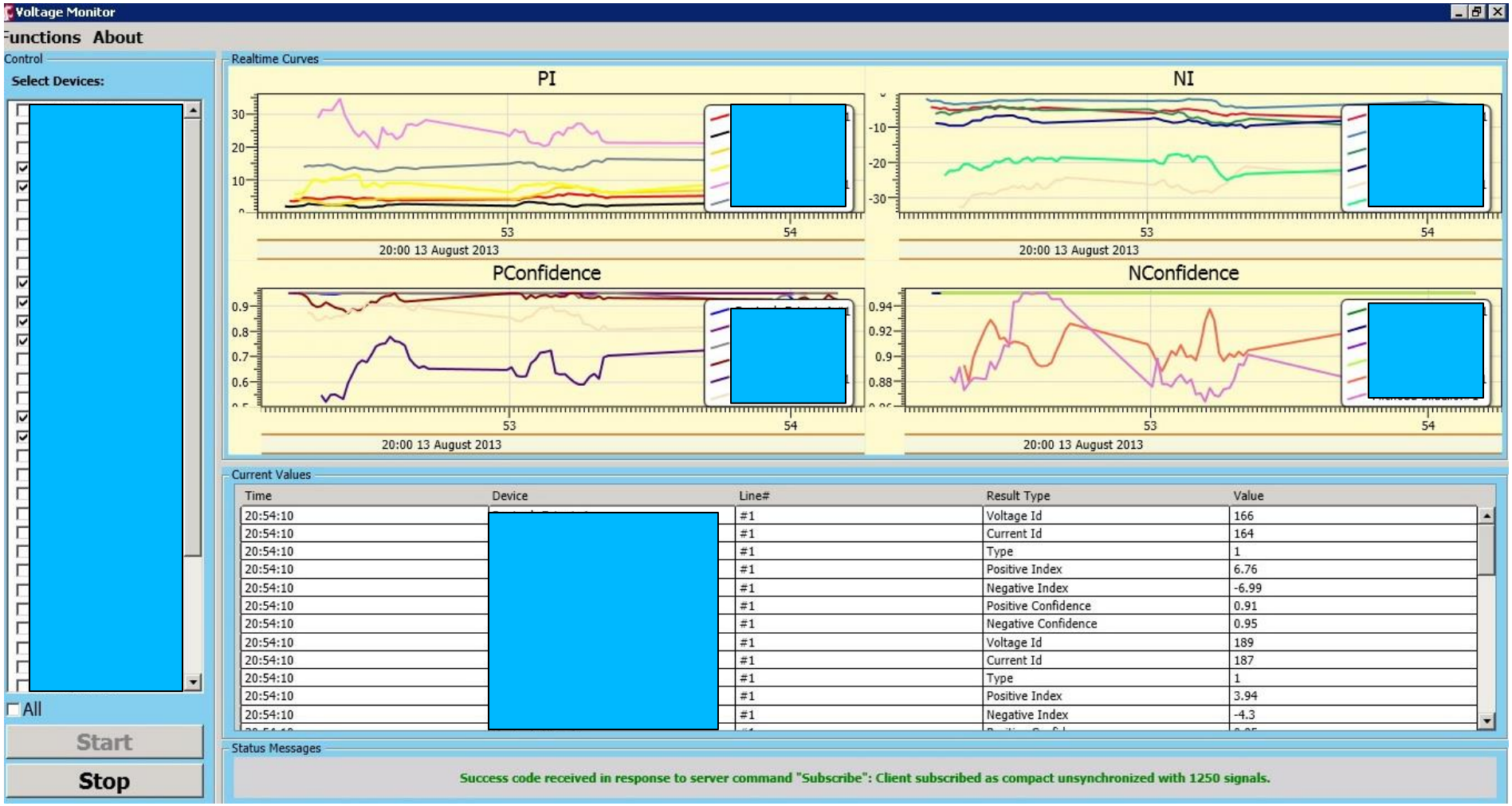


Event Analysis Damping Estimate

Voltage Stability Monitoring System



VSMS Real-time Display



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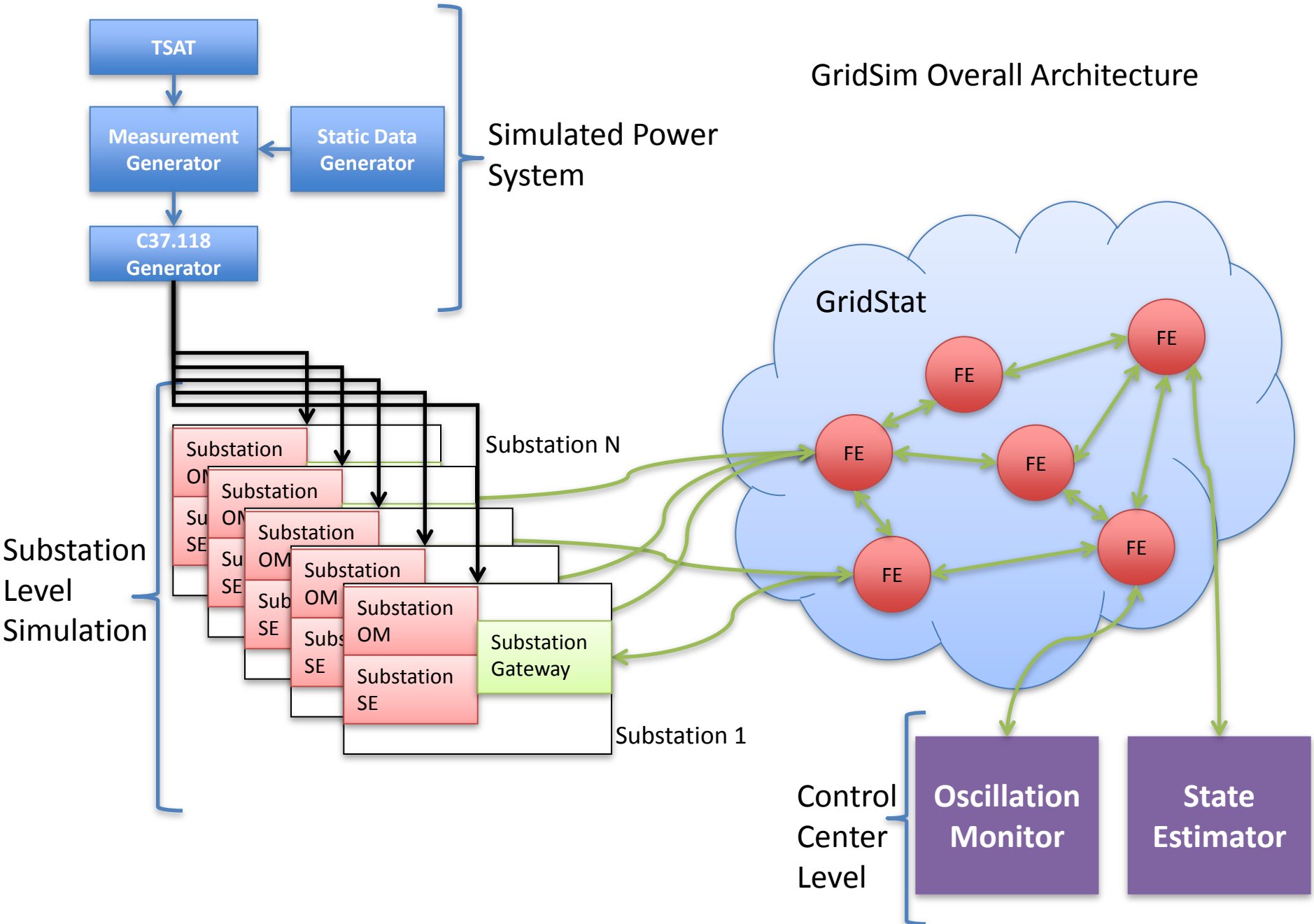
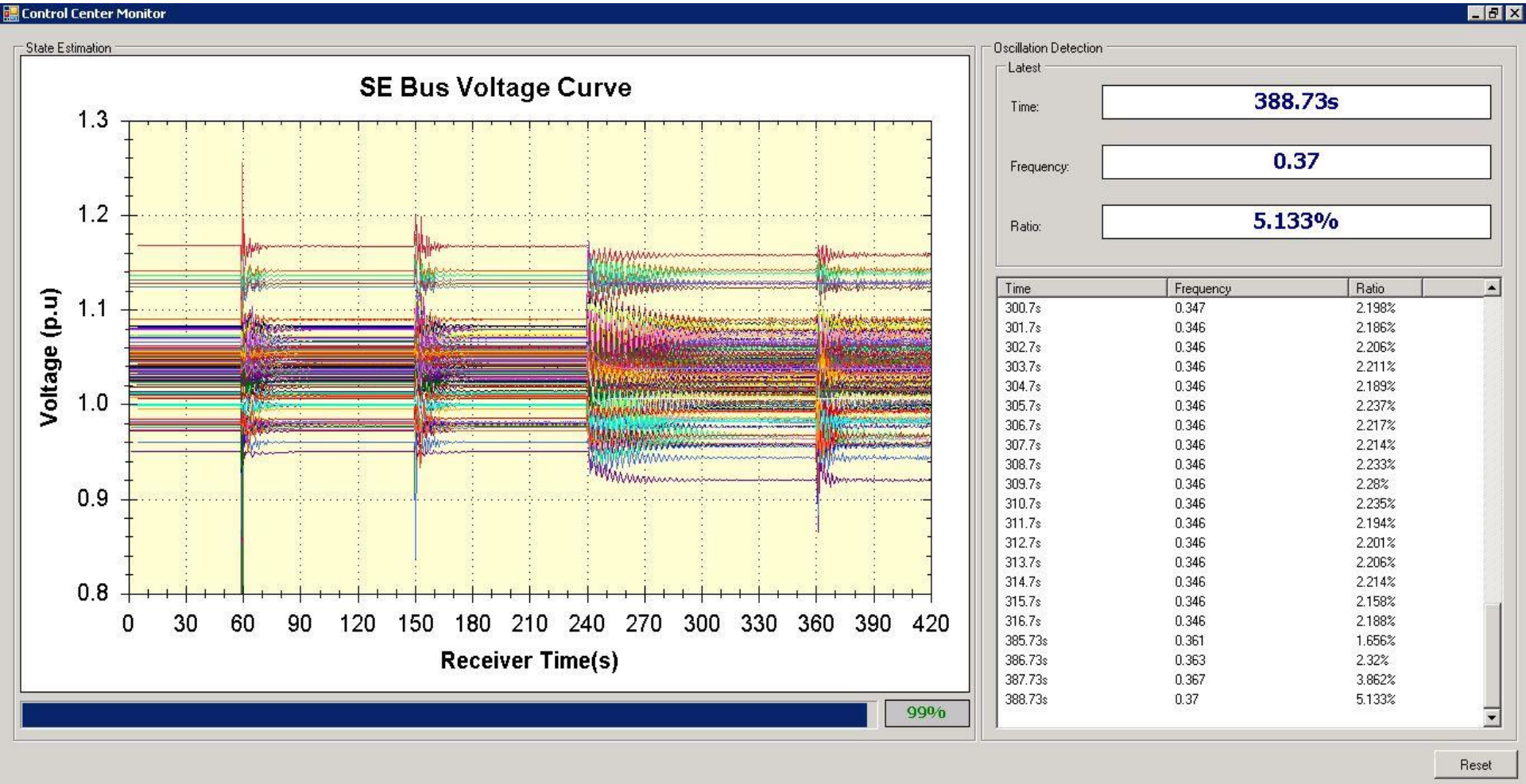
GridSim - Real Time Simulation of Power Grid Operation & Control

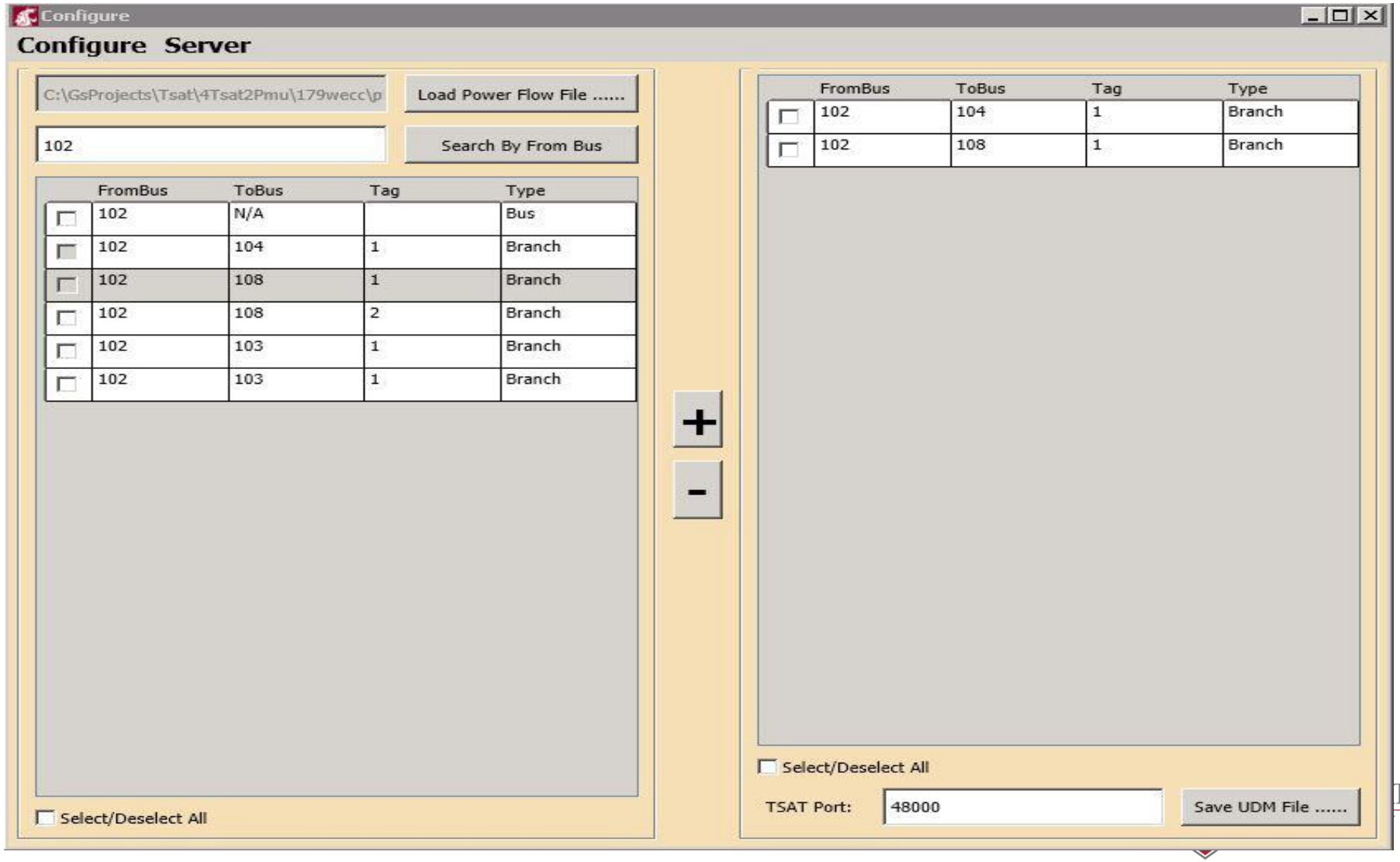
- Funded by USDOE
- Simulate PMU like real-time responses of large-scale power system including power grid dynamics and communication network
- Most of the following slides contributed by Chuanlin Zhao


GridSim Overall Architecture
TSAT
Measurement Generator
Static Data Generator
C37.118 Generator
Simulated Power System
GridStat
FE
FE
FE
FE
FE
FE
FE
Substation N
Substation 1
Substation OM
Substation SE
Substation Gateway
Substation Level Simulation
Control Center Level
Oscillation Monitor
State Estimator

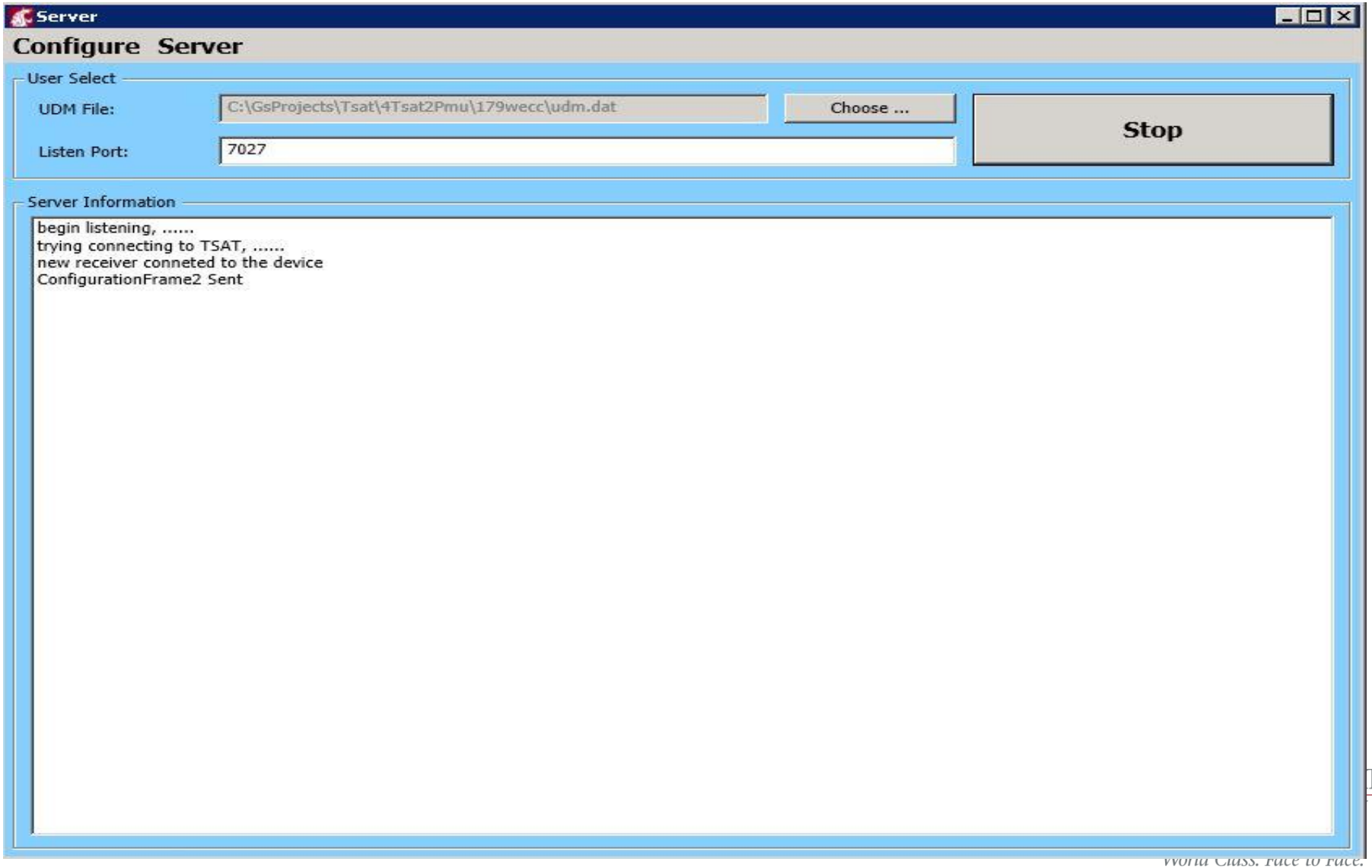
179 Bus Example



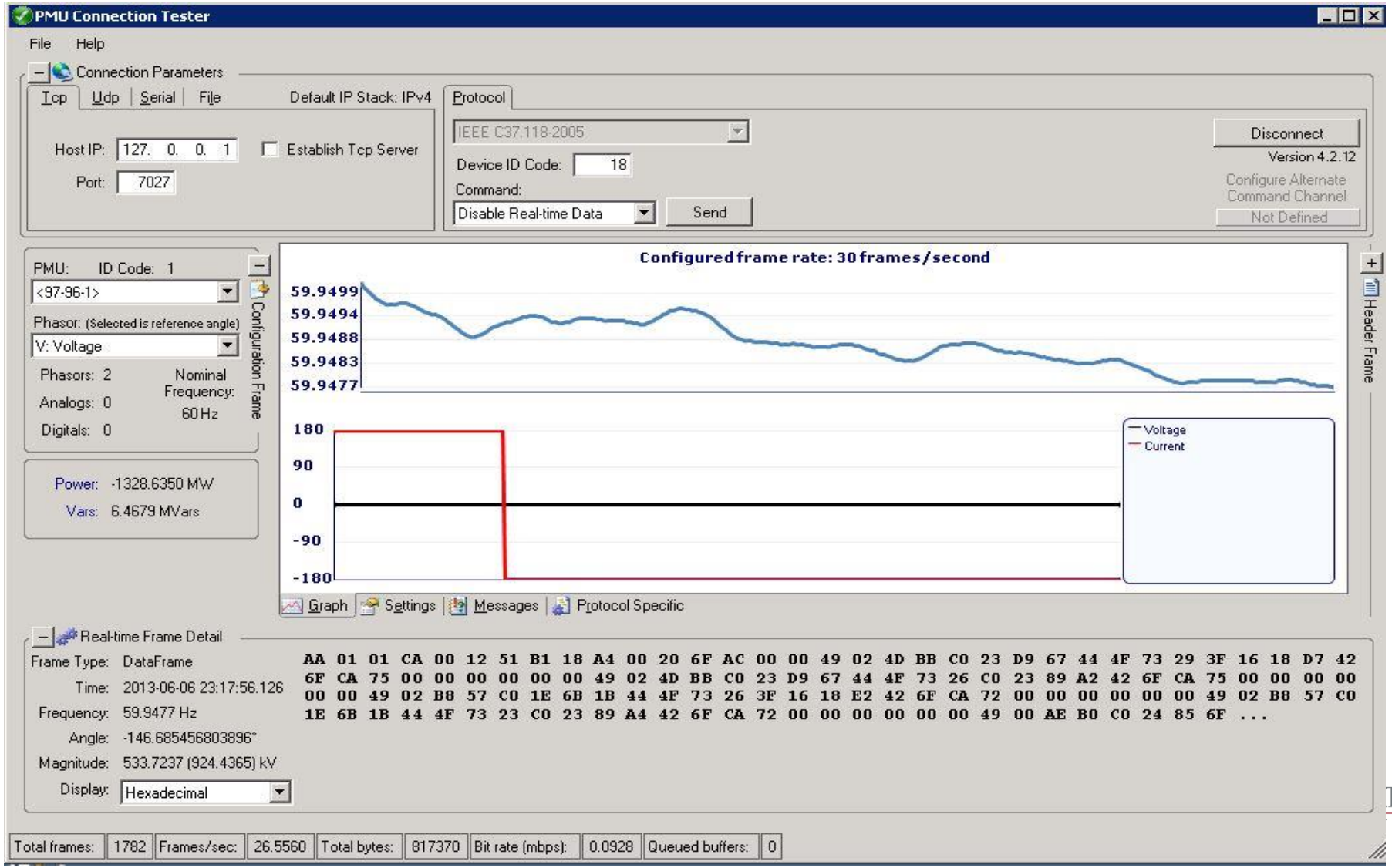
GridSim PMU Configuration



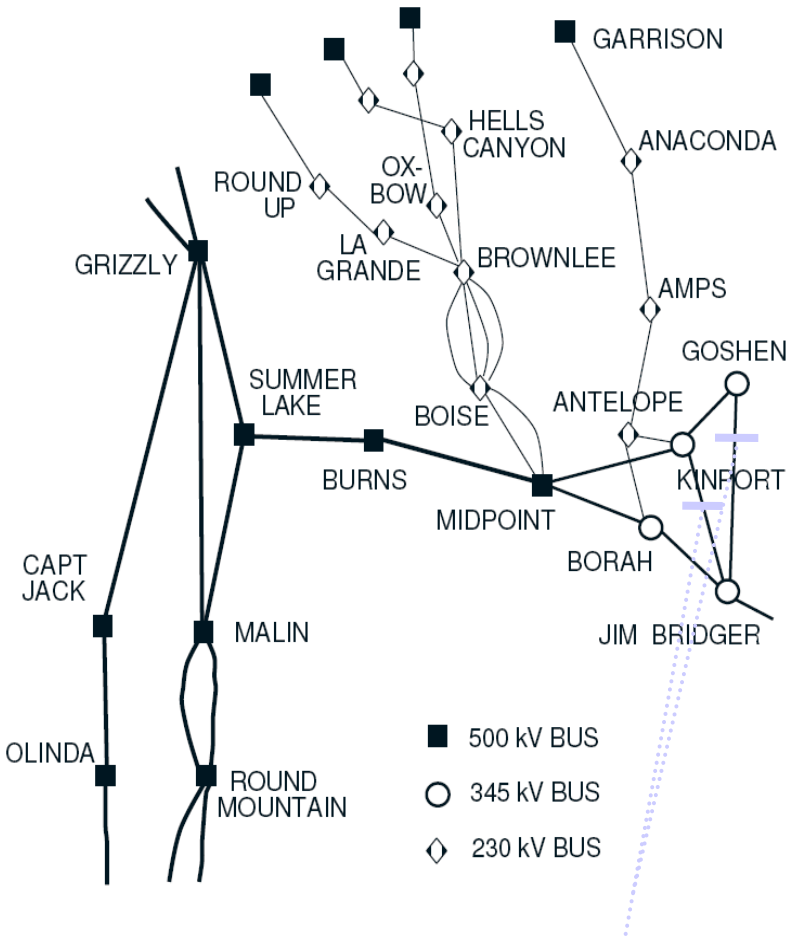
GridSim Comm Port Spec



GridSim 37.118 outputs

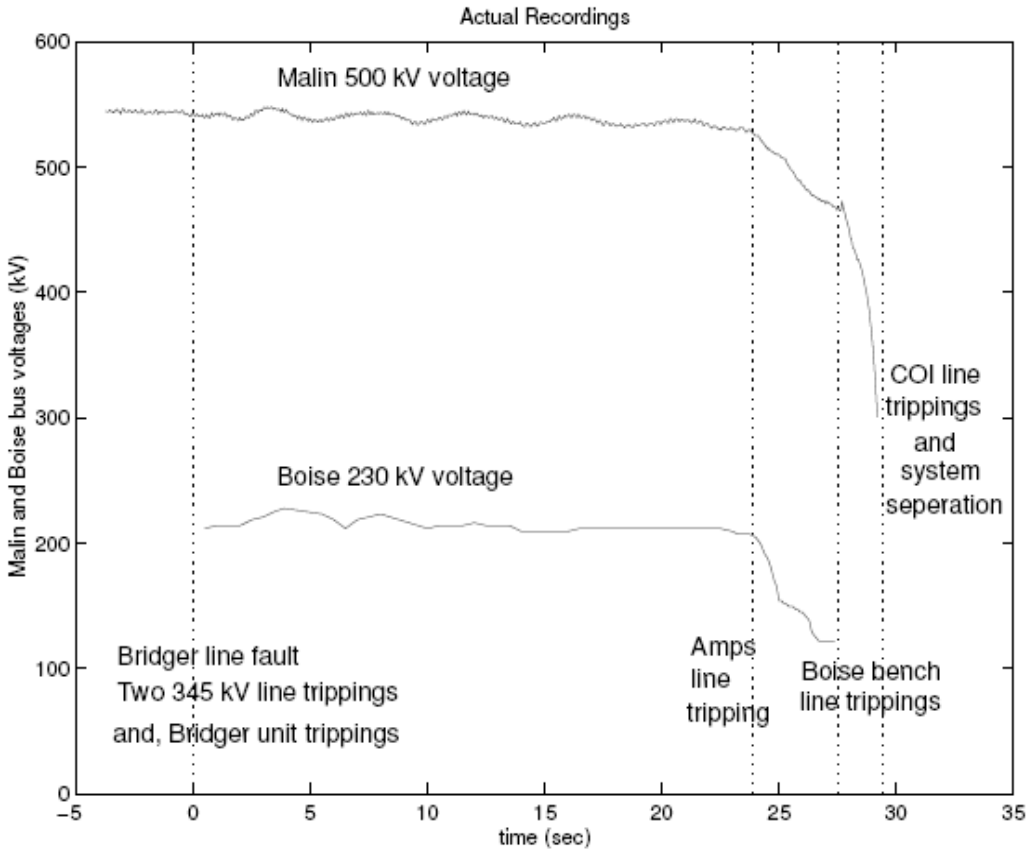


July 2, 1996 WECC Blackout



These Two Lines Tripped

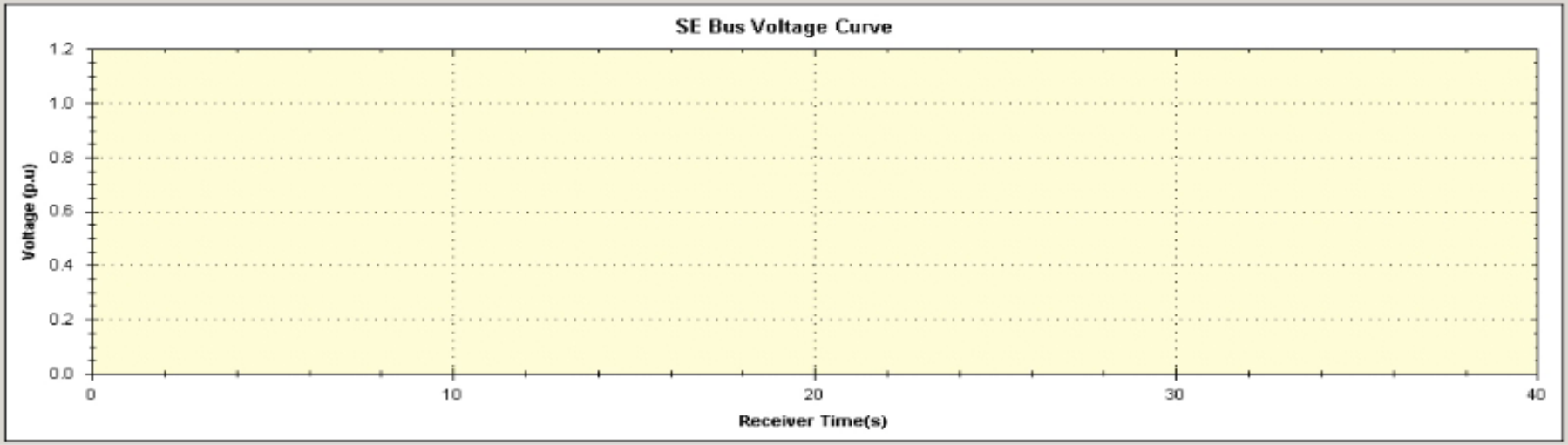
- Heavy loads
- Double line outage near Bridger plants



WECC Test System

- WECC July 2, 1996 blackout case
  - 6180 buses
  - 1005 generators
  - 11982 branches
  - Idaho area monitored by PMUs
  - 109 buses in Idaho
  - 223 branches, 25 generators, 46 loads, 77 transformers
  - 480 PMUs streamed from simulator

Control Center SE MainForm



TSAT - [2jul6.tsa]

File Run View Options Auto Help

Display : Basecase Analysis

Computation Progress | Result Summary

Scenarios

A D V F F R

1 0.00%

The Scenario Has Not Been Processed

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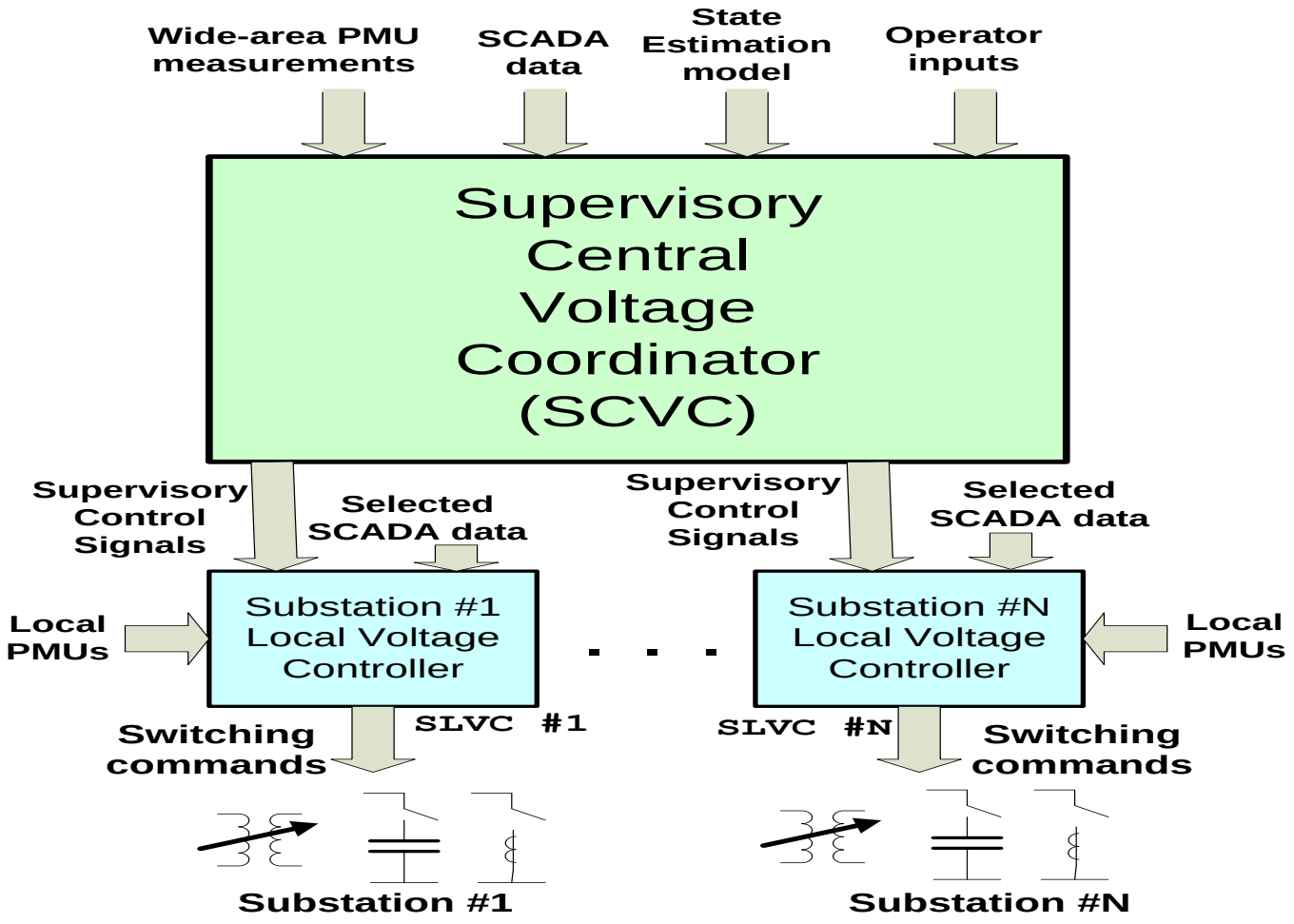
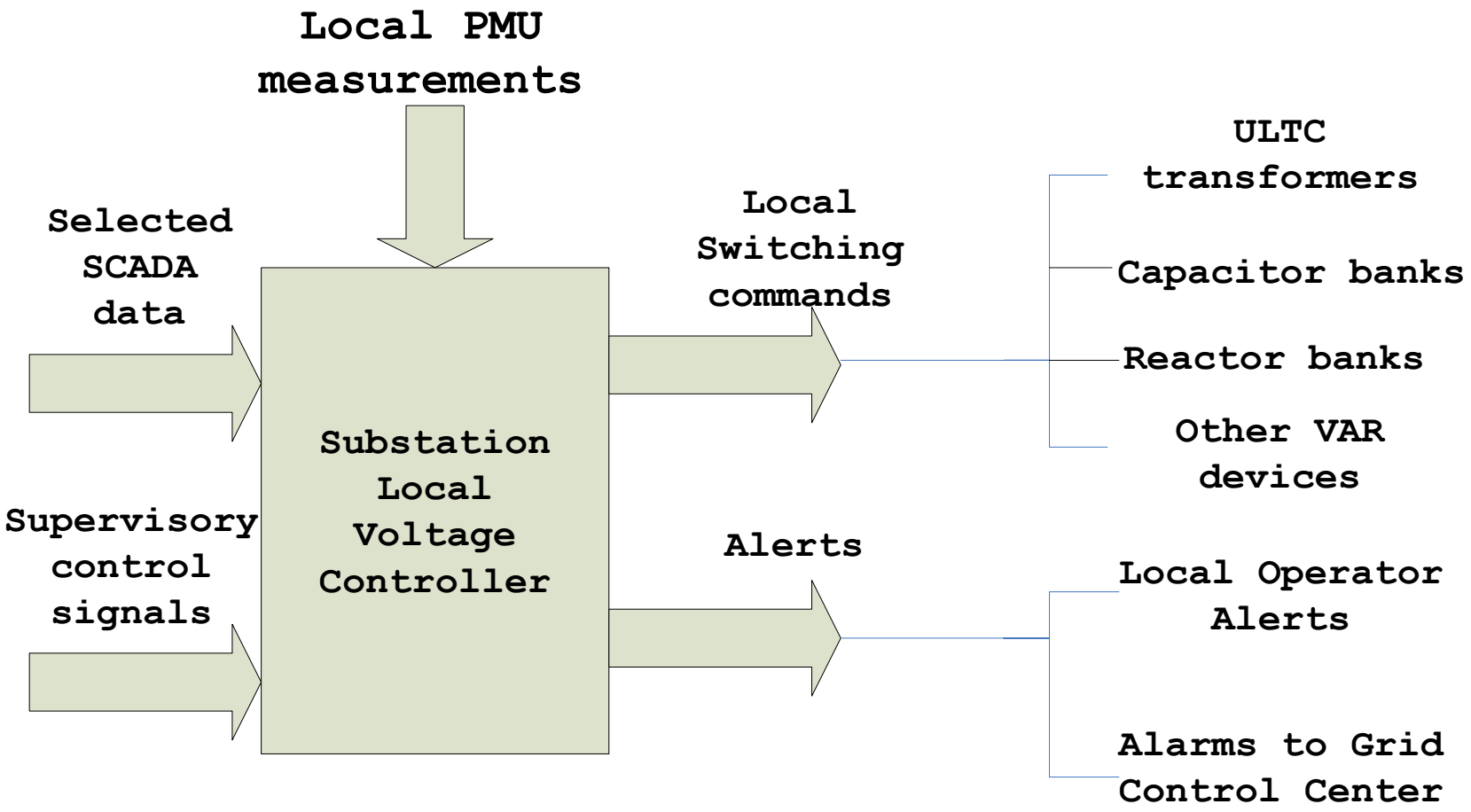
Scenario 1

12:28 PM
10/12/2012

Voltage Controller Structure



SLVC Controller



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OpenPDC at WSU

- OpenPDC used extensively in several projects
- OpenPDC based PMU applications installed at Entergy, TVA, and Idaho Power.
- GridSim – large-scale real-time simulator, commercial version from Powertech.
- Suggestions, Debugging, and WSU code contribution
- Config tools, Visualization tools
- Closed-loop controls for substations and control centers