2024 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

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Collaborative Research: CPS: Medium: ASTrA: Automated Synthesis for Trustworthy Autonomous Utility Services

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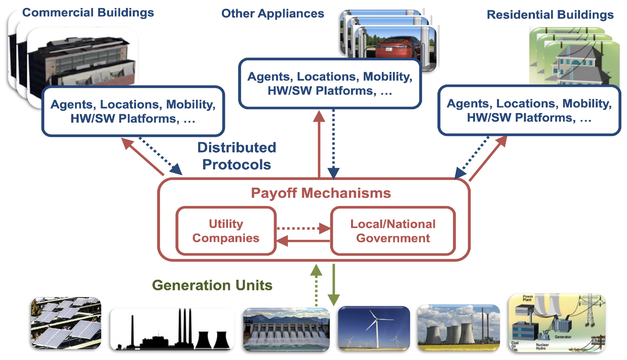
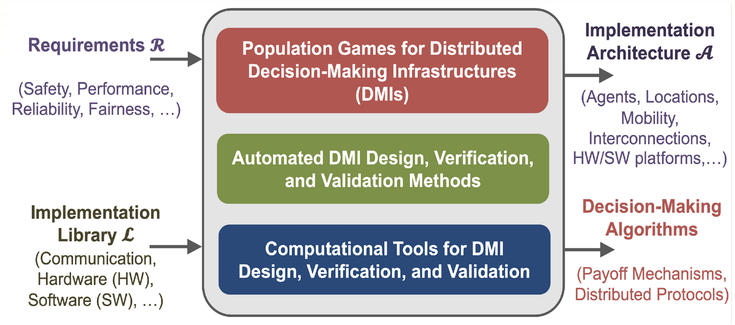
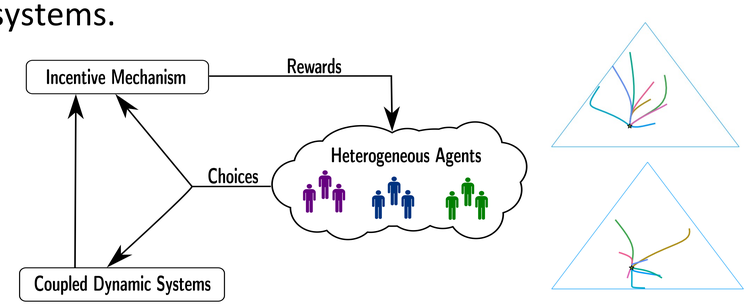
Main Goal: Investigate methods to design and verify the performance of distributed decision-making infrastructures (DMI) meant to effectively allocate the consumption and distribution of energy generated by renewable and non-renewable sources.



The ASTrA Framework: Utility providers and users (residential, commercial and industrial) interact as part of a large-scale and complex distributed system. the users' behavior cannot be known exactly. Users can only be motivated by pricing and assisted by interacting with DMI.

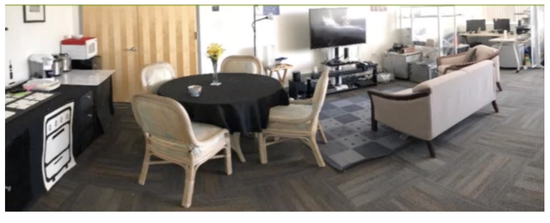


Incentive design method leads a population of heterogeneous agents, whose decisions influence a dynamical system, to make better decisions, even with agents employing different learning rules. This method ensures guarantees on both the population and coupled dynamics system behavior across many systems.



Scientific and Broader Impacts:

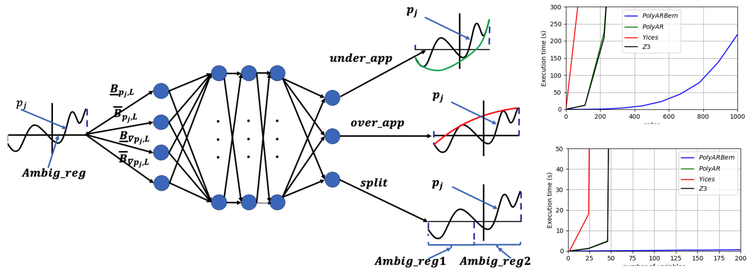
- Lay the foundations for the automated design of large-scale, mission-critical CPSs that operate in a distributed fashion and coordinate their decision-making to achieve a unified goal, with applications from transportation and robotic swarms to smart cities.
- Help mitigate the environmental effects of energy usage and contribute to the training of undergraduate and graduate students on critical multidisciplinary skills.



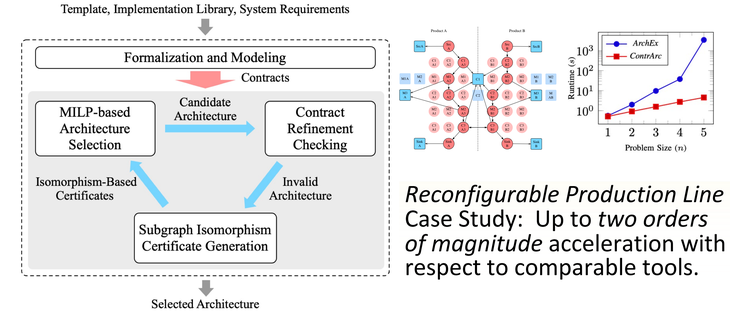
Testbed: Sim Home facility at UCI

Accomplishments:

Neural Network-Guided Solver and Optimizer for Bounded Polynomial Inequalities. PolyARBerNN is a constraints solver that uses a neural network and a novel abstraction refinement process to achieve state-of-the-art performance in solving nonlinear polynomial constraints.



Contract-based methodology for scalable CPS architecture exploration coordinating optimization with decomposition strategies and graph-theoretic, efficient generation of infeasibility certificates to achieve scalability and prune the search space.



Reconfigurable Production Line Case Study: Up to *two orders of magnitude* acceleration with respect to comparable tools.

D. Kirov et al., "Efficient Encodings for Scalable Exploration of Cyber-Physical System Architectures," *TCAD'24*
Y. Xiao et al., "Efficient Exploration of Cyber-Physical System Architectures Using Contracts and Subgraph Isomorphism," *DATE'24*, *Best paper finalist*

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