2019 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

CRII: CPS: Towards a Model-Based Reinforcement Learning Approach for Safe Operation of Distributed Energy Systems

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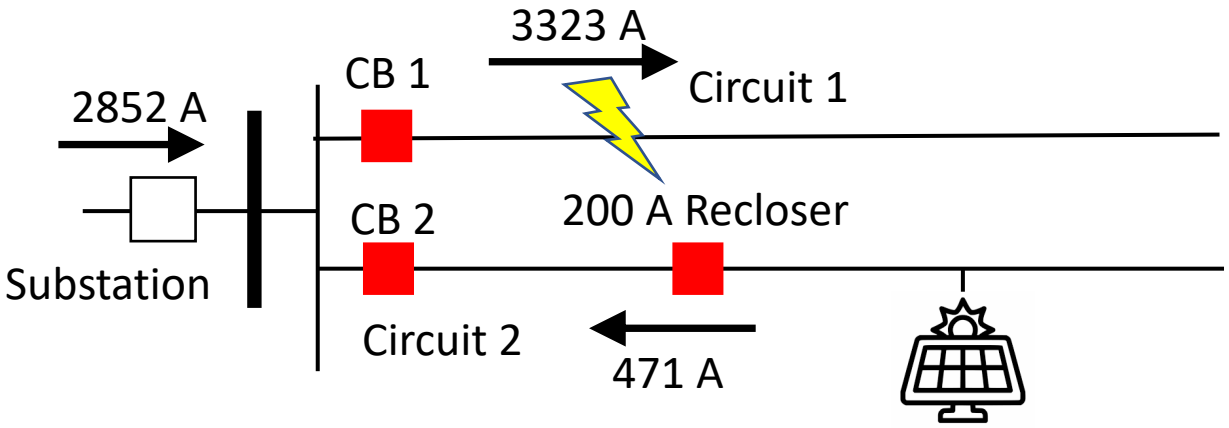
Description

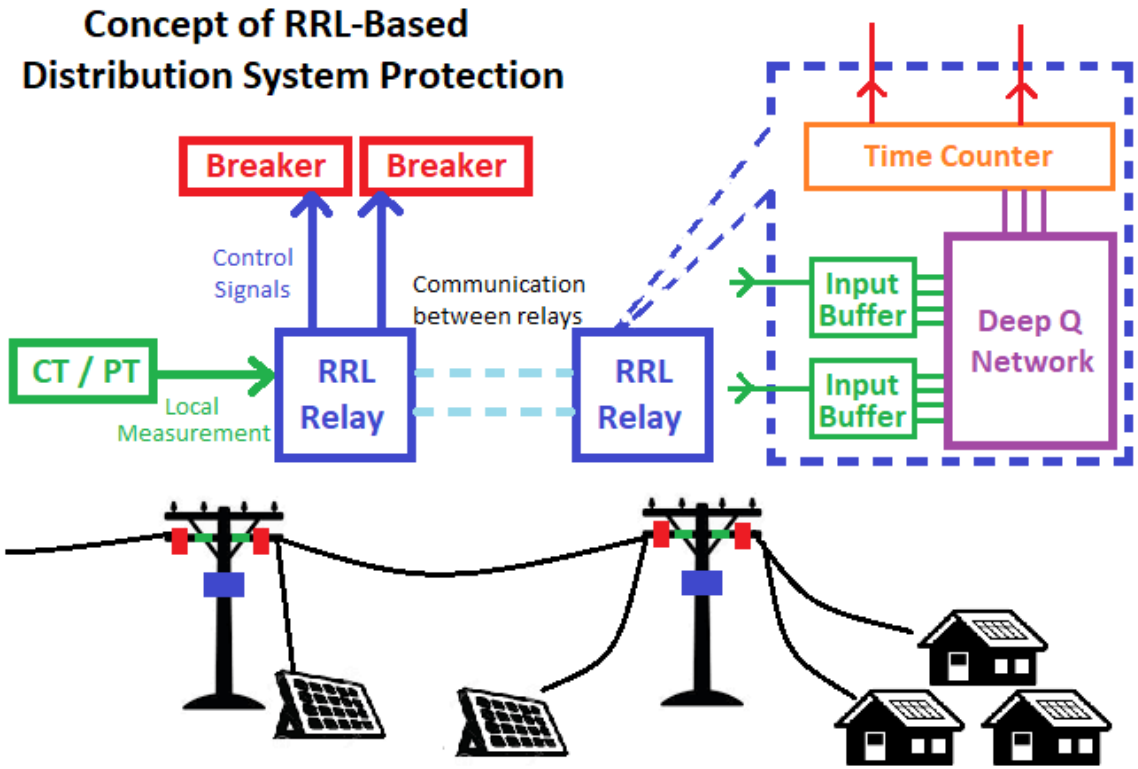
- Energy Cyber-Physical Systems
  - Distributed energy resources such as electric vehicles, electricity storages, rooftop solar panels and smart appliances
  - Smart infrastructure like protective relays, circuit breakers, transformers, voltage and frequency regulators

- Goal of the Project:
  - Reinforcement Learning based methods for seamlessly integrating distributed energy sources into the electric grid more efficiently, effectively and affordably
  - Reinforcement Learning based methods for ensuring the safe, reliable and robust operation of the electricity grid in the presence of increasing uncertainties

Description

- Reinforcement Learning for power system protection



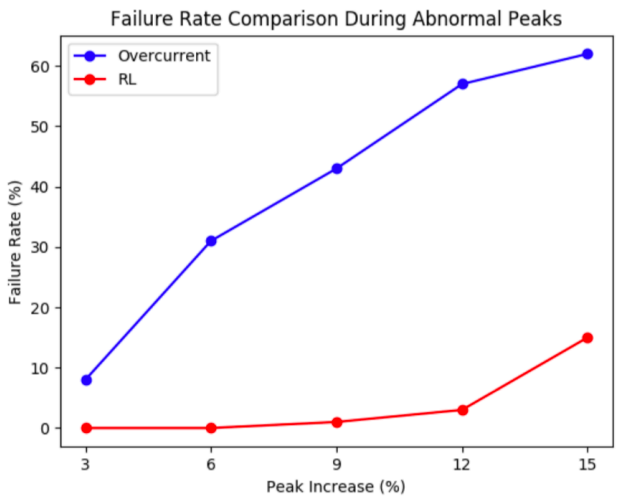


- Protective relay control as a multi-agent reinforcement learning problem
  - Each relay needs to learn to do implicit coordination with other relays for efficient operation

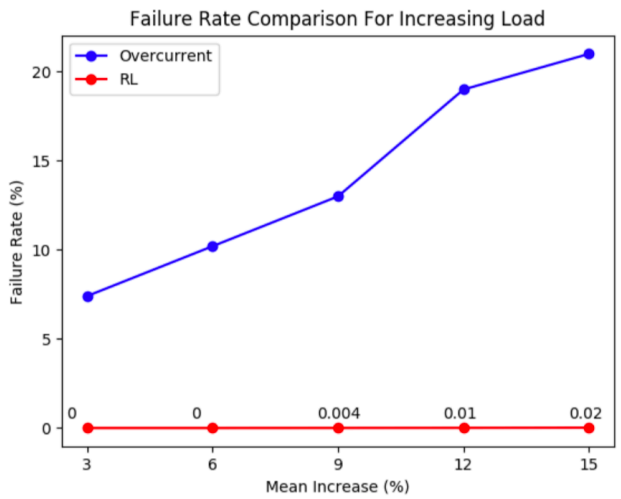
Findings

- Multi-agent RL problems are typically very difficult
- Nested Reinforcement Learning for convergent and scalable learning
  - Exploiting the **radial structure** of distribution systems
  - Operation of a relay is not affected by its upstream neighbors
  - Train relays sequentially according to operation dependency

Scenario	Expected Operation	Failure Rate	
		Conventional	RL-based
Local Fault	Trip	7.7%	0.26%
Backup	Trip	9.6%	0%
Remote Fault	Hold	3.8%	0.08%
No Fault	Hold	1.8%	0%



(e) Failure Rate During Abnormal Peaks



(f) Failure Rate During Increased Mean Load