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Federated Simulation for Development of Improved Incident Detection and Management

An Interactive, Extensible Environment for Power System Simulation on the PMU Time Frame with a Cyber Security Application

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GOALS

- Development of federated simulations of the various energy delivery systems and their underlying cyber infrastructure, coupled with key real-time information-sharing and coordination mechanisms. We will meet this objective in part by leveraging existing commercial packages, such as interactive power system transient stability-level simulations, and in part by developing new prototype packages.
- Development of publicly available synthetic case models that can be used within these environments. (While models of actual infrastructure are best, NDAs limit the use of such models in cooperative university research; hence the need for the synthetic case models.)
- Utilize the environment to develop effective analytics and visualizations that can be used to help the energy delivery sector detect security incidents, intervene, and, if necessary, recover.

FUNDAMENTAL QUESTIONS/CHALLENGES

- The emerging needs for real-time coordination among interdependent energy delivery systems are creating new security requirements for the supporting cyber infrastructure. To help meet those new requirements, this activity is working to improve capabilities for incident detection and management on energy delivery systems.

SOLUTION APPROACH

- Create a prototype client that achieves the objectives of receiving the data from a PMU/PMU simulator, storing the raw data, and generating the COMTRADE file.
- Based on the prototype client, implement, test, and visualize different online cyber-incident detection methods that use real-time PMU simulator data.
- Create a publicly available synthetic case model that can be used within existing commercial packages and can be used for the performance verification of real-time cyber-incident detection methods. Further, create a graphical user interface to visualize the detection results and simulate the response of a power system to a cyber incident (e.g., data injection in a PMU network).
- Based on the Dynamic Studio protocol, improve the prototype client to simulate the power system under a cyber incident, and use the synthetic case to achieve effective real-time detection and visualization of a cyber incident.

RESEARCH RESULTS

- An interactive PMU time frame simulation environment, along with an example application of the environment to provide a flexible platform that can be used to simulate the interaction of the power system with its cyber infrastructure

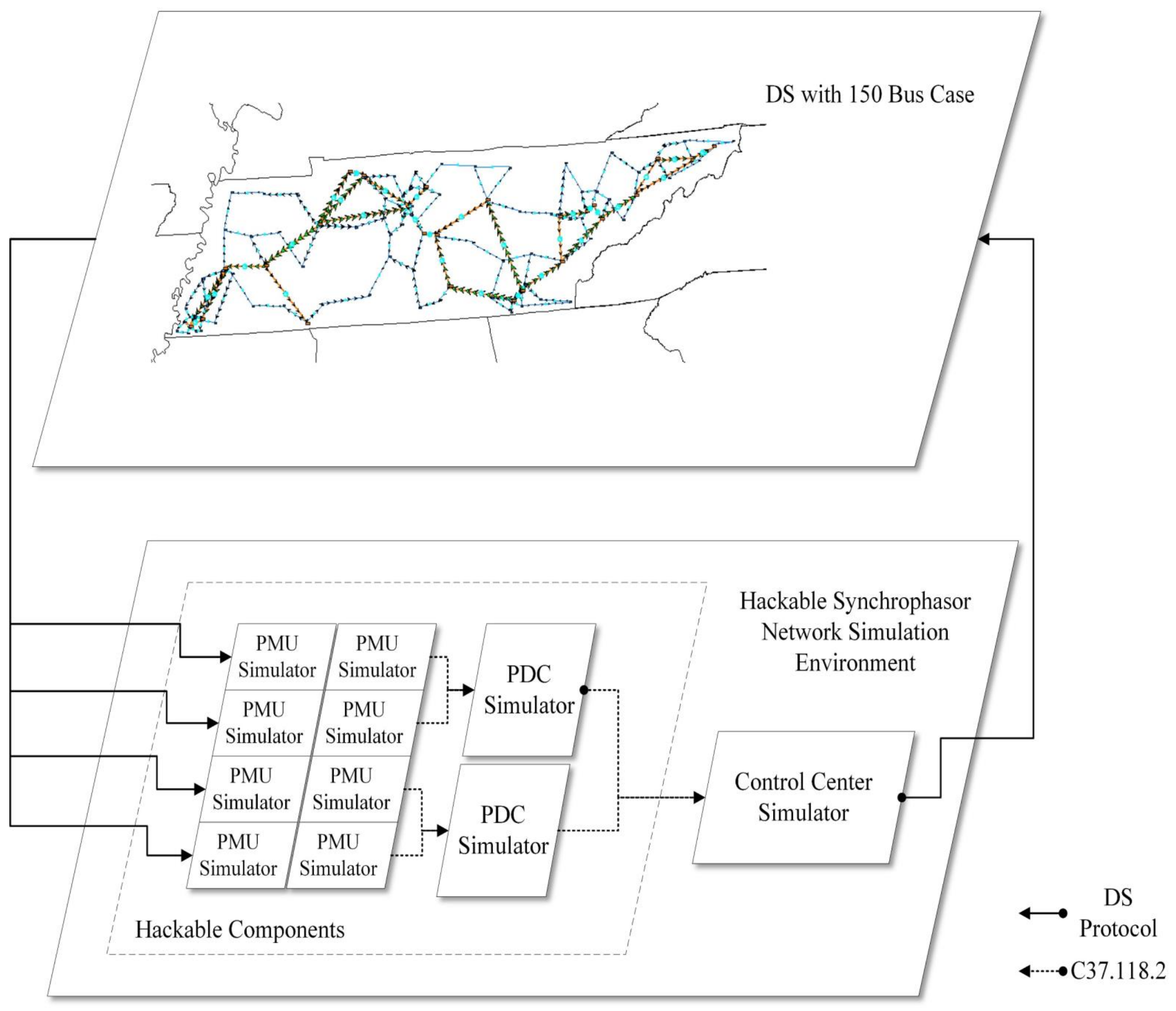


Fig.1 The Interactive Simulation Framework

- Dynamics simulation
  - Utilizes Dynamics Studio as its simulation engine
    - represents different power system dynamics models
    - imports and exports case models in industry standard formats
    - efficiently solves large power system cases

RESEARCH RESULTS

- Synchrophasor network simulation environment
  - Consists of Phasor Measurement Unit (PMU) Simulator, Phasor Data Concentrator (PDC) Simulator, Control Center Simulator, communicating in IEEE C37.118.2 standard protocol

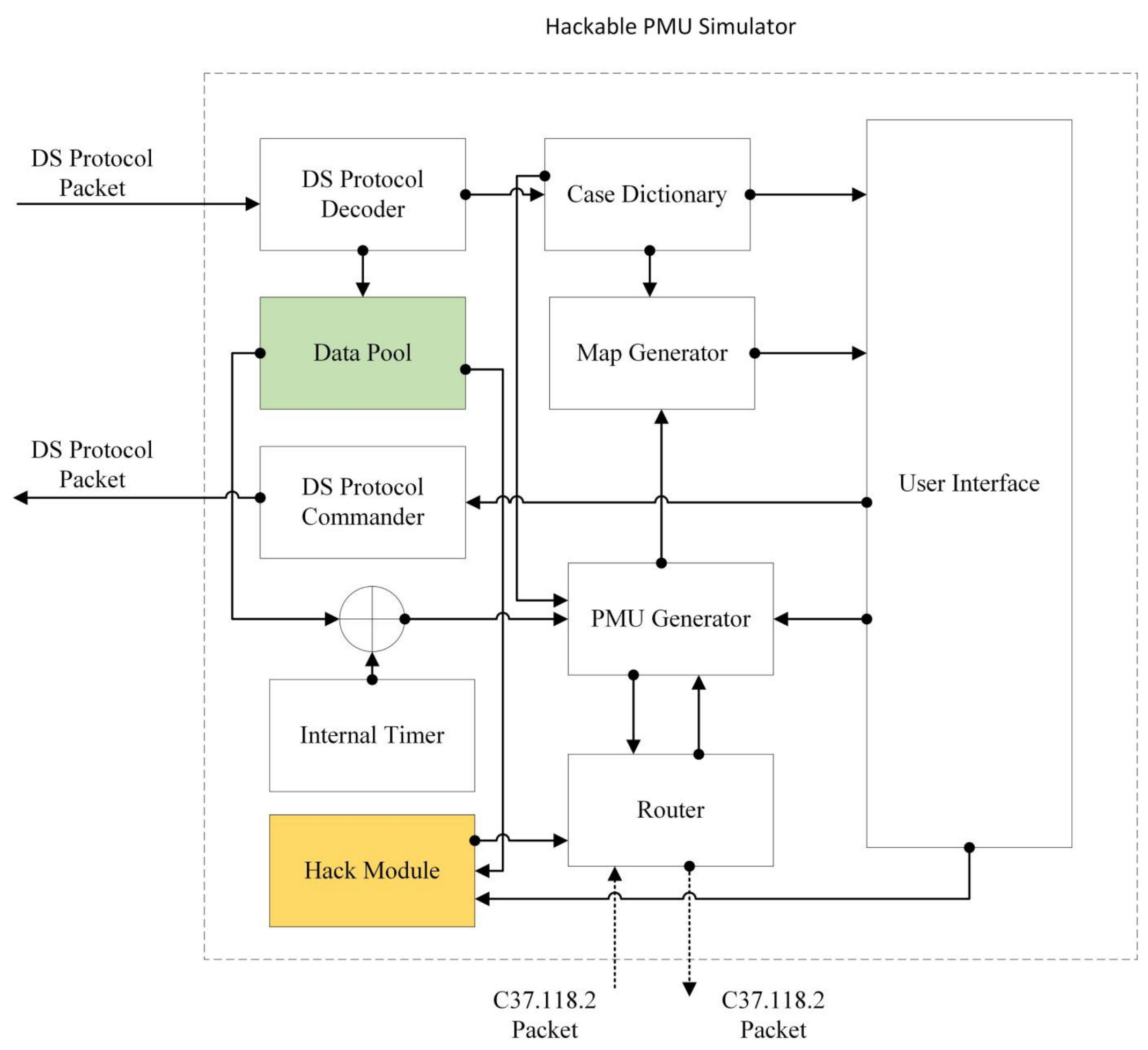
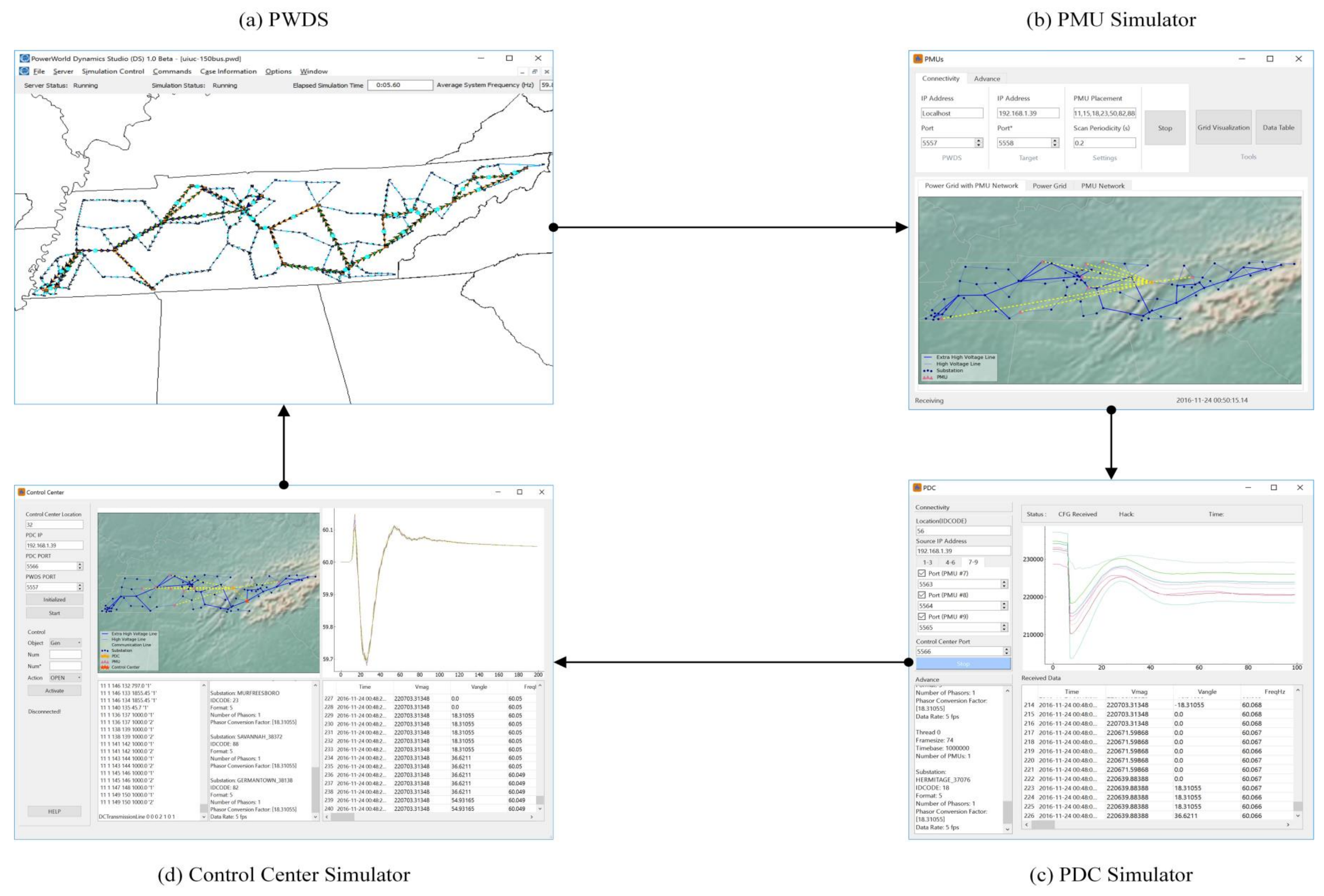


Fig.2 PMU Simulator Architecture


(a) PWDS

(b) PMU Simulator

(d) Control Center Simulator

(c) PDC Simulator

Fig.3 Interactive Simulation

- Real-time data sharing mechanism and interactive control
  - Using Dynamics Studio Protocol between DS and the Synchrophasor Network Simulation
  - Two-way communication
  - Change dynamic models during the simulating process

BROADER IMPACT

Power system simulation environments with appropriate time-fidelity enable rapid testing of new smart grid technologies and are necessary for coupled simulations of the underlying cyber infrastructure. This project focuses on an environment which operates with power system models in the PMU time frame, including data visualization and interactive control action capabilities. The flexible and extensible capabilities enable the interactive simulation to be highly useful in many coupled simulation or cyber security researches.

INTERACTION WITH OTHER PROJECTS

An application programming interface (API) client of the dynamics simulation environment is used in the T-57 project of the Power Systems Engineering Research Center (PSERC)

FUTURE EFFORTS

- To use this interactive system to develop new visualization and analysis methods to detect cyber security events, and other issues in power systems
- More cyber-attack scenarios will be added to the coupled simulation toolkit
- Other applications, clients, scenarios, and control actions will be investigated for coupling with the DS

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