

Design of Wide Area Controls

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What is Wide-Area Monitoring, Protection and Control?

- **Wide-Area Monitoring Systems (WAMS)**
 - First installation of PMUs was called WAMS
- **Wide-Area Protection**
 - Event driven
 - Logic processing of non-local inputs/outputs
 - Switching
 - Now called SPS or SIPS
- **Wide-Area Control**
 - Multiple non-local input/output
 - Analog input/output



Wide-Area Monitoring

Issues

- **Scaling up – number of PMUs**
- **Visualization for the operator**
- **Upgraded EMS applications**
- **Data storage: distributed vs. central**
- **Data processing/mining**
- **Best use has been post-event analysis**
- **Other off-line analytical applications**



What is Wide Area Control?

- Control also implies **computation**
 - Detection of emergencies
 - Identification of emergencies
 - Calculation of controls
- ‘Wide area’ also implies **communication**
 - Signals are sampled (digital)
 - Signals have time delays (latency)



How do we check feasibility?

- **Develop controller**
- **Test on real time simulation**
 - **Nonlinearities**
 - **Discontinuities (digital control)**
 - **Time delays (latencies)**
- **Test on real time data**
- **Test in real time (without closing the loop)**



What WACs are feasible?

- **Slow control (10-seconds)**
 - **AGC**
 - **Regional voltage control**
 - **Phasor measurements not needed**
- **Oscillation control (seconds)**
- **Transient stability control (sub-seconds)**



Model Based Control

- **Real Time Model is updated by State Estimator**
 - **Static model updated in minutes**
- **Hundreds of Contingency scenarios studied**
 - **Operator is alerted**
- **Remedial Action can be calculated by OPF**

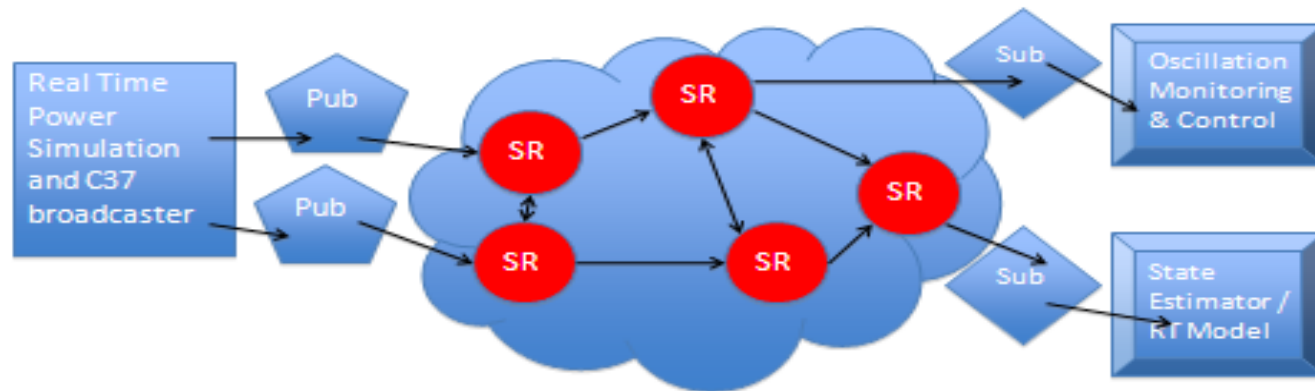
Can the loop be closed?

- **Faster update of Real Time Model is needed**

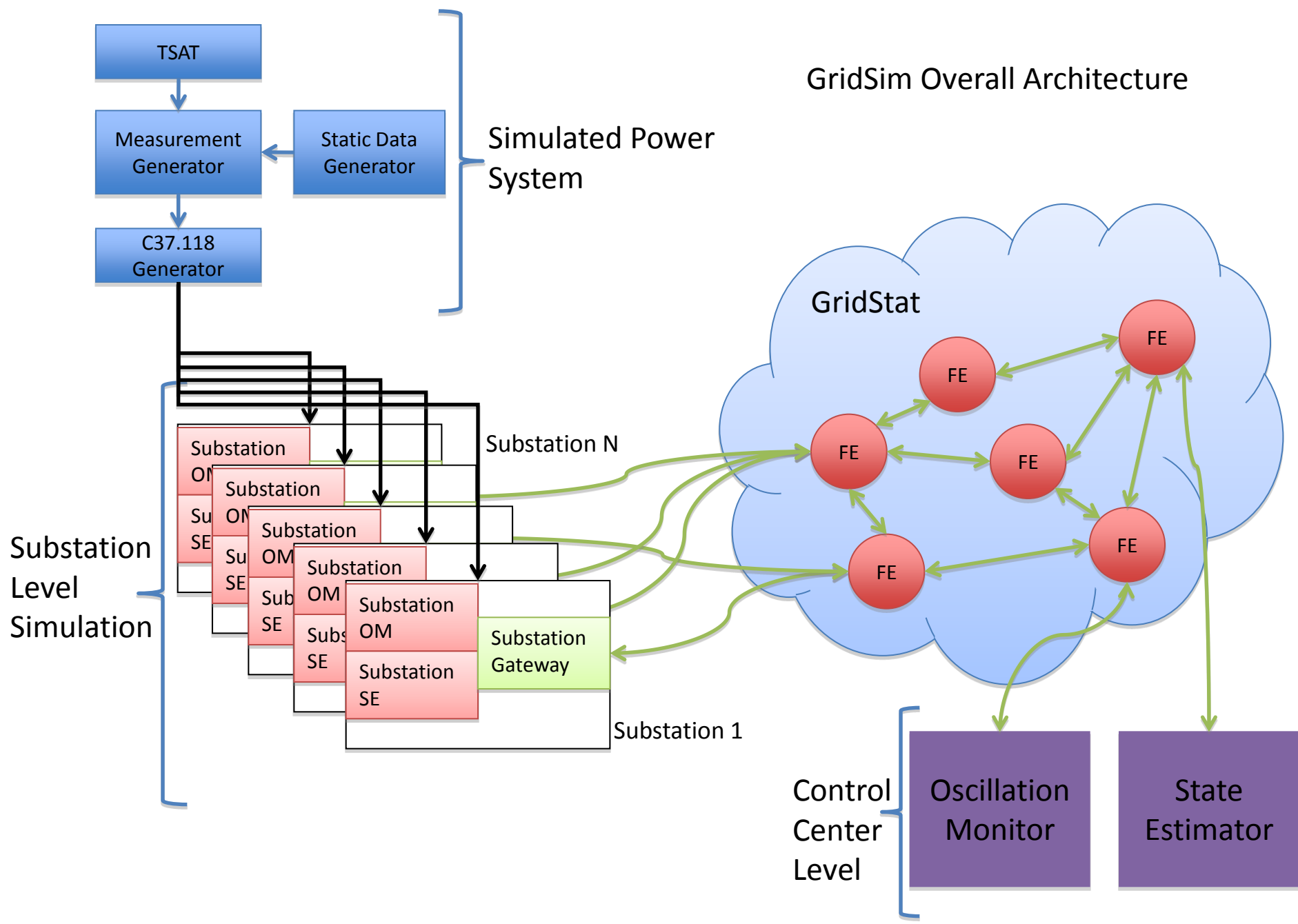


A Critical Missing Piece

Simulation Test Bed for the Smart Grid

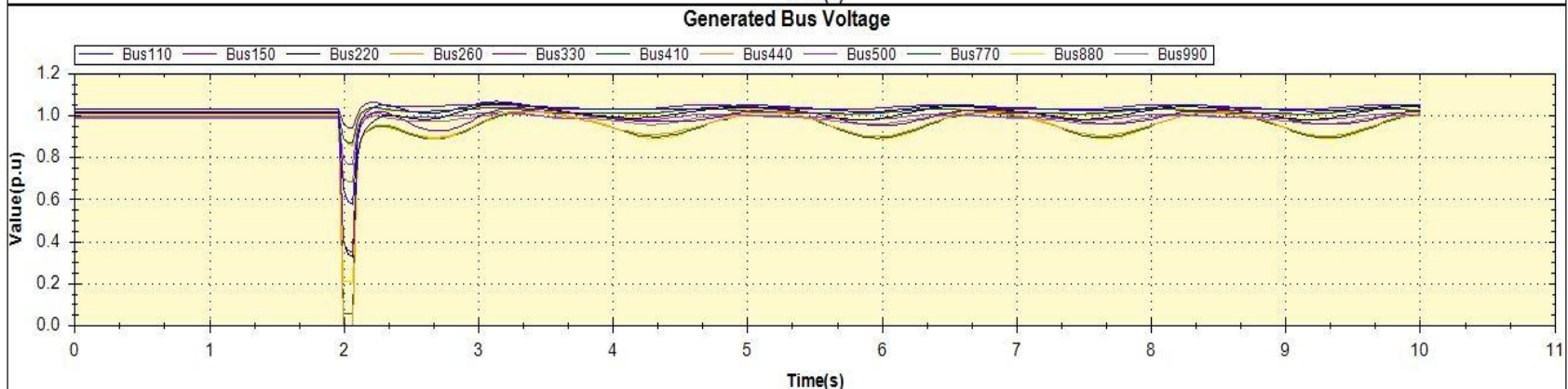
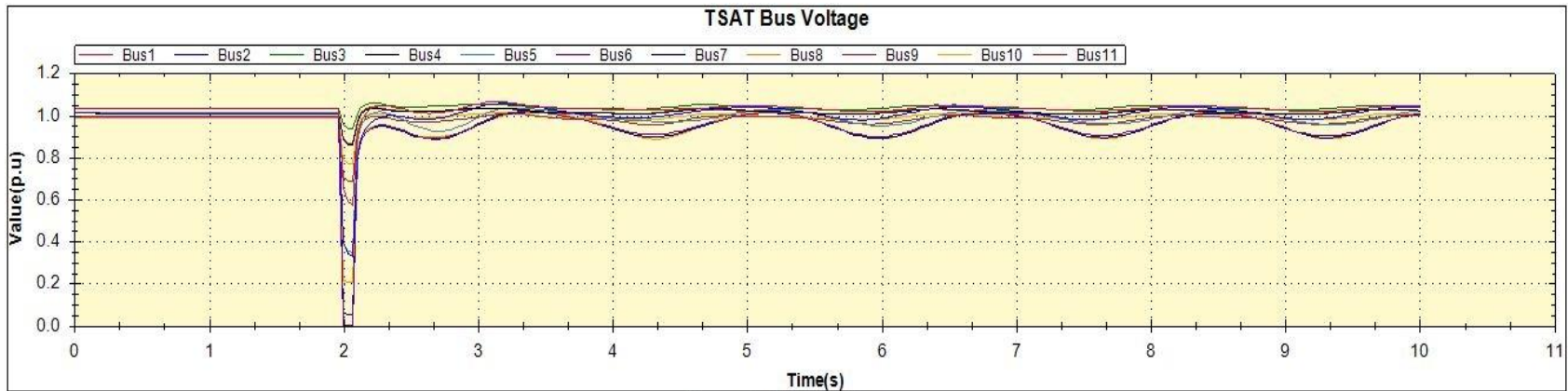


GridSim Overall Architecture





Simulated Bus Voltages by Powertech TSAT Generated PMU Measurements 33 msec time steps

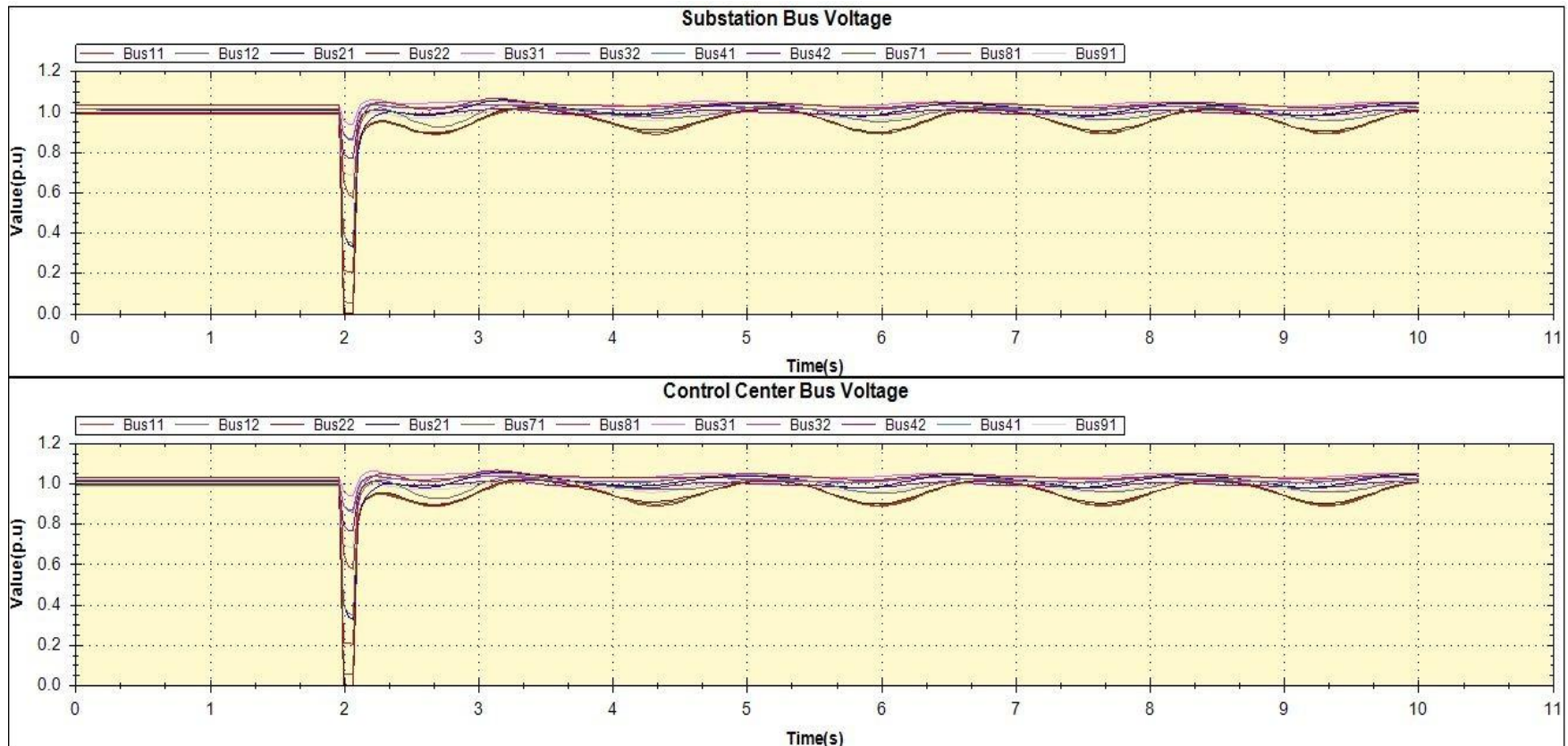




SE Solution at Each Substation

SE Solution at Control Center

30 times per second





SE at Control Center with time jitter

SE Bus Voltage Curve #2

