Cyber-Physical Resiliency Experimentation and Assessment using Federated Testbed

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GOALS

Offer federated testbed resources for validation and verification (V&V) of CREDC research activities. Existing resources are leveraged and augmented with instrumentation or capabilities to develop federation of varied assets.

- Identify experiments that could benefit from federated resources and understand their needs to drive gap filling.
- Develop data interfacing for domain-specific components and simulators.
- Develop methods to address missing data and network artifacts of federation.
- Perform initial remote experimentation tests.
- Develop time synchronization and forward-looking prediction methods to facilitate linked simulation.
- Validate and quantify results of federated experiments against localized results.

FUNDAMENTAL QUESTIONS/CHALLENGES

- A number of cyber-physical testbeds exist throughout the nation, but no single existing testbed can offer full scalability while simultaneously meeting high fidelity requirements for real-life experimentation. Throwing more money at the problem by acquiring additional assets is a losing proposition. By tackling the complexities of federating truly cyber-physical assets, one can offer a scalable experimentation platform that can be leveraged for verification and validation of CREDC research.
- Such isolated testbeds are often focused on very specific problems and are inadequate to model the full coupling between the cyber and physical system components that can accomplish the necessary realism to pass V&V muster. However, having a framework by which specialized testbed environments can be integrated provides value and a platform by which V&V can be explored with more rigor.
- There are a number of challenges in developing such a scalable federated testbed and its associated framework. Some of these include:
  - Identifying the problem domain and bounding constraints under which they operate.
  - Developing interfaces and a management architecture that will allow for near plug-and-play experimentation.
  - Evaluating experimental needs to balance scalability, fidelity, complexity, and cost.
  - Tackling the problems of real-time simulation and controlling time domains in both real and virtual time.
  - Integrating heterogeneous testbeds with different capabilities .

RESEARCH PLAN

This project will gather information on existing and emerging research in testbed

Identifying current gaps in available testbed solutions to meet those identified needs

Working through potential solutions to fill those gaps

Developing identified solutions to realize selected capabilities

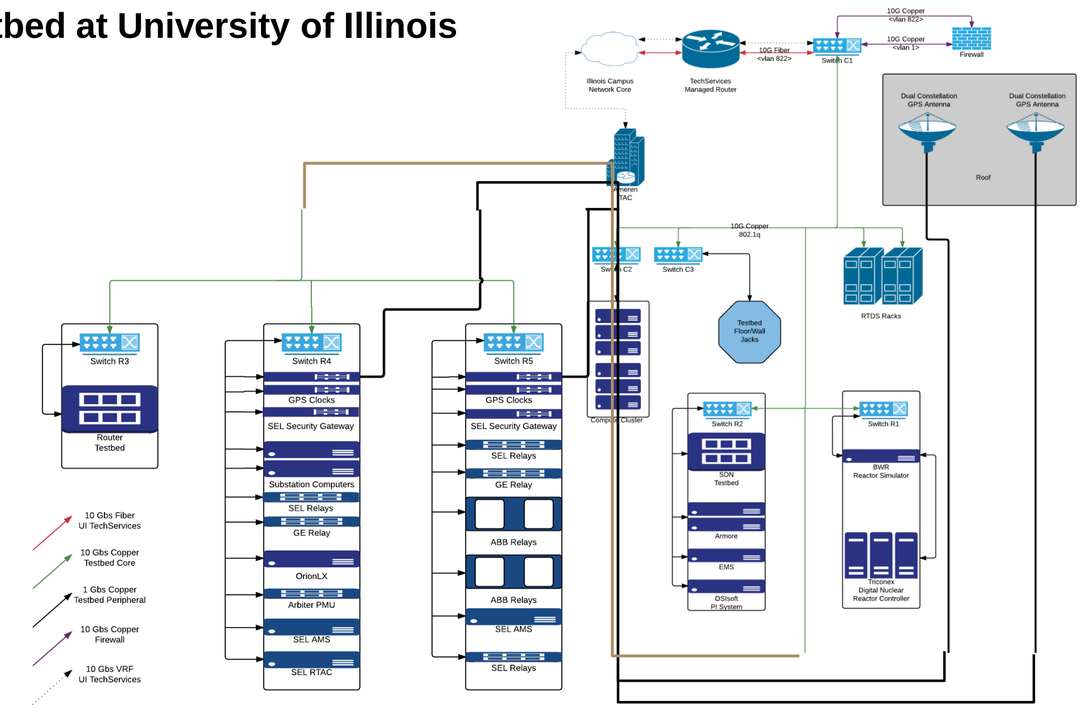
Could include interfacing, synchronization, data transfer, handling exceptions, correcting for delays, and proving validity of results

Developing a methodology by which to assess experimental needs, tradeoffs, and constraints that dictate mapping to solutions

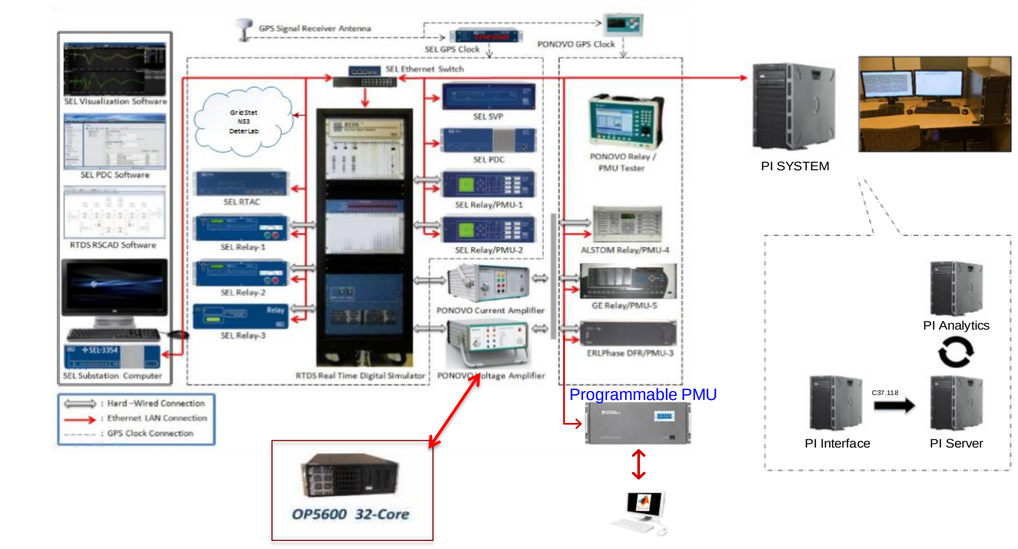
Demonstrate federated cyber-physical experimentation using the federated testbed

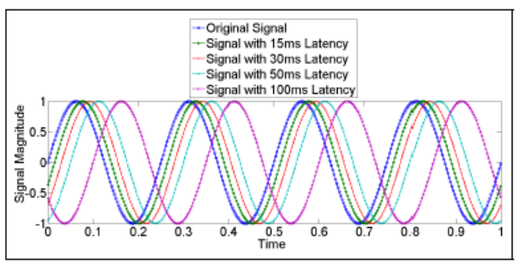
RESEARCH RESULTS

Testbed at University of Illinois

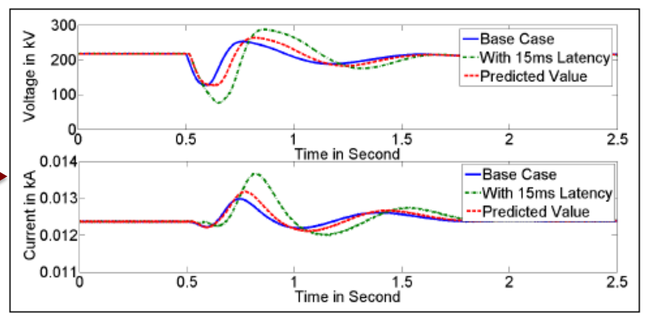


Testbed at Washington State University





Effect of communication delay on simulation will lead to unstable dynamic simulation



Effect of linear prediction on dynamic simulation

BROADER IMPACT

- Federated platform for validation and verification of long-term and mid-term projects.
- Knowledge base and toolsets for deploying federated testbed assets and leveraging for experimentation.
- Experimentation resource for the CPS community.

INTERACTION WITH OTHER PROJECTS

- The project will explore collaboration with other CREDC activities focusing on:
  - Full operational federated testbed resources, tools, and methodologies disseminated to a wide audience.
  - Developing case studies for federated testbed.
- This project will also explore industry collaboration to obtain inputs for federated testbed and seek additional resources.

FUTURE EFFORTS

- Federate testbed at data interface and energy management level for distributed voltage stability.
- Federate testbed for distributed simulation.
- Seamlessly federate cyber-physical assets such that they can be integrated for asset access, scalability, remote experimentation, and advancing the science of cyber-physical federation.

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