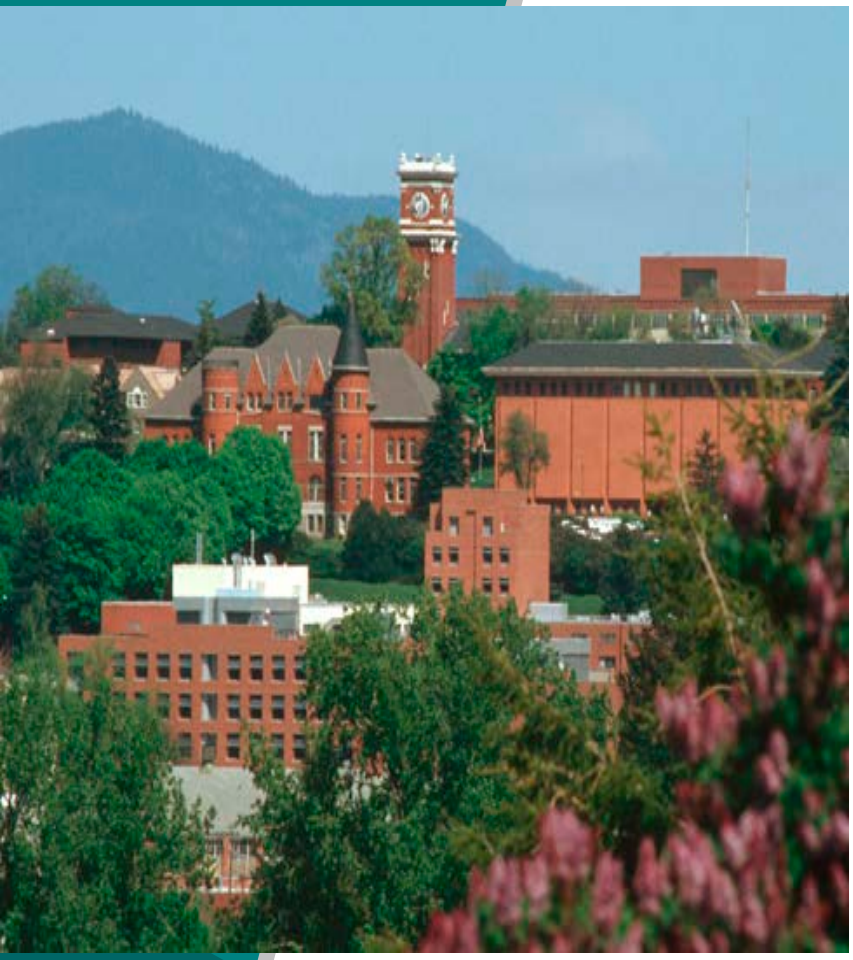
WASHINGTON STATE UNIVERSITY

World Class. Face to Face.

College of Engineering and Architecture



Specifications for the Power Grid Simulator

Anjan Bose
Washington State University
Pullman, WA

CMU Conference on Testbeds

Pittsburgh, PA

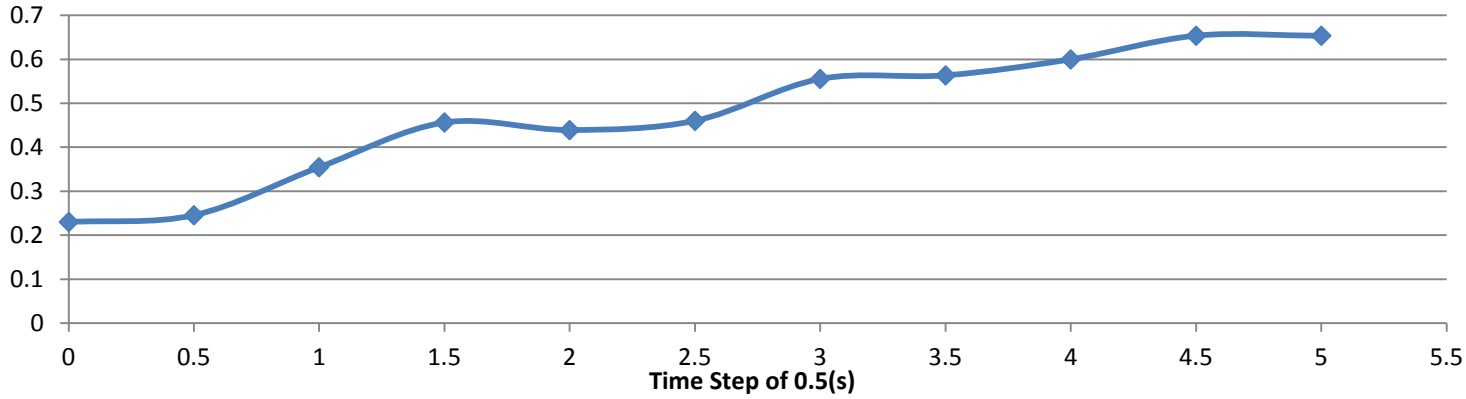
April 1, 2015

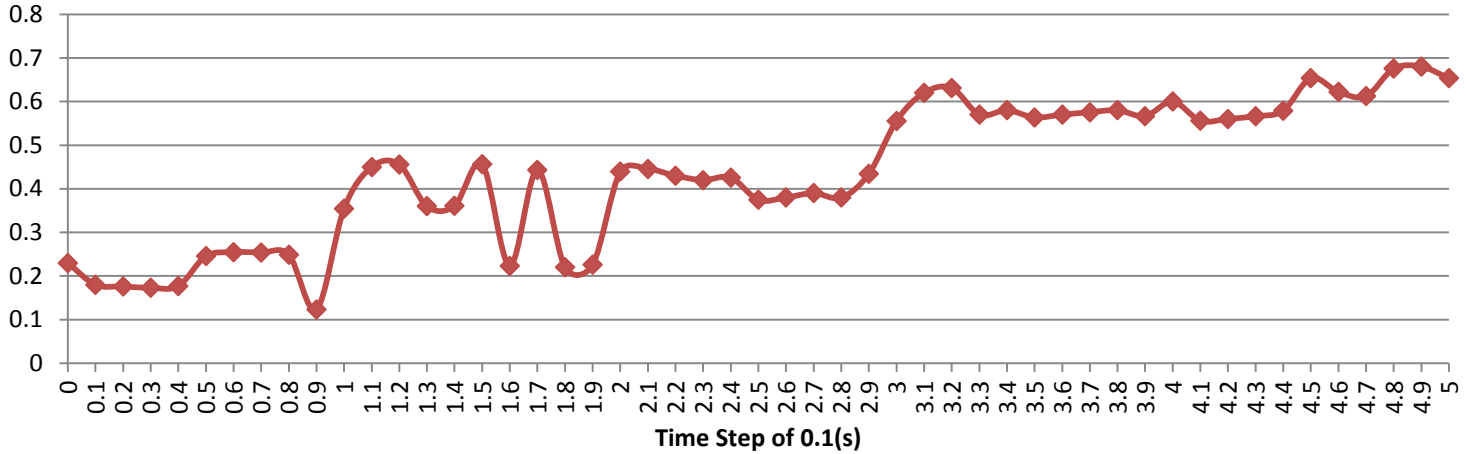
What is Simulation?

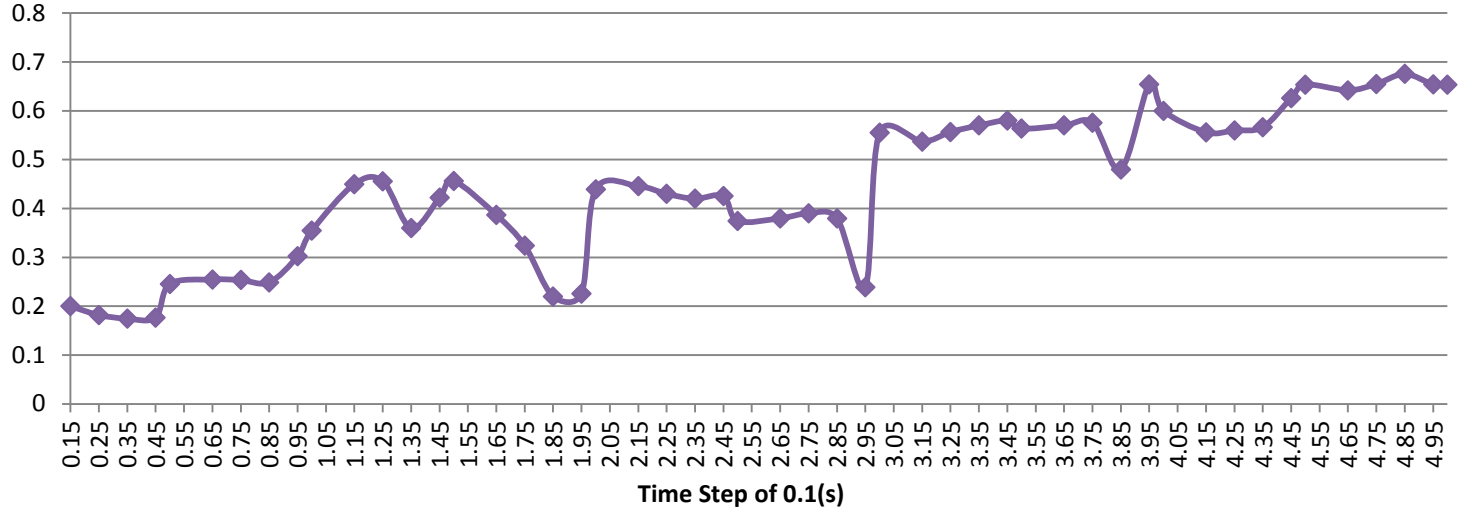
- Testbed?
- Analytical Tools?
- Apps?
- Simulation maybe a part of an analytical tool
- Analytical tool or app requires
  - Input – static vs time variable
  - Output – characterizes the app
- Simulation is a mathematical description of behavior

What is simulation?

- Is power flow a simulation?
- Power flow ‘simulates’ an instant
- Simulation usually implies behavior over time
  - Electromagnetic (<msecs)
  - Electromechanical (>msecs)
  - Uniform frequency (secs)
  - Economic Dispatch (min)
  - Unit Commitment (hours-days-weeks)
  - Hydro Coordination (seasonal)
  - Planning (years)


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
Time Step of 0.5(s)


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Time Step of 0.1(s)


0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Time Step of 0.1(s)

What is Real Time?

- Is the computation time faster than the time step?
- What affects the computation time
  - Size of the grid
  - Complexity of the models (equations)
  - Nonlinearities, particularly discontinuities
  - Computer architecture
  - Algorithm

Are there any real time simulators?

Simulator Characteristics

- Models
  - Algebraic equations (power flow)
  - Differential equations
  - Logic (control, protection)
- Main concern is the speed of dynamic behavior
- Faster behaviors are harder

Many simulators are possible.

Can they be seamlessly connected?

Transmission vs Distribution

- Mostly simulated separately
- Distribution models usually smaller
- Do we have to model distribution in our transmission simulation?
- Distributed generation, dynamic load control
- How much detail?

Why New Simulation Testbeds?

- Faster sensing (PMU)
- Faster communication
- Faster computers
- Faster controllers (FACTS)

Can we operate the grid more efficiently and reliably?

Need better tools to design and test new operational procedures and controls.

Simulation Challenges

- **What is missing in the existing simulators?**
  - **New measurements**
  - **New power electronics equipment**
  - **New controls logic**

  Also
  - **PMUs**
  - **Communications**
  - **Computation**

  Handling of the feedback loop of streaming measurements, control logic and control signals

Real Time Simulation

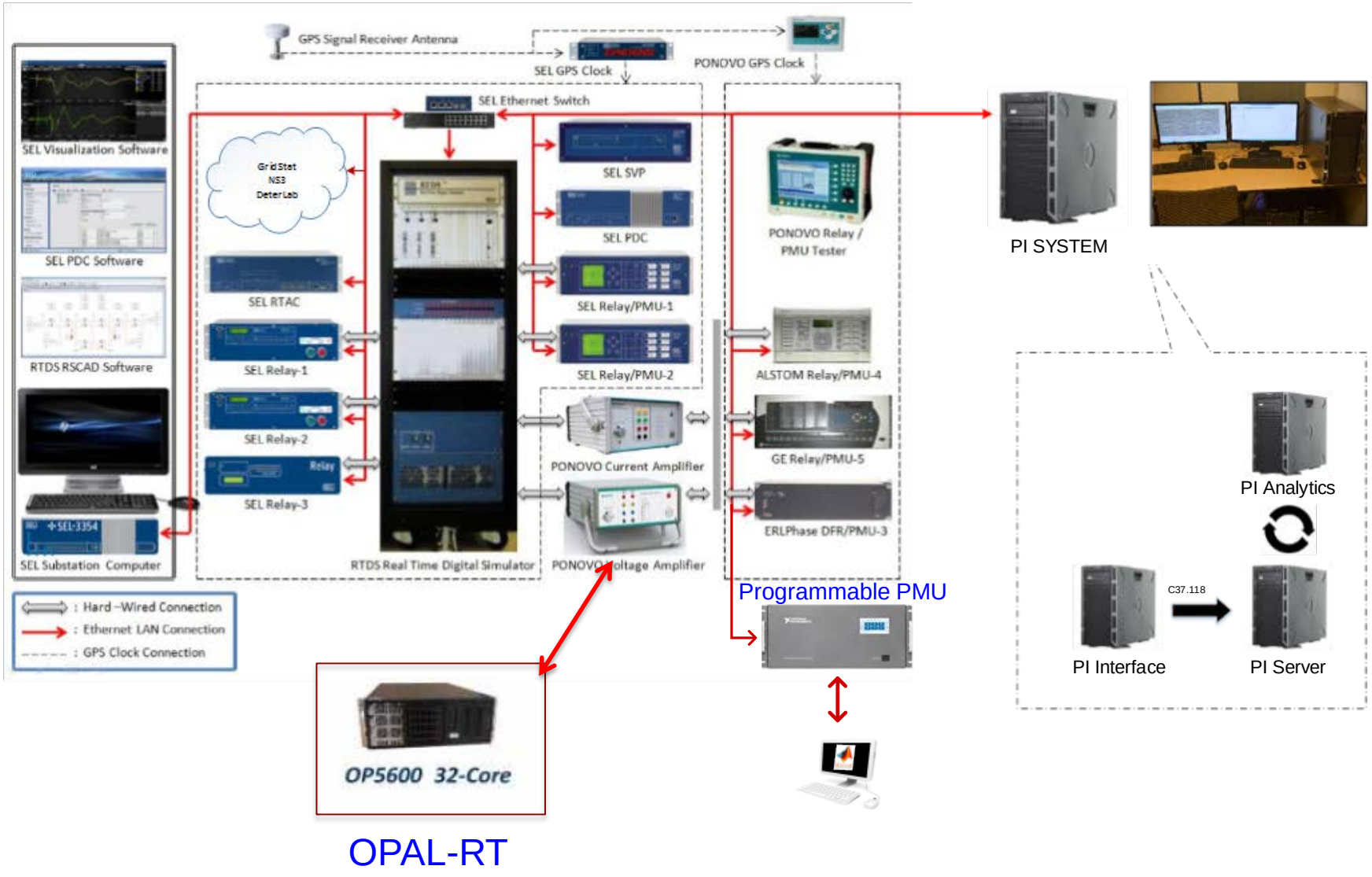
- **Does the simulation have to be real time?**

Issues

- **Synchronizing the simulation of different parts**
  - **Power grid**
  - **Communications**
  - **Computation**
  - **Control/protection logic**

Don’t know how to do time simulation of communication and computation

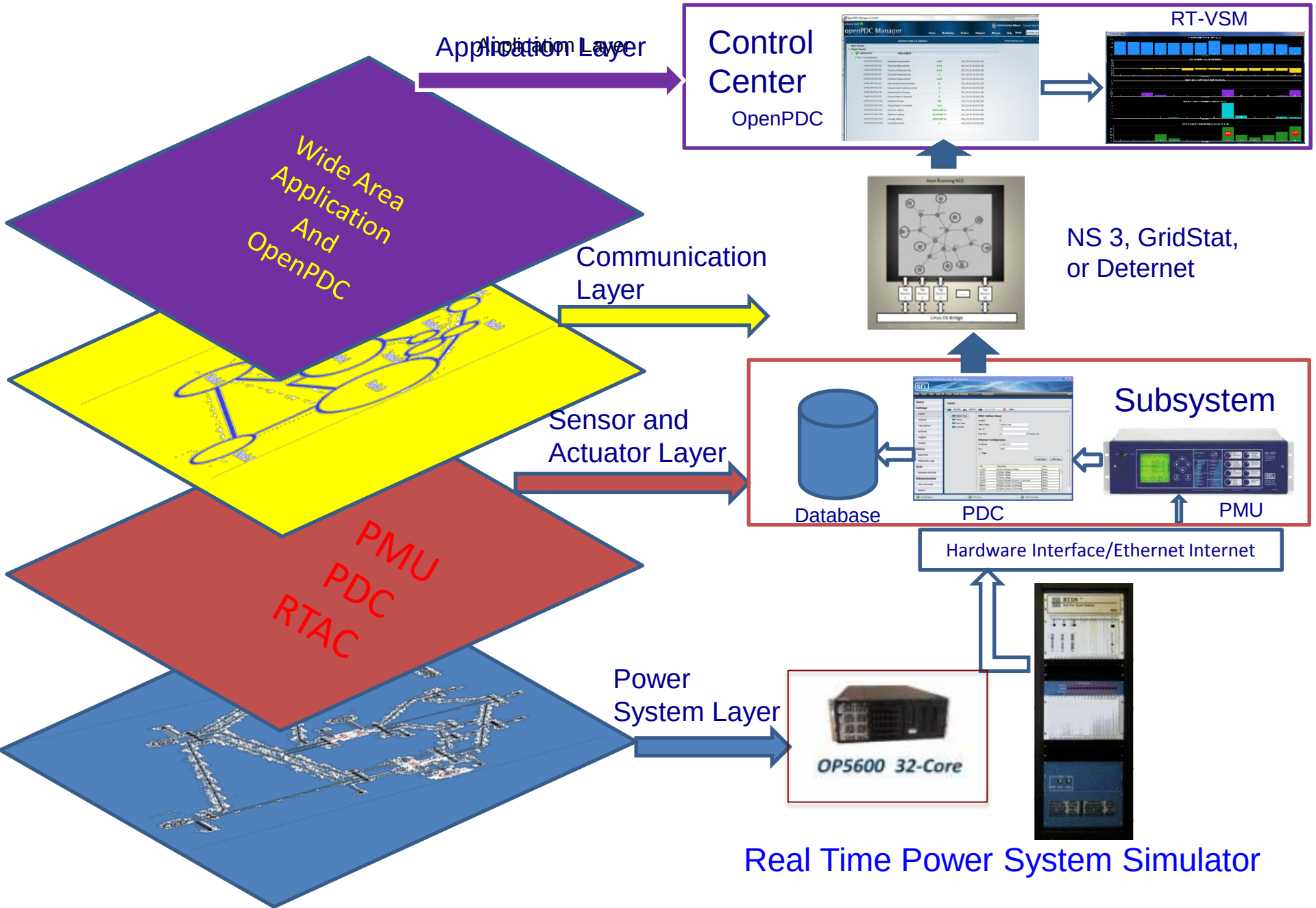
SGDRIL Test Bed at WSU



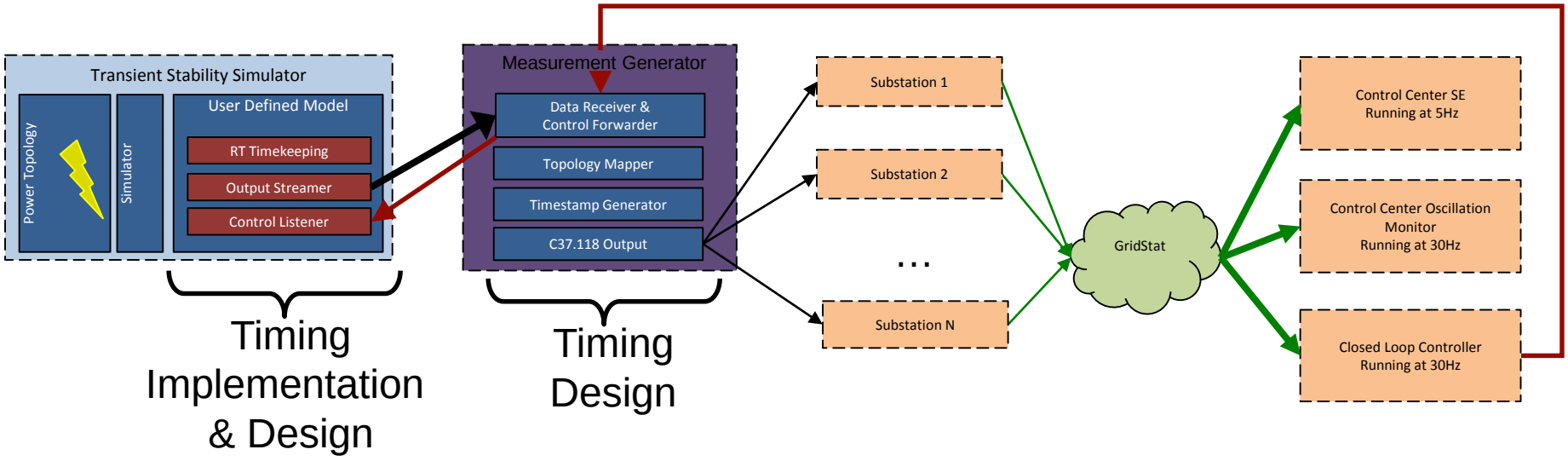
Real Time Digital Simulator and Other Devices

http://www.eecs.wsu.edu/~asrivast/SGDRIL/index.html

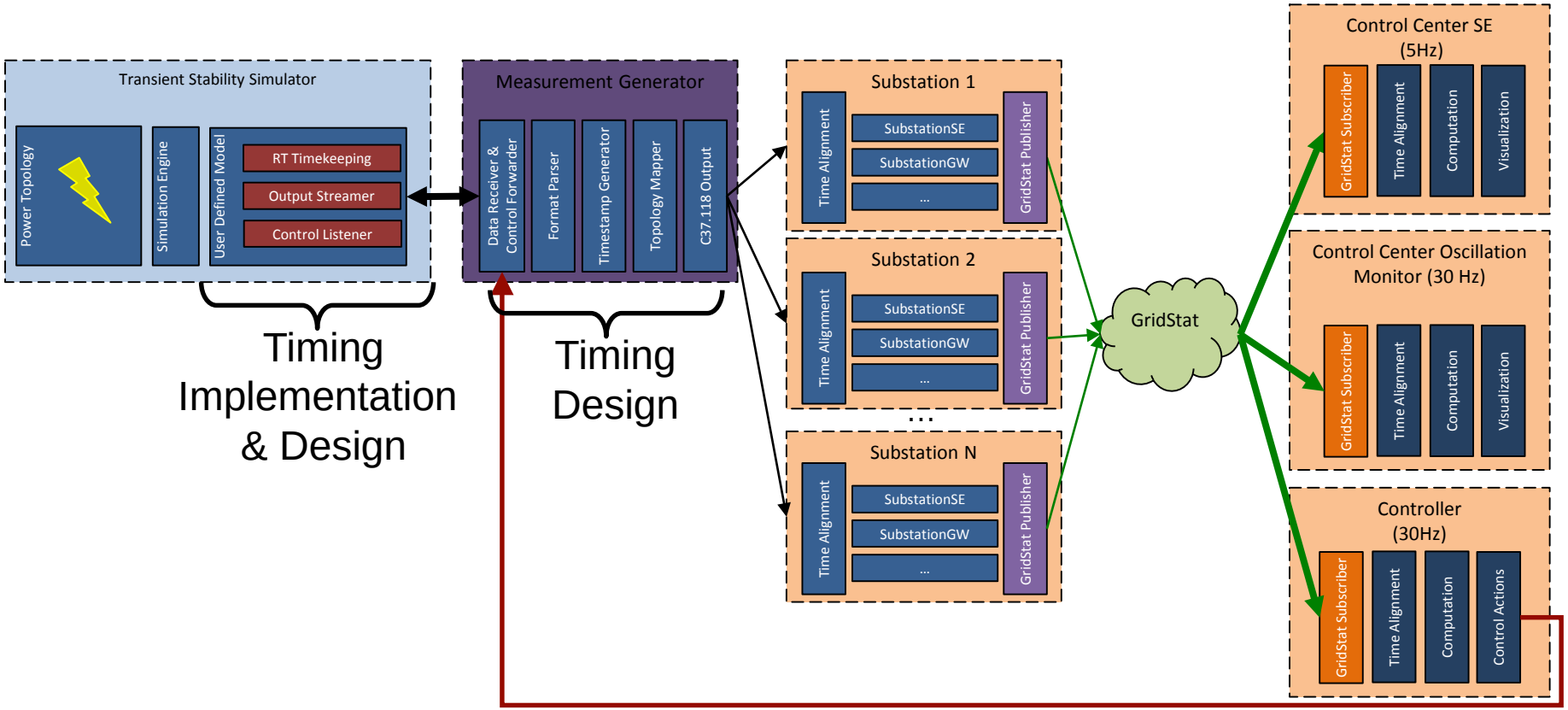
Cyber-Power System Modeling



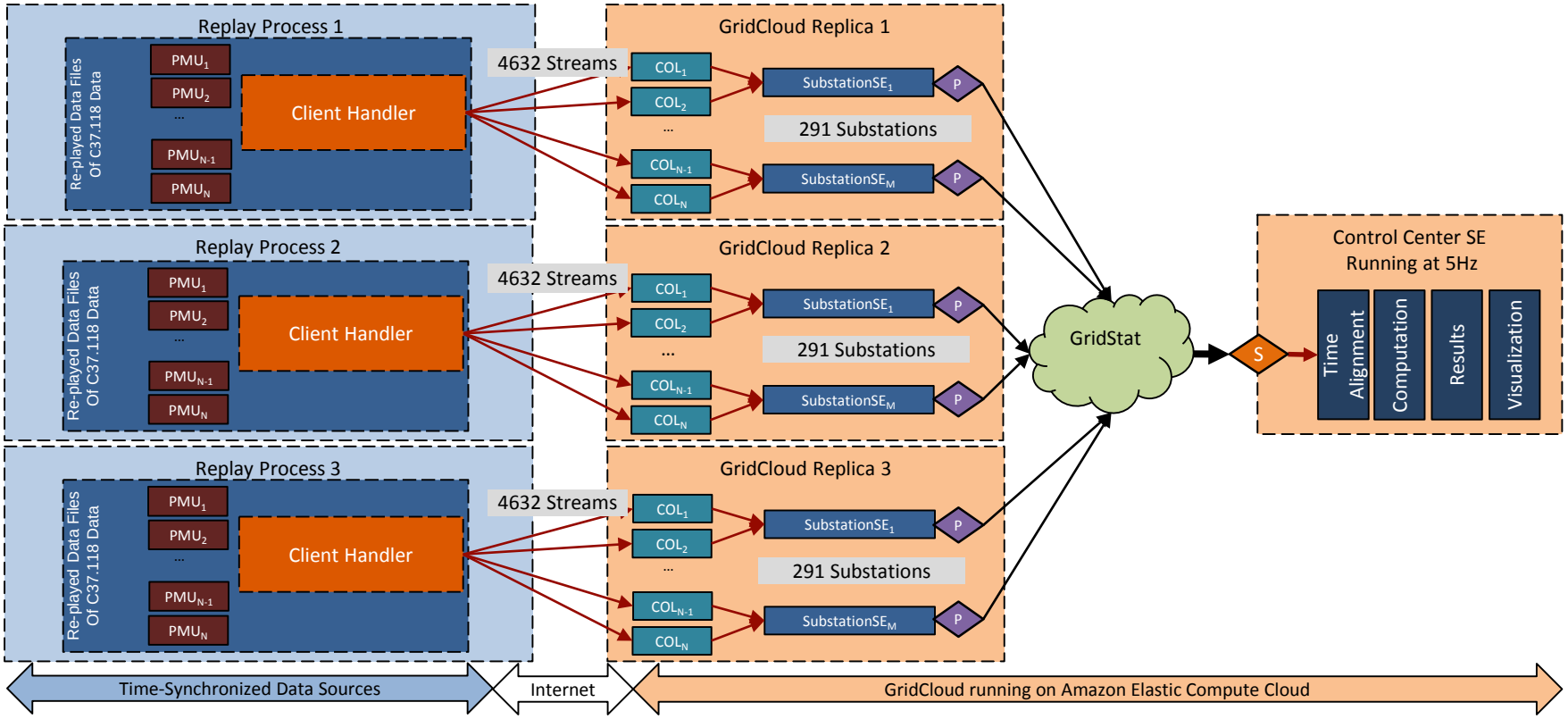
GridSim: High Level Diagram



GridSim: Full Architectural Diagram



Adaptation for GridCloud Architecture



Testbed Challenge

- What are we testing?
  - A scenario
  - A widget (sensor, relay, controller)
  - A control process or protection scheme
- Inputs
  - Streaming measurements (real time data)
  - System data (static data)
- What simulation to use
- Output
  - Must include performance metrics

Testbed Challenge

- Many testbeds?
- Or one very flexible testbed
  - Changeable, flexible simulations
  - Different system data sets
  - Different scenarios (measurement data)
  - Different output sets

This is difficult to design. Maybe a few testbeds can cover the whole range