



PNNL's PRIME is the first-of-its kind method to loop real substation hardware into remote testbed simulations.

PRIME

An interactive, real-time control environment

REPLICATES THE REAL WORLD

PRIME is an interactive cyber-physical systems testbed that looks and acts like the grid in real time. It allows for high-fidelity power system experimentation because it integrates real-time data from power system simulators with commercial energy management system software and remote hardware-in-the-loop.

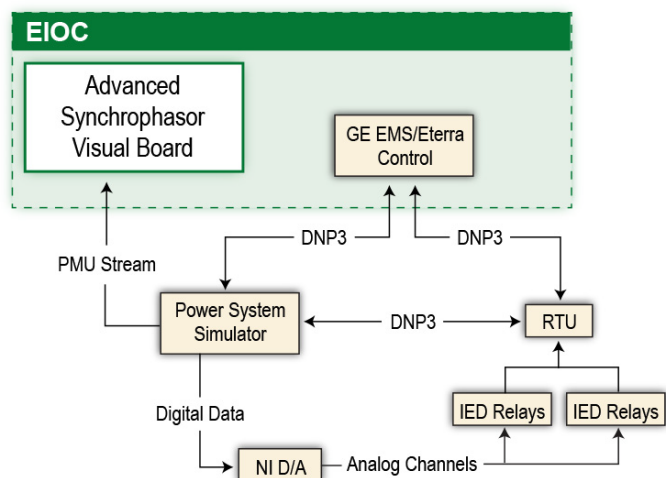
PRIME allows users to visualize real-world implications while they test specific hardware, interact with new technologies, and investigate real pathways for potential cyber threats.

WHOLISTIC CONNECTIVITY

Before PNNL researchers developed PRIME, power grid operators and protection engineers did not have a wholistic, real-world testbed that accurately captured the interactions between communications, control, and power systems. This inhibited power systems from employing new technologies, performing interactive operator trainings, and conducting realistic cyber-defense exercises.

TECHNOLOGY FEATURES

- Remotely integrates real-world hardware into electric grid simulations.
- Allows operators to experiment with advanced applications from a familiar control room interface.
- Offers a first-of-its-kind method to identify cyberattack routes and quantify cyberattack impacts on the power system.
- Flexibly combines power system simulators with industry-standard hardware, software, and communications protocol.
- Bridges communication gaps between monitoring and operations through a familiar, interactive platform.



PRIME translates simulated data into analog signals that real-world hardware can understand and respond to. Hardware responses are linked back to create a closed-loop simulation that alters the underlying power system simulation. This allows for real-time, interactive visualization of advanced applications, realistic cyber red team exercises, and remote hardware testing using industry standard interfaces.

HOW IT WORKS

The flexible structure of PRIME's code decouples simulations that only interact with their required hardware to connect with any device, even ones that are in remote locations.

This generalized code creates a physical separation that allows operators, researchers, and protection engineers greater flexibility to understand, test, and strengthen their unique power system. Because it does not rely on a custom code or protocol, it allows operators to trust simulation outcomes to reconfigure their systems with data that relies on their exact hardware, software, and communication protocols.

AN INTERACTIVE, REMOTE TESTBED

PRIME is the only interactive testbed proven to visualize advanced high-fidelity applications and events. Others have attempted this, but they have not created an interactive, real-time test product that can truly integrate real-time data with remote hardware information. These products are limited to the number of hardware that can be physically wired into a simulator. In addition, these systems are cost prohibitive, particularly for smaller utilities.

INDUSTRY APPLICATIONS

PRIME allows operators to interact with new technologies using a familiar interface and as-built protocols. Because PRIME loops actual hardware information into a continuing simulation, operators can see and respond to the compounding impact of their choices.

These features make PRIME ideal for supporting use cases involving wide-area monitoring, protection, and control applications, including interactive operator training with advanced visualizations of synchrophasor data streams. Moreover, because PRIME loops real hardware responses back into a simulation, it can replicate more lifelike cyberattack vectors, validate cyber protection measures, and quantify the impact of a potential cyberattack on the grid.

Pilot testing with an active user proved PRIME's ability to detect insufficient relay settings in a real utility. This allows a new practice of testing all the relay settings with a single, remote device to prevent system malfunctions.

PARTNER WITH US

PRIME is available for licensing with utilities and other markets. We are also seeking industrial or research partners interested in improving the security and resiliency of the electric grid through advanced cybersecurity testing and real-world training and operations improvements.

LET'S CONNECT

If you have questions, please contact:

Research collaborations:

James O'Brien

POWER SYSTEMS ENGINEER

509-375-2677

james.obrien@pnnl.gov

Licensing information:

Peter Christensen

SENIOR COMMERCIALIZATION MANAGER

509-371-6159

peter.christensen@pnnl.gov

availabletechnologies.pnnl.gov