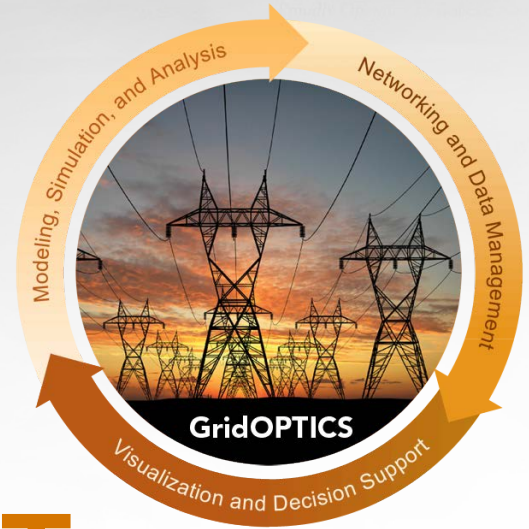




Pacific Northwest
NATIONAL LABORATORY

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GridOptics™ powerNET Testbed

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What is it?

- ▶ Multi-user power system testbed
 - Sandbox environment
- ▶ Experiment based
 - Access controls by project/user
- ▶ Auto-configuration
 - Built upon cloud technology
- ▶ Remote access
- ▶ Scalable
 - Emulation and simulation
- ▶ User friendly
 - Configuration/monitoring portal
 - Common library of scenarios

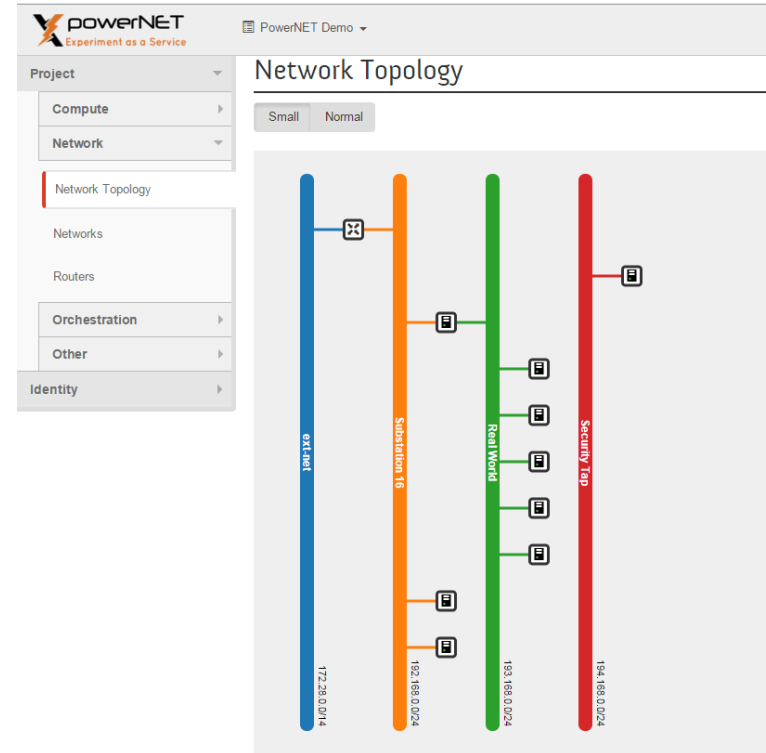


What is it?

- ▶ Modular and extendable
 - Support for multiple cyber physical industries
 - Federation with internal and external testbeds and resources
- ▶ Current capacity
 - 2-3 projects at once
- ▶ Vision
 - National user facility



- ▶ **Cloud technology based orchestration with web based user portal**
- ▶ **Network Emulation**
 - Emulate LAN/WAN communication characteristics. Examples:
 - Dedicated Line
 - Dial-up
 - Wireless
- ▶ **SCADA environments**
 - Real equipment to model ~2 substations
 - Software simulation of dozens of SCADA equipment
 - Support for legacy communications



- ▶ **Physical Process Emulation**
 - Hardware-in-the-loop modeling
 - Opal-RT
 - Large scale simulation
- ▶ **Synchrophasors**
 - 9 PMUs from variety of vendors
 - 1 PMU Development Platform
 - 1 Hardware PDC
 - (Many software PDCs possible)
- ▶ **Up to ~1000 general purpose virtual nodes possible**
 - XenServer hypervisor
- ▶ **Energy Management System**



Testbed Uses

- ▶ Validation and verification
- ▶ Technology assessment and prototyping
- ▶ Simulation and modeling
- ▶ Training and education
- ▶ Communication networks
- ▶ Demonstration (with PNNL EIOC)

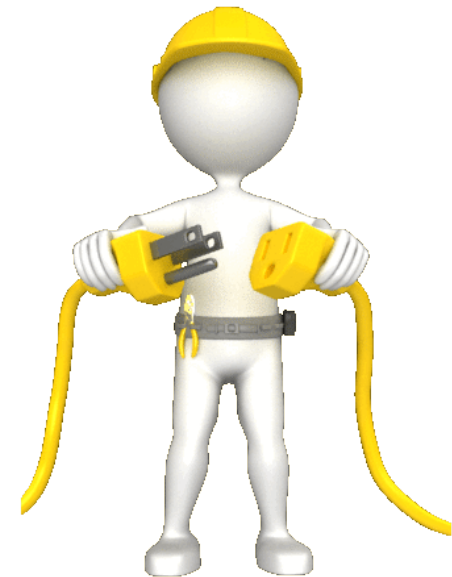


Research Topics

- ▶ Cyber security
- ▶ Cyber-physical system
 - Cyber impact/interaction on physical processes
- ▶ Distributed applications
 - Smart Grid
- ▶ Interoperability testing
- ▶ Application prototyping

powerNET Usage Examples

- ▶ Gridlab-D Analysis Project
- ▶ FPGI: A Distributed Systems Architecture for the Power Grid
- ▶ CEDS Digital Ants
- ▶ IEC 61850/62351 Interoperability Testing
- ▶ SCADA network determinism
- ▶ Cyber-Physical Training
- ▶ DHS Cyber-Physical Federation Demonstration



GridOPTICS powerNET Testbed Benefits

- ▶ Multi-user shared facility and equipment
- ▶ Time and resource efficient
- ▶ Dynamically configurable
- ▶ Remote access
- ▶ Test wide scale federation of testbeds and understand associated management and security concerns
- ▶ User benefits:
 - Researchers: Efficiency, Realistic Sandbox
 - Industry: Conformance and Interoperability testing
 - Academia: Hands-on Education

- Peer Capability
- Model and emulation enterprise environments
 - Enterprise services
 - User modeling and simulation
- Federate resources for bigger experiments
 - IT and OT joint experiments



cyberNET
Experiment as a Service

Questions



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