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Power Grid Simulator

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GridSim - Real Time Simulation of Power Grid Operation & Control

- Funded by USDOE
- Project team: Mani Venkatasubramanian (Project Lead), Anjan Bose, Dave Bakken, Carl Hauser, Chuanlin Zhao, Dave Anderson, *Alex Ning, Ming Meng, Lin Zhang*
- Simulate PMU like real-time responses of large-scale power system including power grid dynamics and communication network

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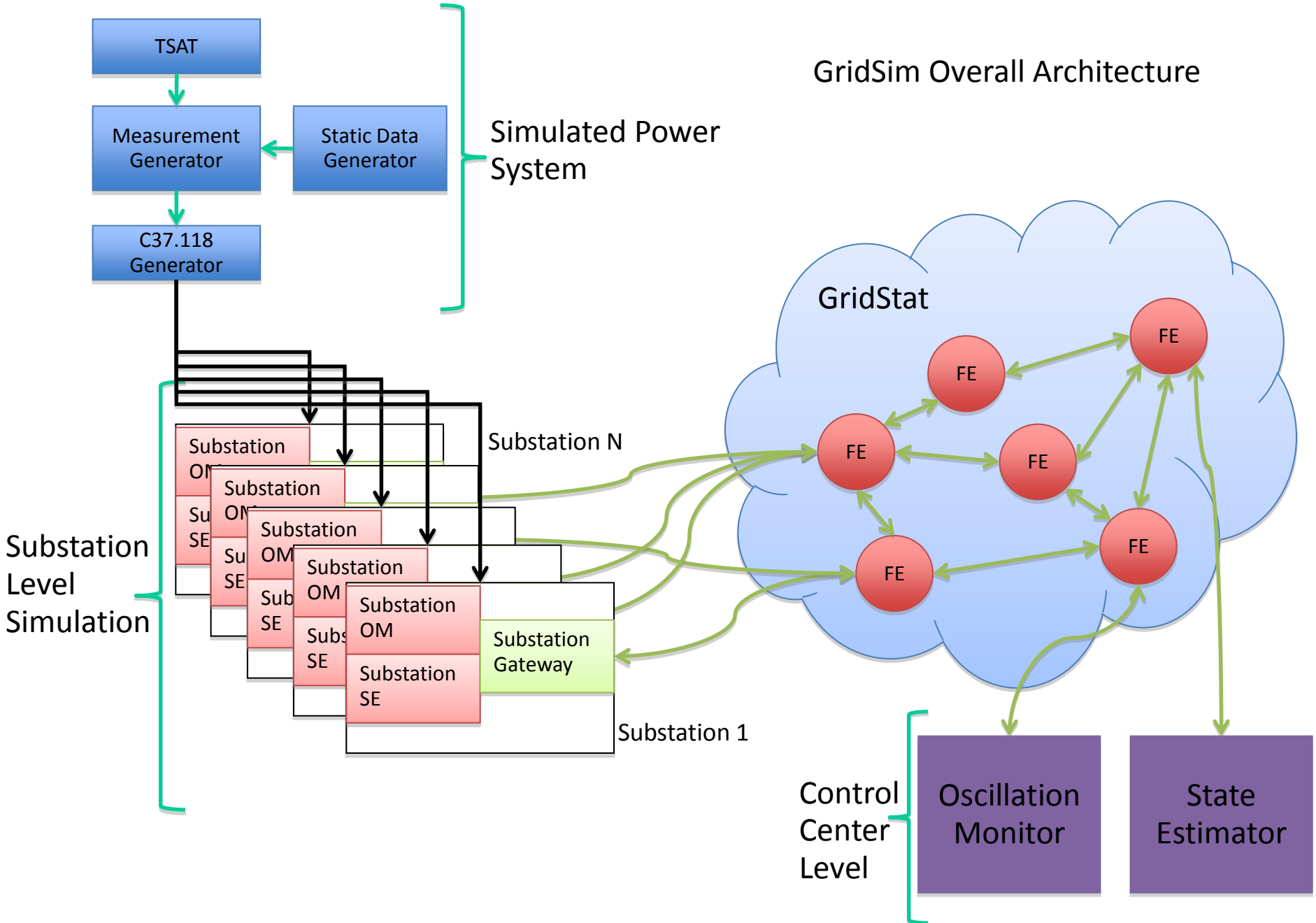
Project Objectives

Improve Reliability and Security of the Electric Power Grid by developing

- The new communications and information systems needed to support better automatic controls and operator support tools
- The new wide area automatic algorithms needed for detecting and mitigating oscillations and instabilities
- The new operator support tools, like next generation state estimators, for better human decision making

GridSim Overall Architecture



Project Tasks

1. Real Time Power Grid Simulation
2. Streaming Measurement Data
3. Data Communications – Gridstat Middleware
4. Oscillation Detection – Wide Area Monitoring
5. State Estimation – Real Time Modeling

Tasks 1 and 2

- Real Time Power Grid Simulation
  - Use commercial grade transient stability program – Powertech TSAT
  - Simulate a large real system in real time
  - Replace output file with streaming data
- Streaming Measurement Data
  - Streaming data needed at PMU locations
  - Measurement data in IEEE C37.118

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FY12 Technical Objectives

- Demonstrate GridSim on 179-bus Western system model
  - 29 generators
  - 1577 PMUs
- Integrate Real-time TSAT, GridStat, State Estimation and Oscillation Monitoring engines for 179 bus system
- Demo at NASPI Denver meeting, June 2012
- Proof-of-concept
- **No comparable tool available today**

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FY12 Risk factors

- Stability and numerical accuracy of TSAT
- Computational burden
- OpenPDC updates
- Validation of simulations

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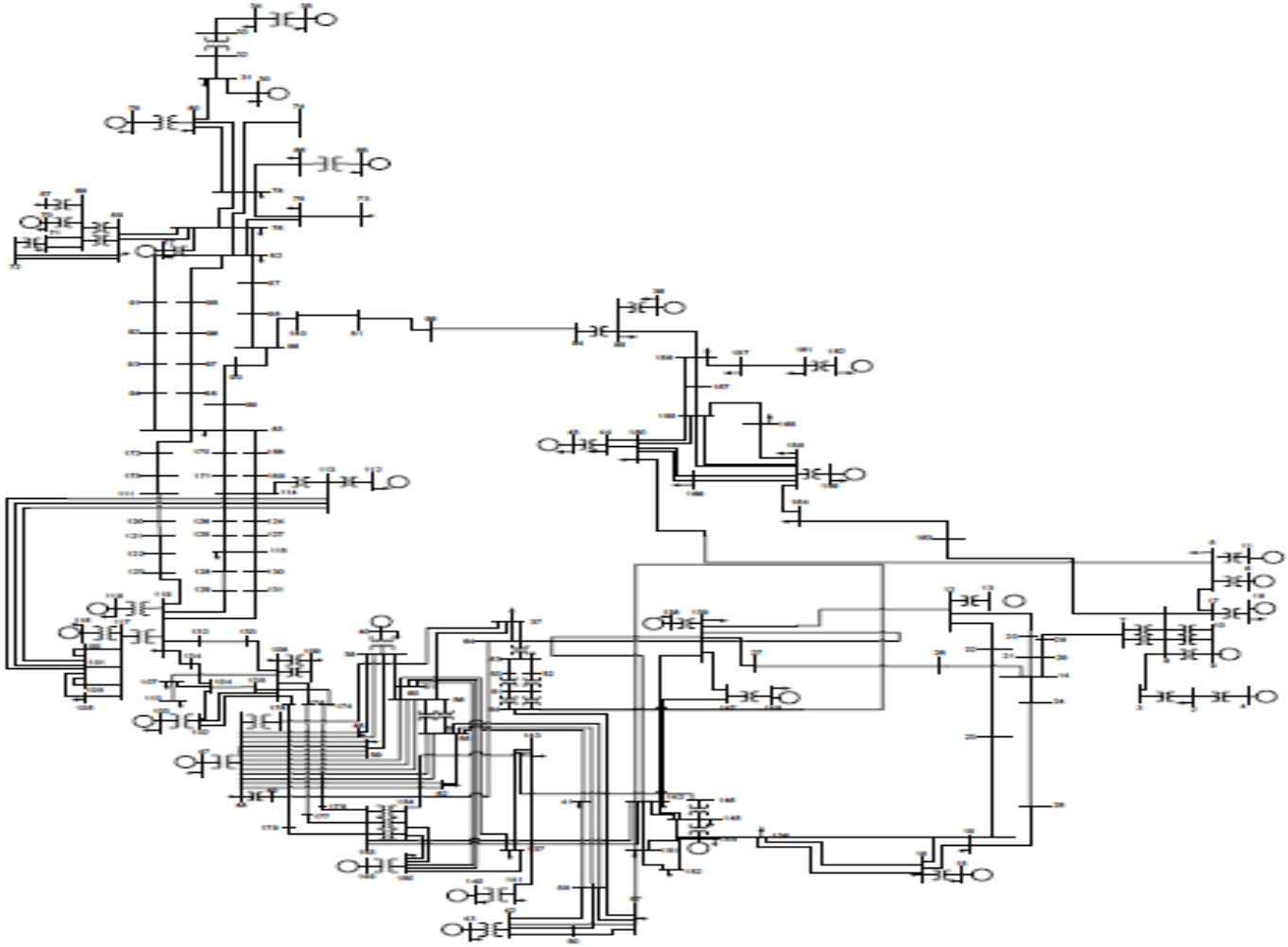
179 Bus Simplified WECC Model



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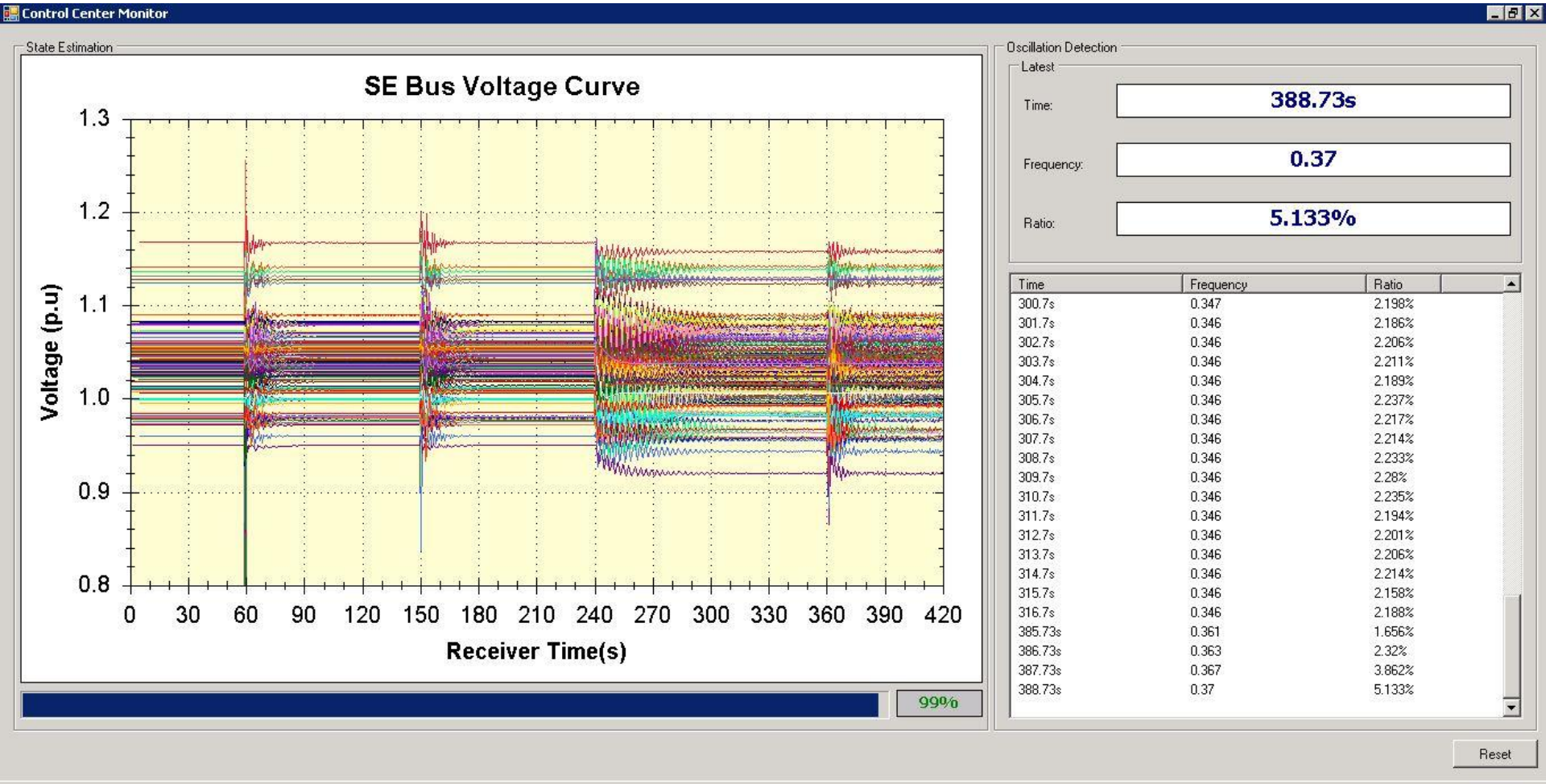
179 Bus Example



FY13 Project Objectives

- Demonstrate GridSim on 3000 bus “WECC reduced model”
  - Real-time simulator including communication component
  - Real-time TSAT, GridStat, State Estimation and Oscillation Monitoring
- Identify industry partners for field demonstrations
- 14,000 bus WECC full model (FY14)
- 50,000 bus Eastern grid full model (FY15)

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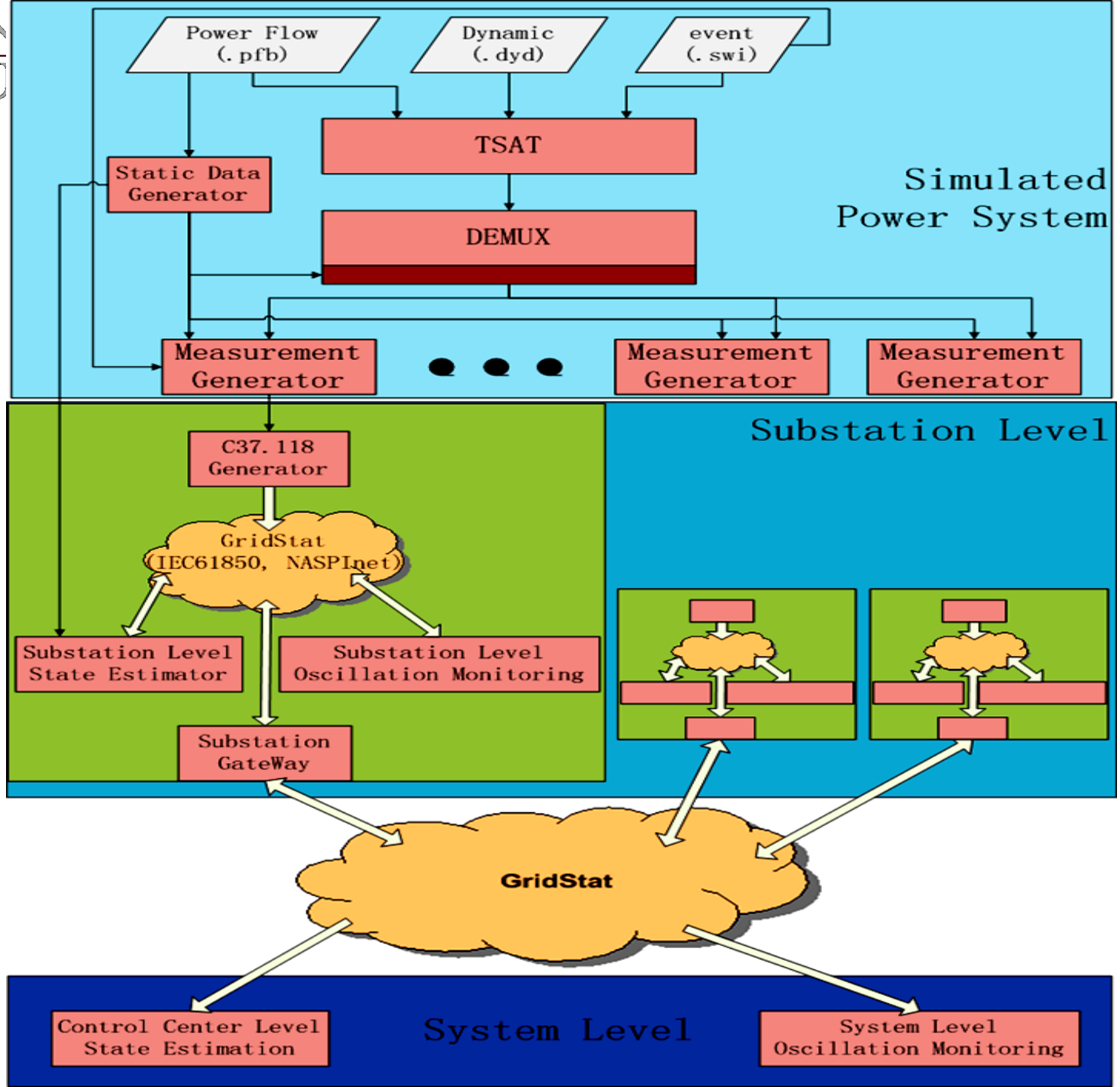
Back-up Slides

Assumptions

- PMUs will increase and phasor measurements at high sampling rates will be ubiquitous
- The hardware technologies to move this data in large volumes and high speeds are available
- Power control devices (FACTS) will be deployed in larger numbers
- The software to manage and move this data is feasible but needs to be developed
- The software and algorithms for the next generation control and operation tools need to be developed

Summary: Tasks 1 & 2

- Measurement Stream from Simulated Power System
  - Static Data Generator
  - Measurement Generator
  - C37.118 Generator
- Substation Level Data
  - Each substation is a separate process
  - Time delays within substation neglected
  - Application algorithm at substation
- Tested on 179 bus system


Power Flow
(.pfb)
Dynamic
(.dyd)
event
(.swi)
TSAT
Static Data
Generator
DEMUX
Simulated
Power System
Measurement
Generator
Measurement
Generator
Measurement
Generator
Substation Level
C37.118
Generator
GridStat
(IEC61850, NASPInet)
Substation Level
State Estimator
Substation Level
Oscillation Monitoring
Substation
GateWay
GridStat
Control Center Level
State Estimation
System Level
System Level
Oscillation Monitoring

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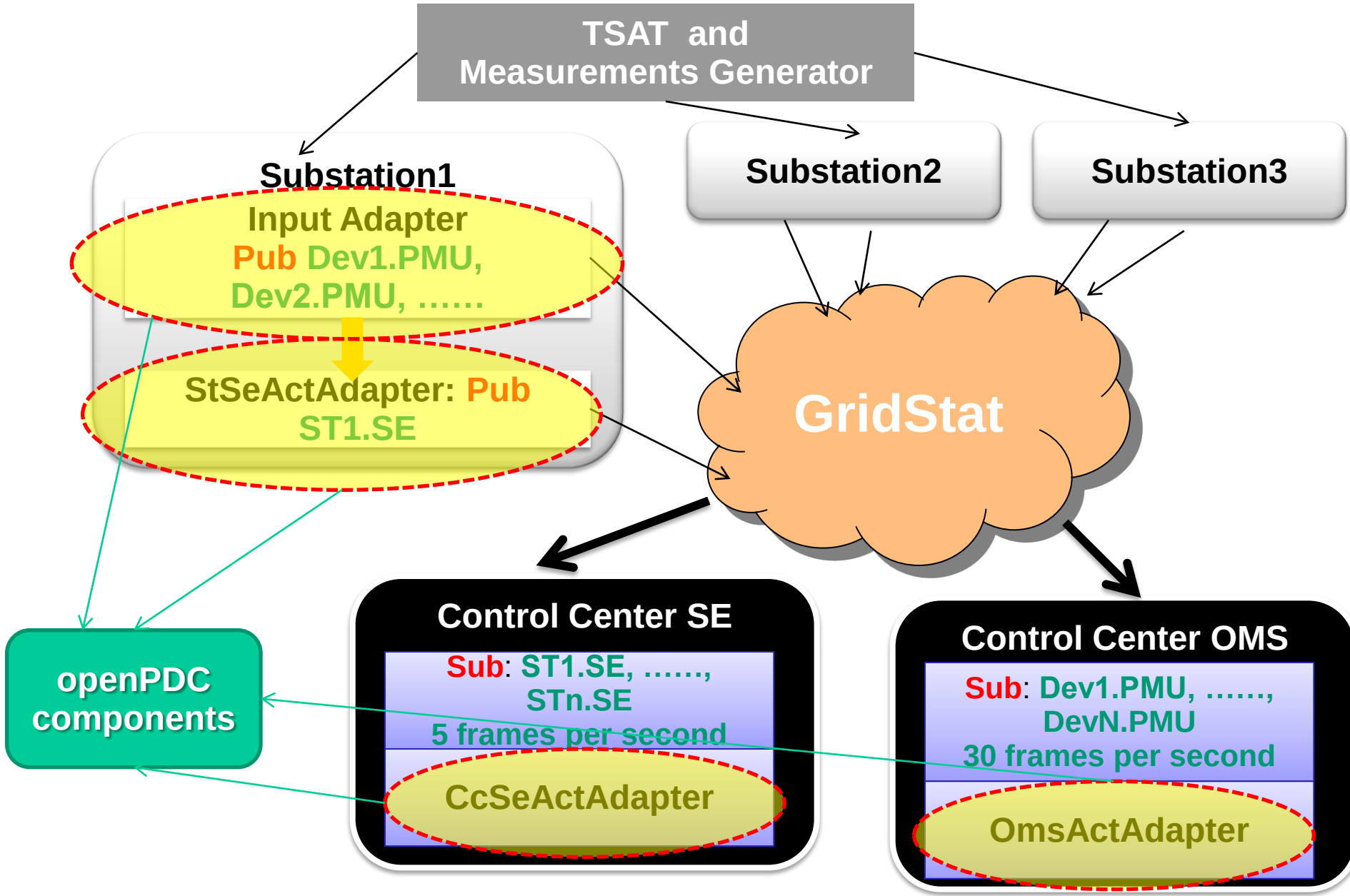
Simulation Test Bed

Generating measurements of power system

- Static Database
  - Circuit Breaker - Bus Section Database
  - Bus Section – Equipment Database
  - Equipment Parameters Database
- Real-time Database
  - Currents
    - Circuit Breakers
    - Bus Section Injections
  - Voltages
  - Circuit Breaker Status

Overall Architecture



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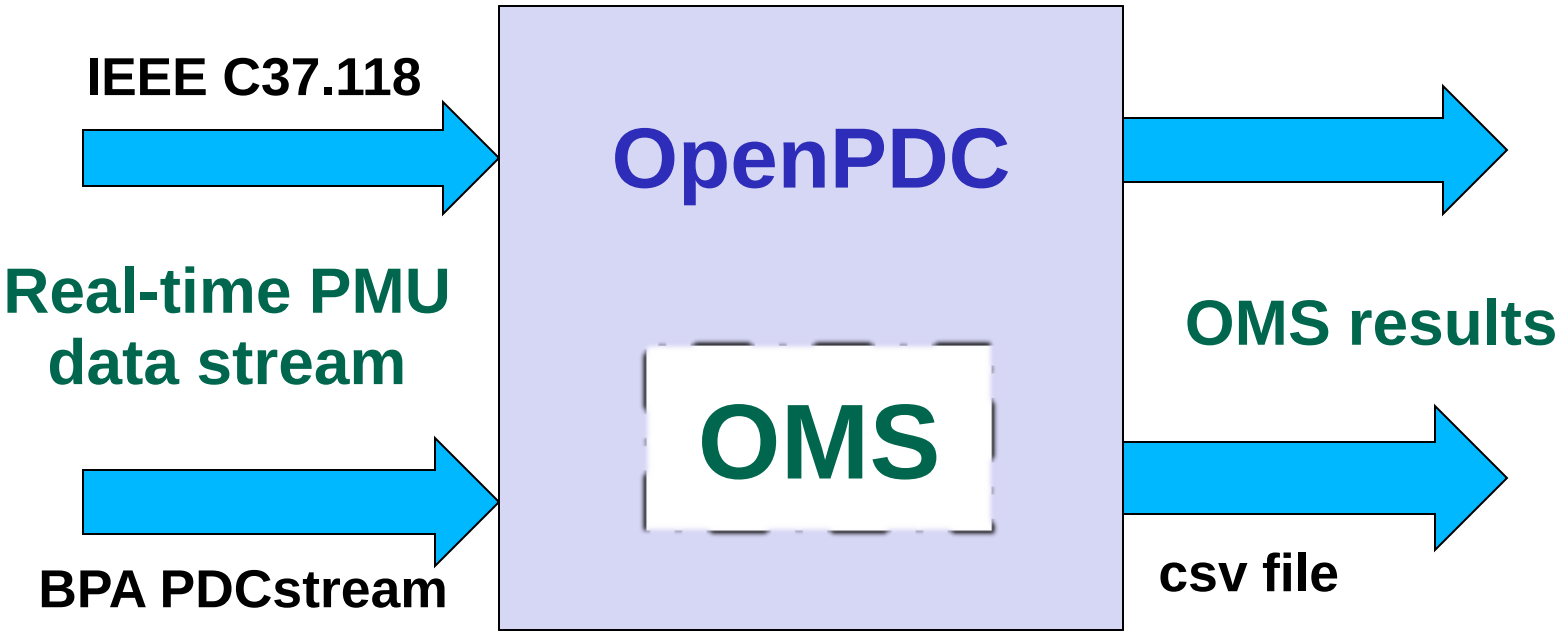
GridStat

- Data delivery middleware for Smart Grid
- Data plane components provide pub-sub model for data sources and applications
  - Multi-cast to use resources efficiently
  - Per-subscriber rate and latency management
  - Conserves network resources and simplifies applications
- Management plane handles resource allocation and subscription setup
  - Reserve multiple paths per-subscription
  - Provides authentication and authorization for access to published data streams

Oscillation Monitoring System



Substation level OMS and Control center level OMS.
Light version of OMS for substations developed.