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- **James McConnell Professor at UTK, CURENT UTK Campus Director, CURENT Large-scale Testbed (LTB) project lead**
- **Research Interests: LTB, demand response, resilience, microgrid, machine learning for power.**
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2020-2021 Research Projects/Highlights

1. CURENT LTB (**NSF/DOE**) – Hantao Cui, Jinning Wang, Nick West
2. WISP: Watching grid Infrastructure Stealthily through Proxies (**DOE, Raytheon**) – Qiwei Zhang
3. Cyber-Physical Dynamic System (CPDS) Modeling (**NREL**) – Jinning Wang, Trey Mingee
4. National Transmission Resilience and Reliability (**DOE**) – Hang Shuai, Jin Zhao
5. Resilient Distribution Systems Enabled by Responsive Resident Building Loads (**ORNL, EPRI**) – Xiaofei Wang
6. Intelligent Control of Refrigerating Load for Peak Reduction (**State of Tennessee - REVV Program, GridFruit**) – Justin Martinez, Vince Wilson
7. Model-Free Adaptive Control (MFAC) for Autonomous and Resilient Microgrids (**DOD ESTCP**) – Buxin She, Hantao Cui
8. From AlphaGo to Power System AI (**NSF**) – Mariana Kamel, Jin Zhao
9. Adaptive dynamic coordination of damping controllers through deep reinforcement and transfer learning (**NSF**, with Dr. Hector Pulgar as PI) – Jingzi Liu

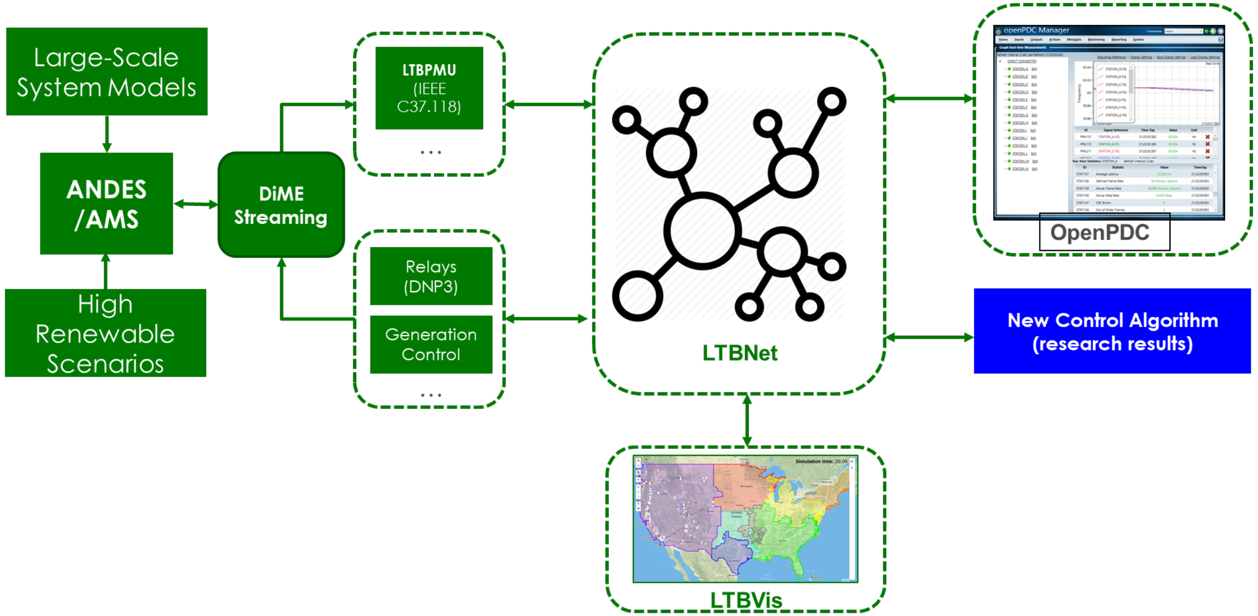
CURENT Large-scale Testbed (LTB)

Project Objectives

- To develop a power market simulator for market clearing and generation scheduling
- To enhance ANDES model library for renewable energy resource and distributed energy devices
- To integrate with distribution system simulation as a closed-loop T&D co-simulation tool

Recent Achievements (Year 10)

- The developed market simulator AMS can solve typical market clearing and scheduling problems.
- The enhanced ANDES library supports standard renewable energy resources and distributed energy devices such as electric vehicles, decarbonized power generation.
- It enables LTB for modernized components and scenarios, and the newly integrated AMS allows for market study.



Latest Architecture of LTB

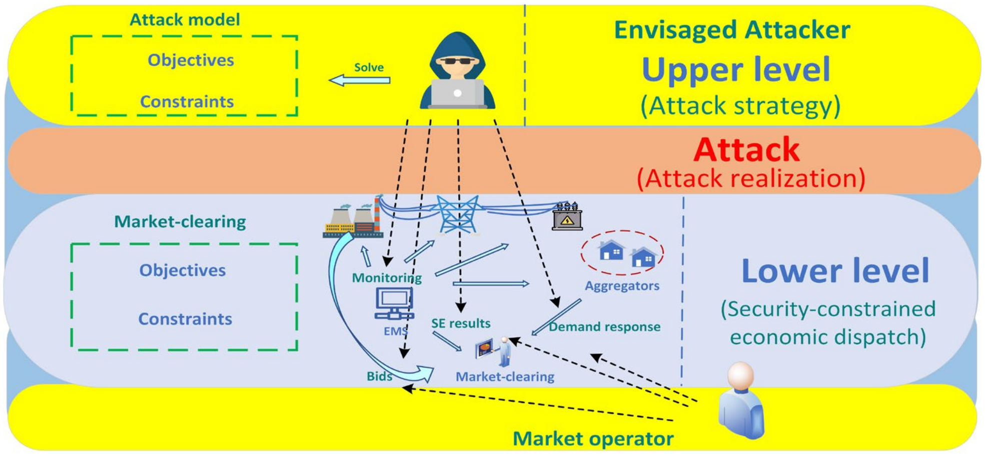
Cyber-vulnerability Analysis (CVA) for RT Market Operation

Project Objectives

- Cyberattacks could cause significant disruption by disturbing market operations, considering the U.S. power market clears hundreds of GW loads hourly
- There is a lack of impact analysis model for power market cybersecurity.
- There is a lack of vulnerability analysis on power market cybersecurity

Recent Achievements (Year 10)

- A comprehensive cyber-vulnerability analysis (CVA) model is proposed, where market operator can analyze the impact of different cyberattacks on power market operations.
- Developed four cyber-vulnerability analysis algorithms in terms of
  - Success possibility
  - Severity
  - Load level
  - Defense strategies.



Cyber-Vulnerability Model Structure

CURENT

Raytheon Technologies

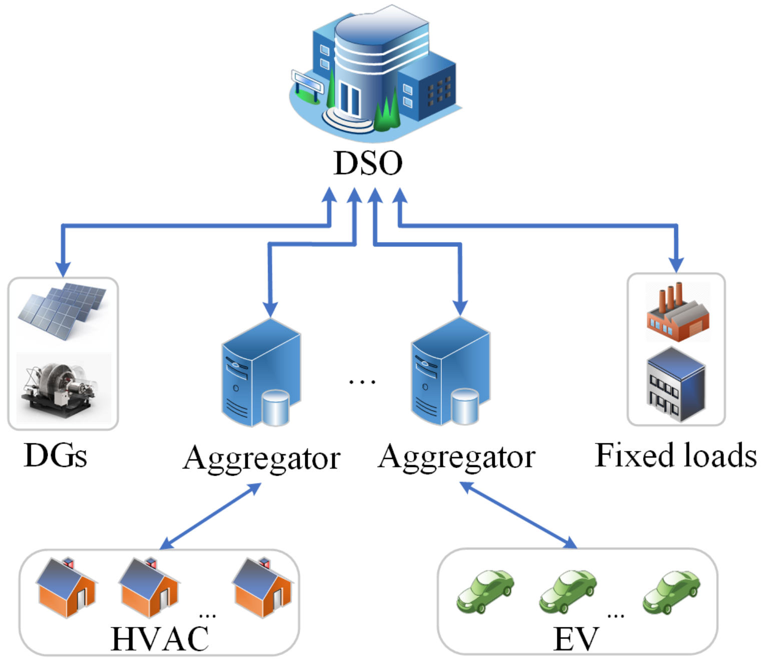
Intelligent Demand Control in Competitive Distribution Markets

Project Objectives

- To develop a closed-loop control system of refrigeration loads utilizing micro-controllers
- Operation: To reduce the overall electricity payment for residential consumers via Distribution LMP algorithm.
- Planning: To determine the optimal sites and sizes for DERs in a profit-oriented manner.

Recent Achievements (Year 10)

- A demonstration platform compliant with ADR standards for refrigeration load controls was created.
- A tri-level dispatching framework is established based on the competitive distribution operation with DLMP. Uncertainties from renewable energies, weather condition, and consumers' behaviors are considered.
- A two-stage stochastic bilevel programming (TS-SBP) model is proposed to obtain the optimal siting and sizing of BESS.



Three-layer day-ahead distribution-level electricity market

Model-Free Adaptive Control (MFAC) for Autonomous and Resilient Microgrids

Project Objectives

- The challenges of resilience, plug-and-play, and control coordination are present in microgrids.
- Devices in microgrid systems are controlled separately based on pre-configured controller gains, which cannot adapt to unpredictable disturbances.
- It is crucial for microgrid controllers to achieve accurate tracking of the desired response trajectory through adaptive gain tuning.

Recent Achievements (Year 10)

- Proposed a time-varying-gain based PQ control method for microgrids, combining model-based analysis and data-driven implementation.
- Proposed an adaptive inertia and damping factor tuning method for virtual synchronous generator (VSG) controlled microgrids, using deep reinforcement learning.

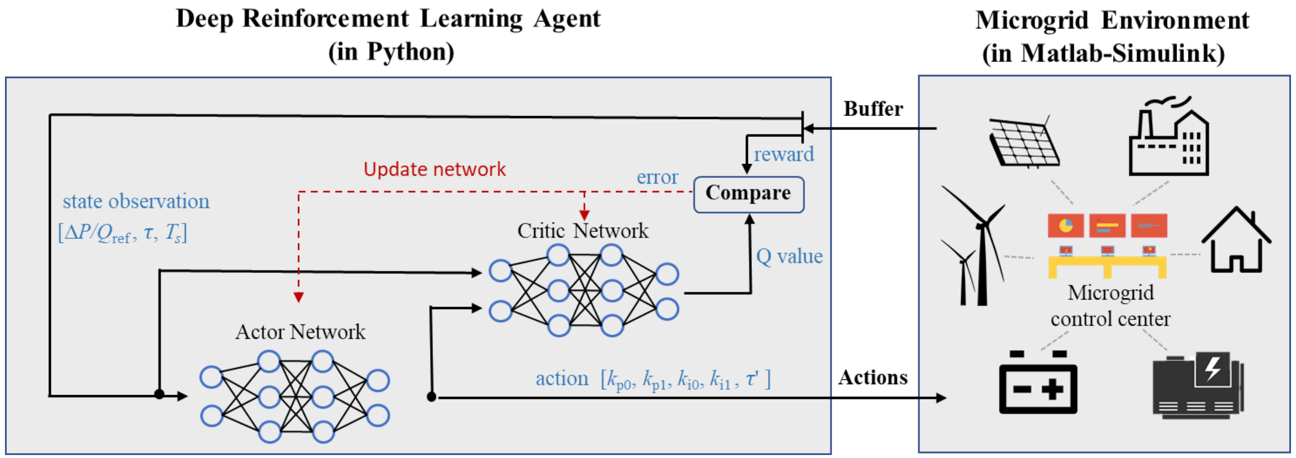


Diagram of Implementing Deep RL in Microgrid Model-free Adaptive Control

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