High Performance Computing for Advanced Power Controls

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Introduction

As the cost of solar energy continues to fall, utility-scale solar generation facilities become more attractive. In 2019, 5,400 MW of utility-scale PV was installed in the US, accounting for 60% of new PV installations. As the size and number of utility-scale solar installations grows, rural sites served by relatively weak feeders become more important. In multiple ways, battery energy storage and advanced control strategies are important for maximizing the capacity and energy yield of these facilities, while minimizing the negative grid impacts possible with intermittent distributed generation.

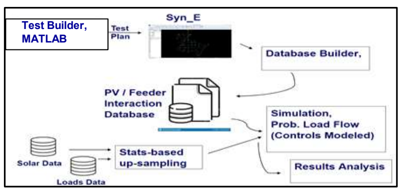

Figure1: Layout of the Database-based PV+Storage +Grid Simulation. Syn_E is used to build a database of PV and feeder interactions.

Photo Voltaic +Storage + Control Simulator

We have developed the innovative Database-based PV+Storage +Grid modeling tool (PSG Modeling). The tool combines the advantages of access to a commercial feeder model with those of control modeling in MATLAB and is based on a PV / Feeder Interaction Database that captures 22 feeder characteristics – such as grid-wide highest voltage, LTC operations and loading on selected sections - for 5,000 combinations of load plus PV+Storage active and reactive power.

High Performance Computing Mortimer Specifications

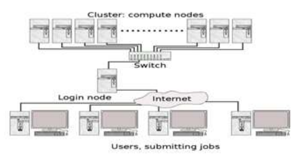

Figure 2: Cluster Computing Architecture

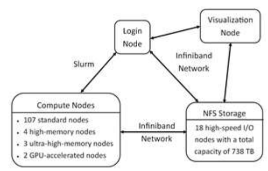

Figure 3: Mortimer Architecture at UW-Milwaukee

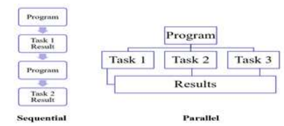

Figure 4:Sequential vs. Parallel Computation

Results

- The current processing time of an yearly simulation with one-minute resolution is 2403.5s, or 40 minutes(Represented by each point in Figure 4).
- A Probabilistic Load Flow(PLF) study requires ten irradiance profiles, seven load profiles, 28 installation configurations and four control policy alternatives, we would require 10x7x28x4x0.66 = 5175 hours, or 7 months.
- One such analysis is shown in Figure 5
- Using MATLAB's compiler tool to implement the simulation as a license-free stand-alone executable, the simulation will be deployed to the cluster computer . The cluster computing allows the program to run around 200 tasks at once which means the 7 months will be brought down to about 40 hours. And the license-free executable has the advantage of potential deployment to interested users.
- Advanced controllers have higher computation costs, and using Parallel computation reduces these costs.

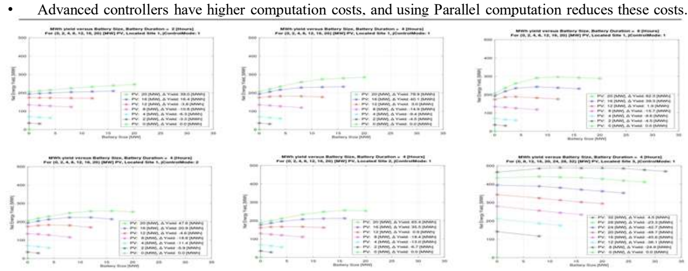

Figure 5: Net energy yield plots for different configurations of the simulator.

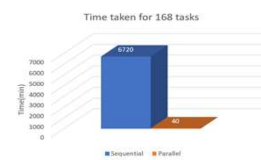

Figure 6: Time Comparison for Sequential vs Parallel Computation for Figure 5

Future Work

The speedup of computation time of different configurations of the program allows the team to try new control strategies. One such controller that can be implemented in the PSCG simulator is a model predictive controller.

An economic model predictive control technique which runs a plant with thermal energy storage optimally, while considering real-time electrical energy pricing, demand charges was presented in (Wenzel et al., 2014).The flowchart of the resources is shown in Fig 7. In their simulation, the system has demonstrated more than 10% savings over other schedule-based control trajectories.

A similar technique can be used to control the battery charge can be controlled in the PSCG, while considering real-time electrical energy pricing and demand charges.

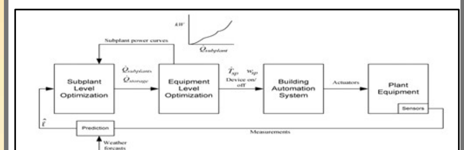

Figure 7: Illustrative view of resource use and assets of a central plant

Conclusions

- The use of Parallel Computation for the PSCG Simulation has speed up the computation time by a factor of 200
- This High-Performance computation method will allow our team to design, analyze and compare new controllers with fewer computational costs.

Literature cited

[1] "Power distribution system and electrical simulation software – synergi electric," https://www.dnvgl.com/services/power-distribution-systemand-electrical-simulation-software-synergi-electric-5005

[2]"UWM Research Computing User's Guide"(August 2020)

[3] Wenzel, Michael J., Robert D. Turney, and Kirk H. Drees. "Model predictive control for central plant optimization with thermal energy storage." (2014).

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