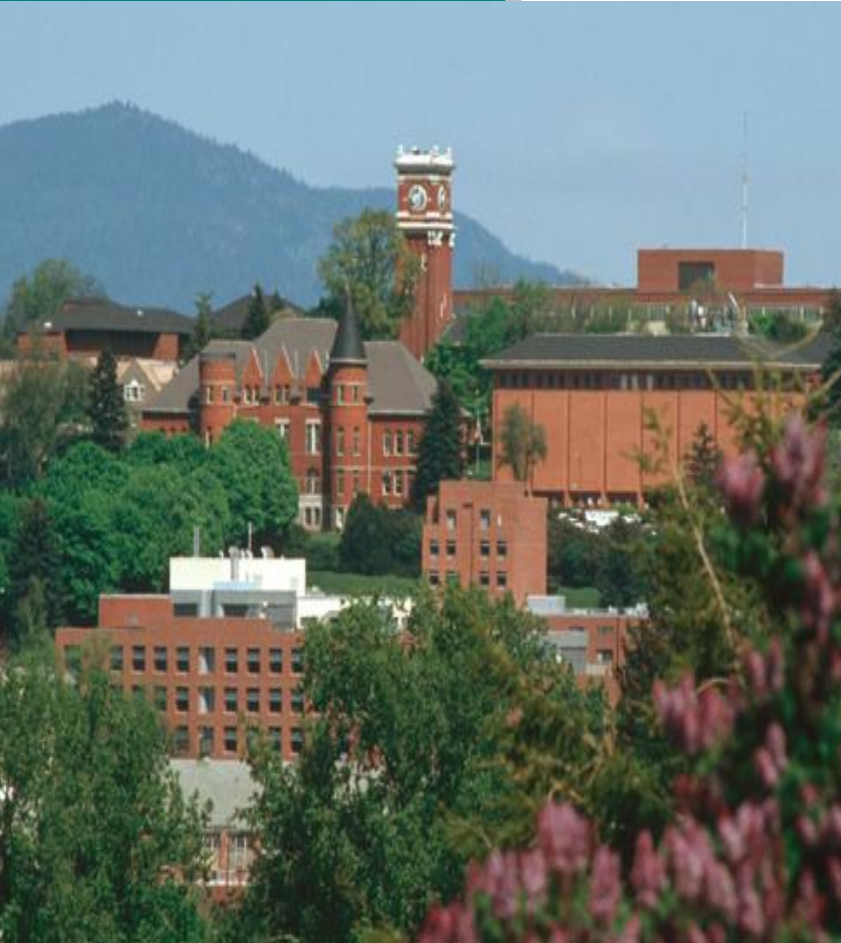


Specifications for the Power Grid Simulator

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Workshop on Distributed EMS
Arlington, VA
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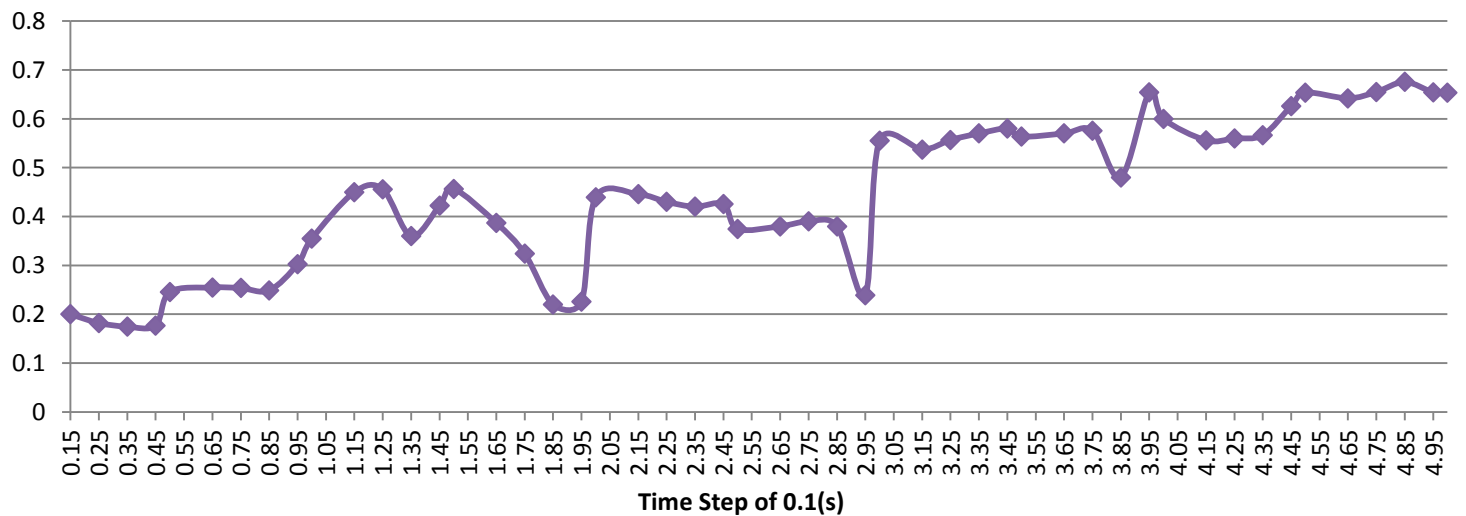
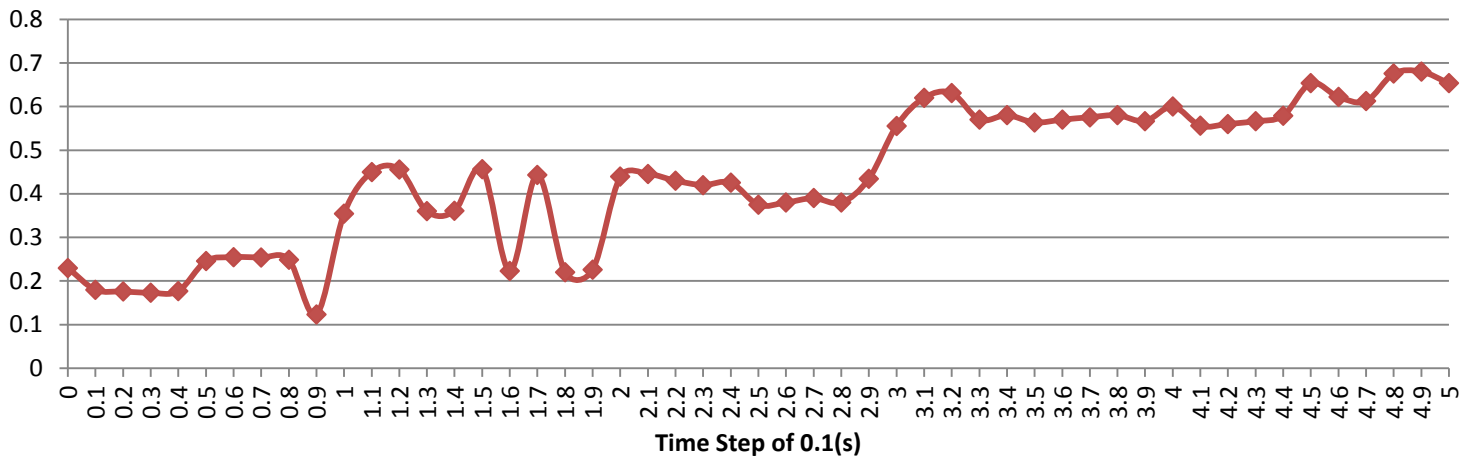
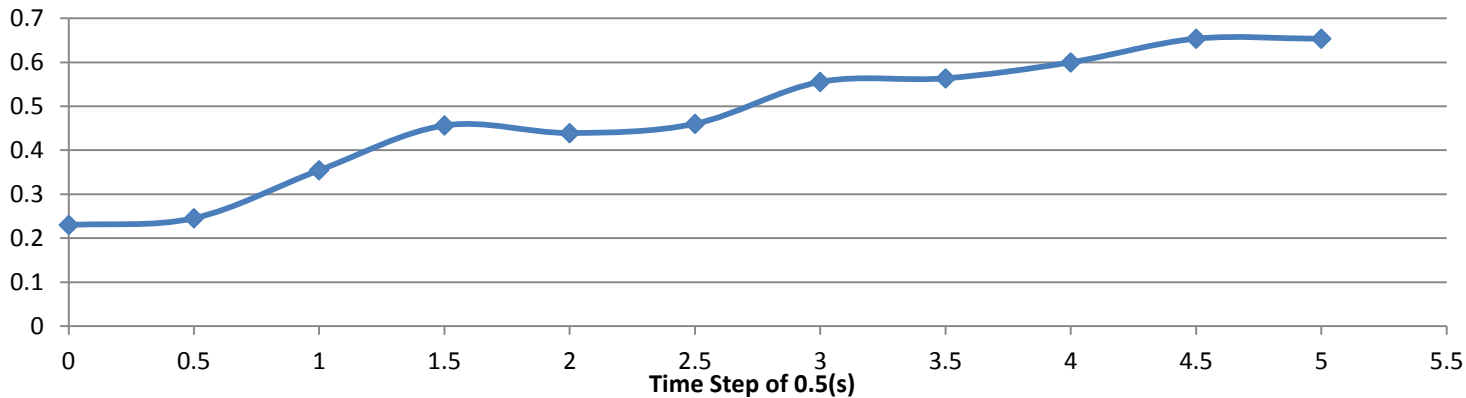
What is Simulation?

- **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)**





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

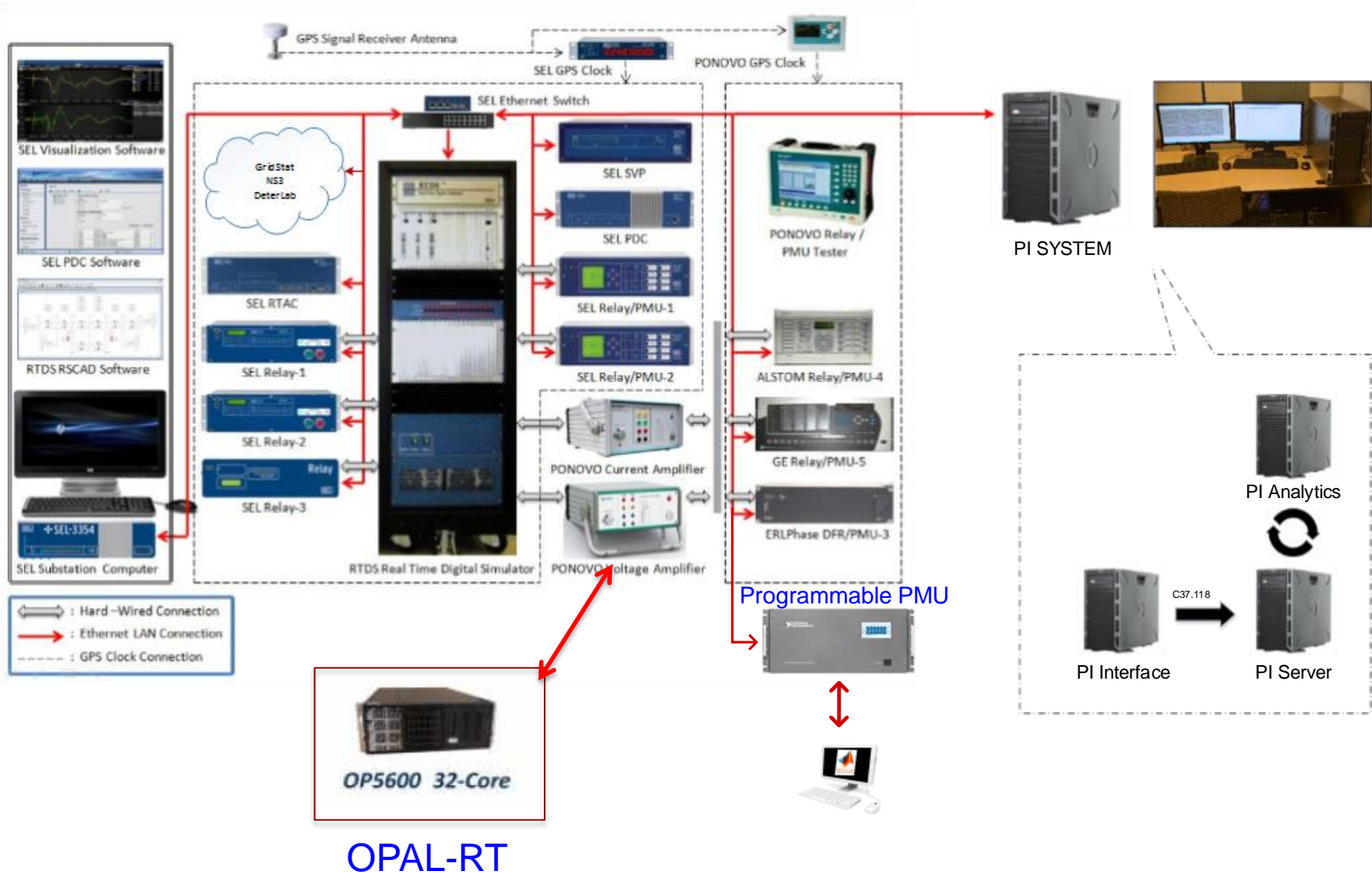
- Does the simulation have to be real time?

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

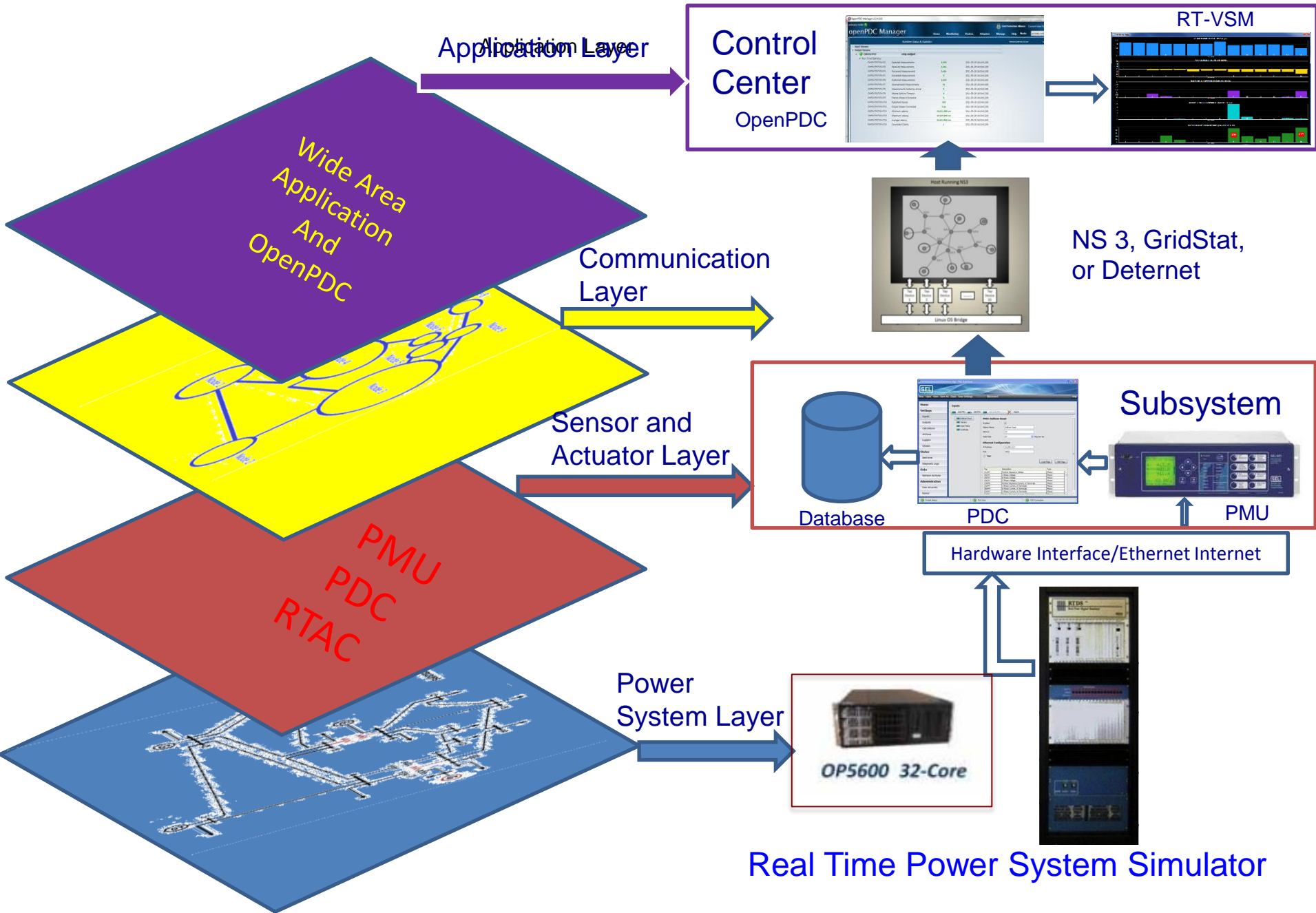
SGDRIL Test Bed at WSU



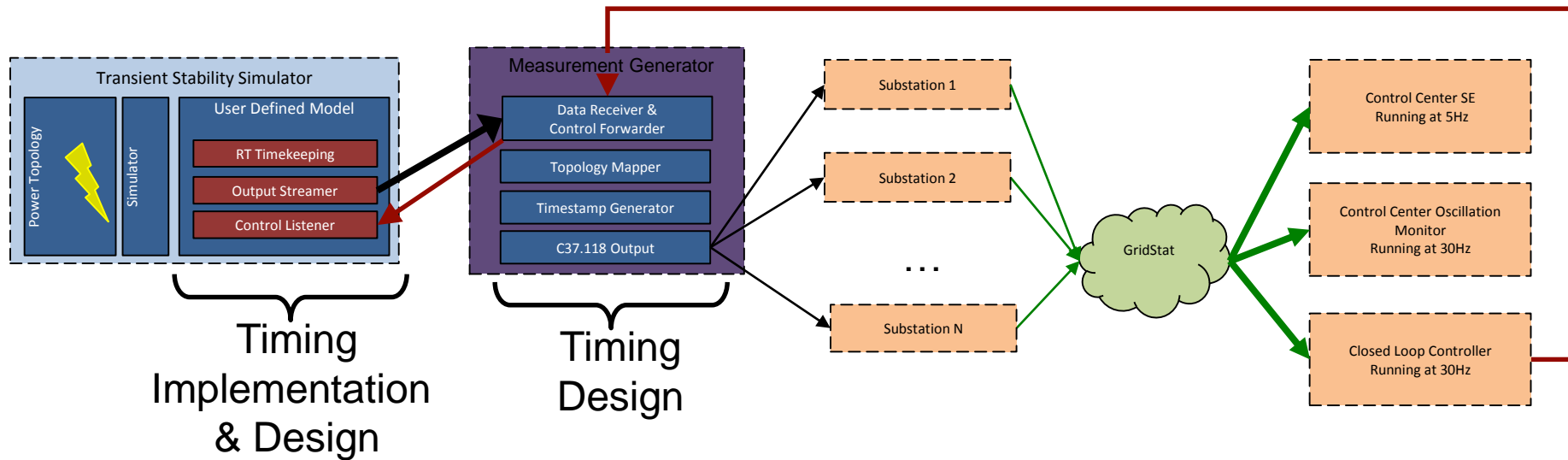
Real Time Digital Simulator and Other Devices



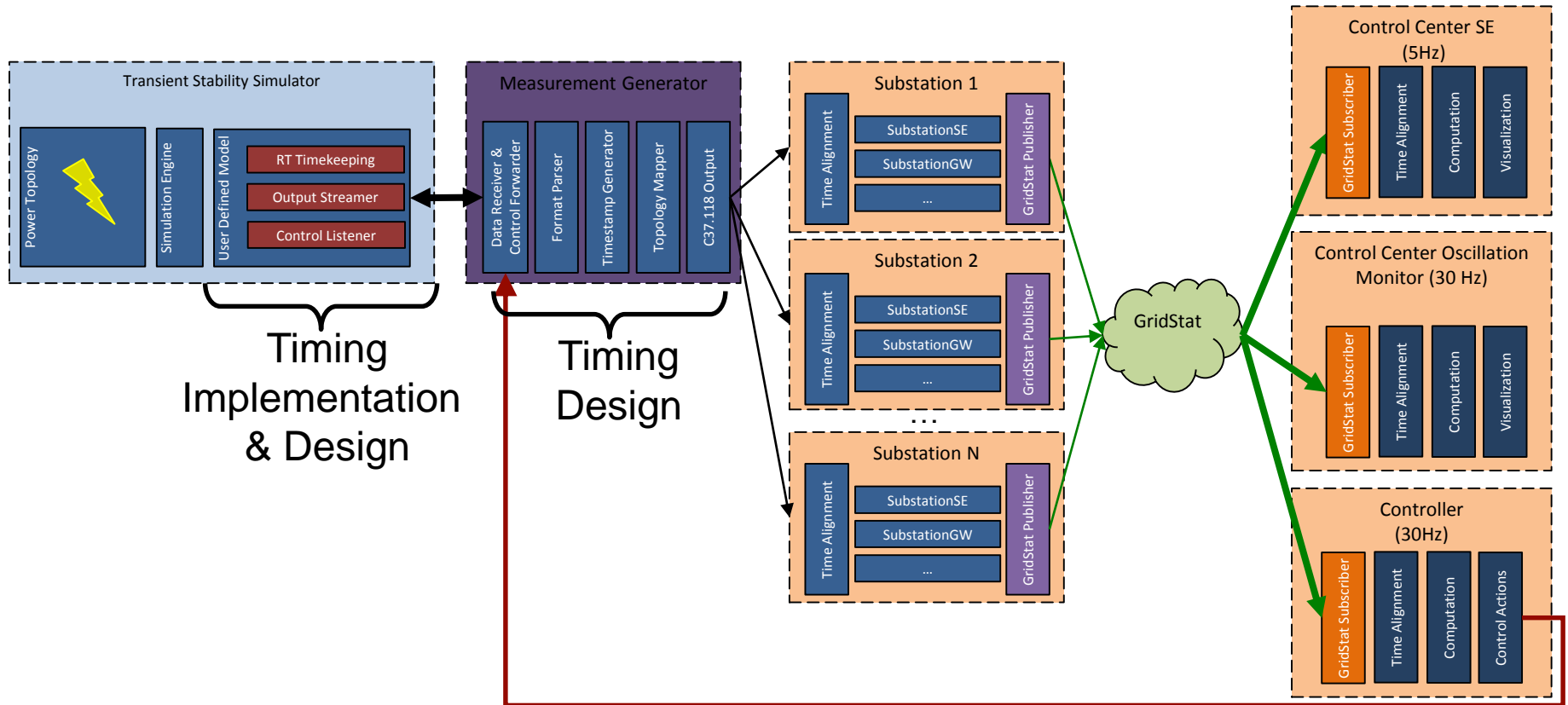
Cyber-Power System Modeling



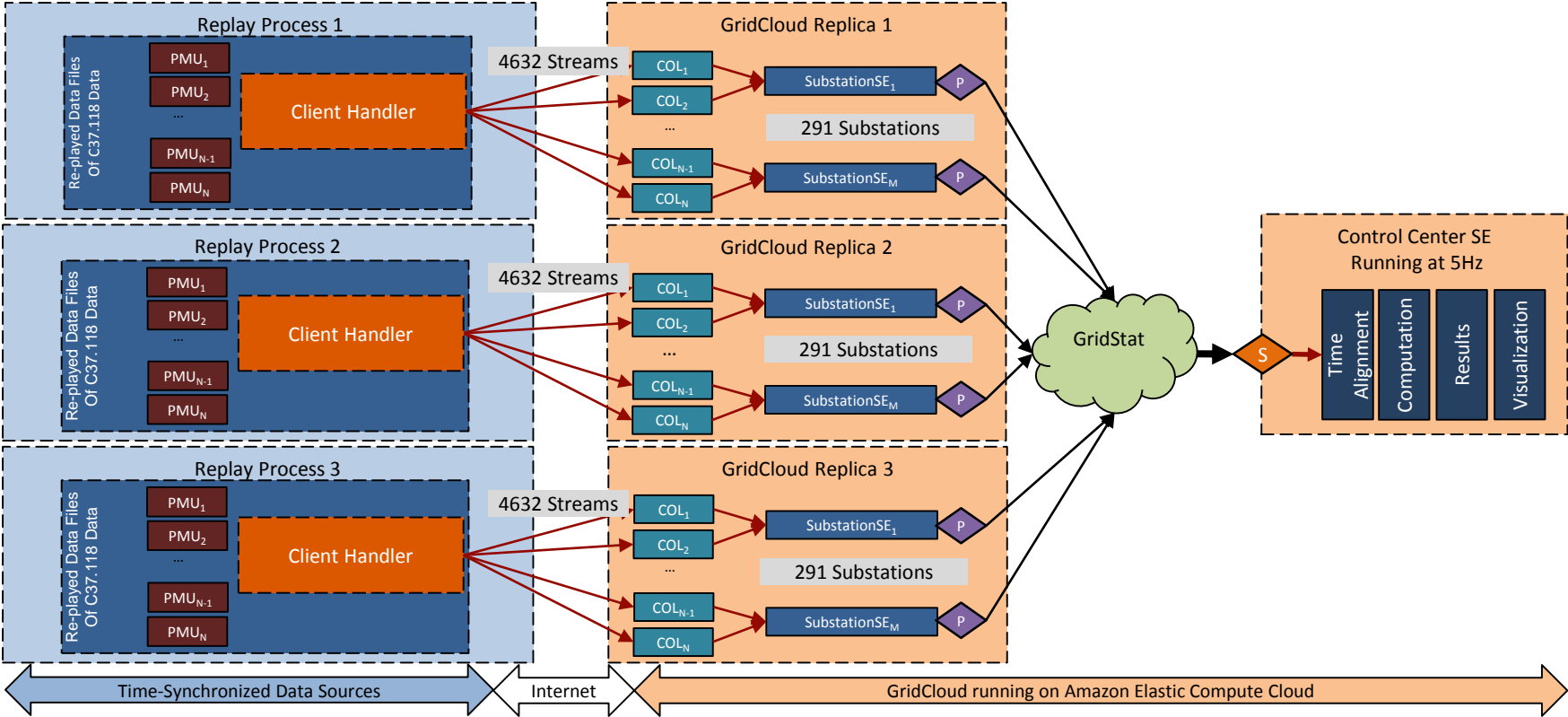
GridSim: High Level Diagram



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