Cyber Physical Resiliency Experimentation and Assessment Using Federated Testbed

Website: https://cred-c.org/researchactivity/fedtestbed

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Industry Collaboration:

- We are collaborating with multiple vendors who have donated or provided us devices and software tools to develop individual testbeds, which need to be customized and federated for large scale resiliency experimentation.
- Additionally, our plan will be to identify needs of CREDC stakeholders to recruit additional users of this federated testbed. For more information, contact Anurag Srivastava.

Description of research activity: In order to do large-scale power grid experimentation and leverage investments between different research labs, academic research centers, and the industry, it is desired to integrate geographically dispersed assets for energy systems research. This includes large-scale Real-time (RT) cyber-physical co-simulation environments for analyzing the interaction among electric grid components.

In this research work, requirements will be gathered to set the stage for motivating needs of federated RT simulation assets. From these needs, the solution space will be explored to determine what approaches can meet the needs of expected experiments and how science can be advanced in this area. The end goal is to 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. The initial goal will be to offer federated testbed resources for validation and verification of CREDC research activities. Existing resources will be leveraged and augmented with instrumentation or capabilities to develop federation capabilities of varied assets.

How does this research activity address the Roadmap to Achieve Energy Delivery Systems Cybersecurity?
The research goal is to offer federated testbed resources for validation and verification of Cyber Physical System (CPS) research activities. Existing resources will be leveraged and augmented with instrumentation or capabilities to develop federation capabilities of varied assets. This research will lead to

- Federated platform for validation and verification of long term and mid-term CREDC projects
- Knowledge base and toolsets for deploying federated testbed assets and leveraging for experimentation
- Experimentation resource for the CPS community
- Training and education resource for the CPS community
- Validating tools developed for assessing, monitoring and reducing risks

Summary of EDS gap analysis: 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 specifically customized for resiliency analysis. 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.

Full EDS gap analysis: Real-time (RT) simulator is a powerful tool for analyzing performance of operational and control algorithms in electric power grid before field deployment [1-2]. For resiliency experimentation, number of domains within the power grid need to be modeled and simulated including distribution, transmission, generation and associated cyber system. A single unit of RT simulator has limited simulation capabilities. The most common way of augmenting simulation capability is using a bank of locally connected RT simulators. However, creating a large-sized bank of RT simulators involves significant financial investments and hence may not be feasible at all research facilities. Power systems research facilities that use RT simulators are at diverse physical locations. In addition to RT simulators, research facilities around the world house an array of facilities with unique power, energy, control and cyber systems for innovative research. To leverage these unique research facilities, geographically distributed RT simulation based on Wide Area Network (WAN) is required.

In order to enhance collaboration and leverage investments between different research labs, academic research centers, and the industry, it is desired to integrate geographically dispersed assets for resiliency experimentation. This includes large-scale Real-time (RT) digital co-simulation environments for analyzing the advanced grid and its component interactions [3-4]. Simulations are classified based on the type of environment used. With respect to simulation clocks and application timeline, simulation environments may be classified as either RT, non-RT, or faster than RT [5-6]. The software, hardware, and external interface mechanisms constituting a RT simulation environment varies significantly from the non-RT and faster than RT environments. For instance non-RT or offline simulation environments may not require dedicated computational hardware. However, RT or faster than RT simulation environments typically require specialized computational hardware with dedicated processors, and lower operating system overheads to provide the necessary computational capability.
There are number of challenges in developing such a scalable federated testbed and its associated framework. Some of these include [7-8]:

- 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
- Tackle the problems of real time simulation and controlling time domains in both real and virtual time
- Integrating heterogeneous test beds with different capabilities

Proposed work is to fill this gap and provide customized solutions for CREDC researchers to validate their solutions.

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