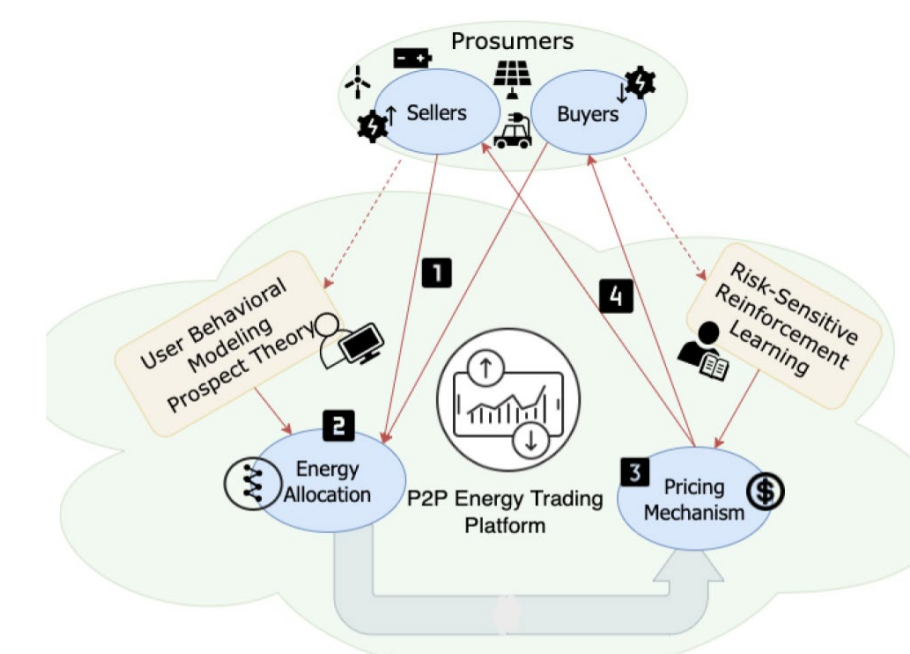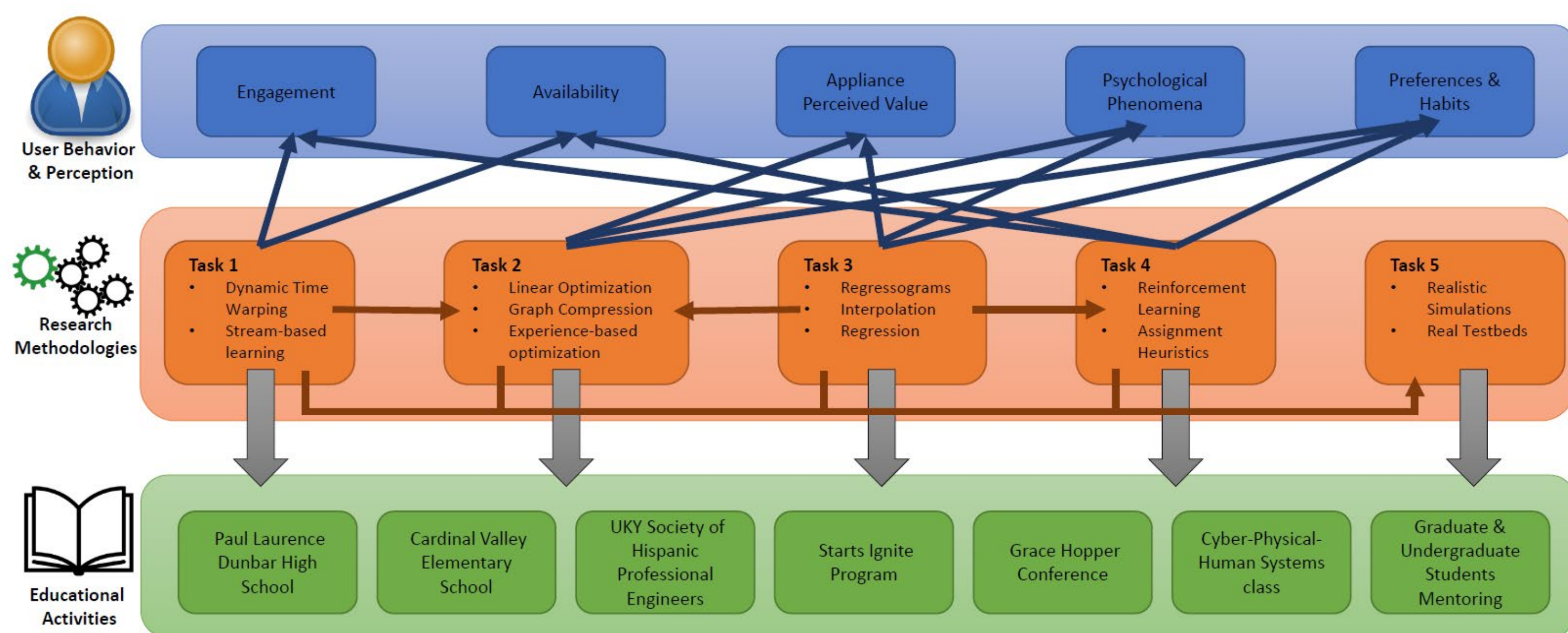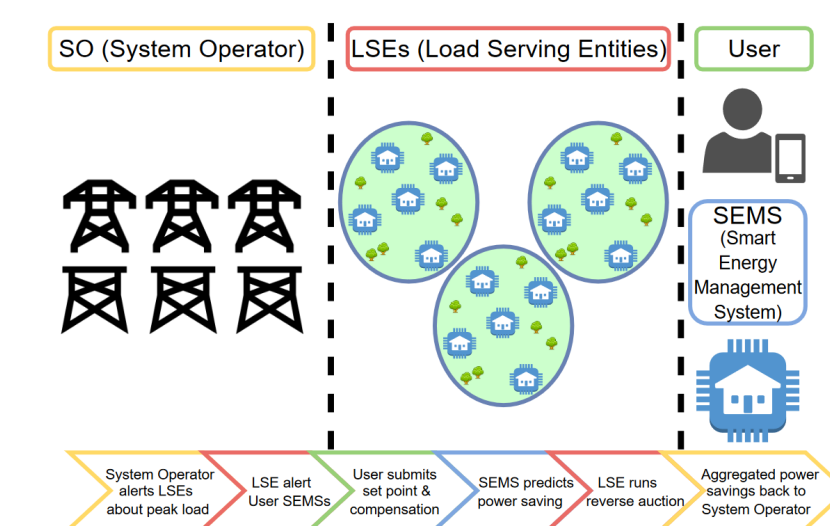# CAREER: Energy Management for Smart Residential Environments through Human-in-the-loop Algorithm Design

PI: Simone Silvestri – University of Kentucky
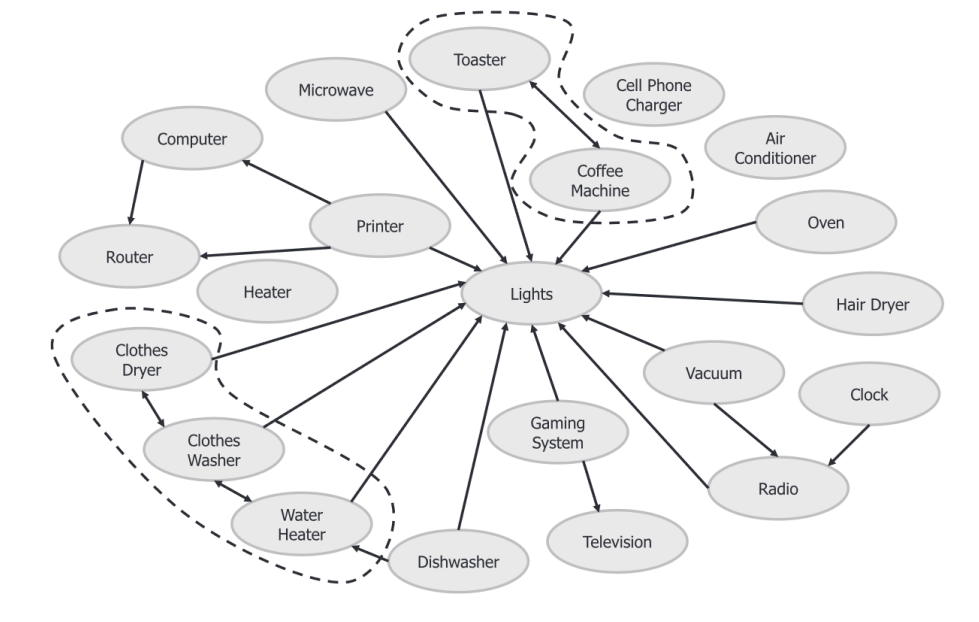
web: silvestri.engr.uky.edu/

P2P Energy Trading

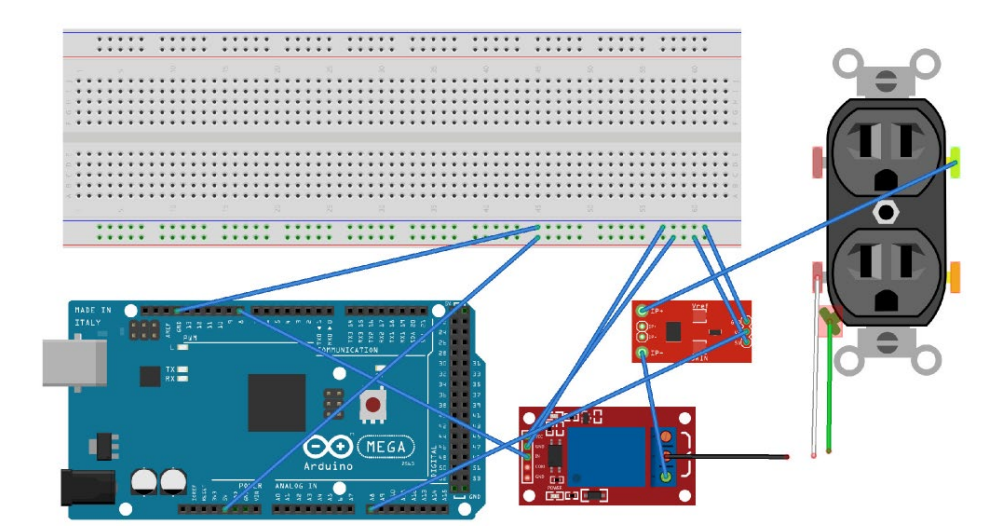Survey: Appliance Dependency

HVAC Power Conservation

Arduino-based Smart Outlet

Challenges:

- Residential energy consumption has been rapidly increasing (e.g., 2.6 trillion KWH in 2015)

- Complexity of human behaviors and perceptions, when interacting with energy management systems, is often overlooked

- Negative attitudes increase energy consumption and may result in abandonment of energy systems

Solutions:

- Algorithms, machine learning models, and optimization techniques that consider user behaviors, perceptions, and psychological processes

- User-Centered Active Learning for Appliance Recognition

- Perceived-Value Optimization of Energy Consumption

- User-participation/perception Aware Energy Sharing Mechanisms

Scientific impact

- Reduce residential energy consumption

- Tools to learn and model human behavior and integrate these models in CPS algorithm design

- Improve the design and optimization of CPS through human in the loop

- Auction based peak-load reduction based on HVAC

- Online surveys to study user preferences and behaviors

- Real testbed in collaborations with Tennessee Valley Authority (TVA) and Louisville Gas and Electric and Kentucky Utilities (LG&E-KU)

Broader Impact & Education

- Paul Laurence Dunbar High School coding challenges and research experience

- Hispanic elementary students through Society of Hispanic Professional Engineers

- Several REUs involved in research and publications

- Two PhD students graduated, one is an Energy Analyst at Cambridge Energy Solutions, the other is a Faculty at Penn State University

- STARS Computing Corps IGNITE Program

Publications

A. Timilsina, S. Silvestri, "P2P Energy Trading through Prospect Theory, Differential Evolution, and Reinforcement Learning" in ACM Transactions on Evolutionary Learning and Optimization, special issue on Evolutionary Reinforcement Learning, Vol. 3, Issue 3, 2023.

R. Alden, A. Timilsina, S. Silvestri, D. Ionel, "V2G Optimization for Dispatchable Residential Load Operation and Minimal Utility Cost" in Proceedings of the IEEE Transportation Electrification Conference & Expo (ITEC), 2023

Codispoti, Jackson and Khamesi, Atieh R. and Penn, Nelson and Silvestri, Simone and Shin, Eura "Learning from Non-Experts: An Interactive and Adaptive Learning Approach for Appliance Recognition in Smart Homes" ACM Transactions on Cyber-Physical Systems , 2022

A. Timilsina, S. Silvestri, "Prospect Theory-inspired Automated P2P Energy Trading with Q-learning-based Dynamic Pricing" in Proceedings of the IEEE Global Communications Conference (GLOBECOM), 2022

Casella, Enrico and Sudduth, Eleanor and Silvestri, Simone "Dissecting the Problem of Individual Home Power Consumption Prediction using Machine Learning" 2022 IEEE International Conference on Smart Computing (SMARTCOMP) , 2022

Timilsina, Ashutosh and Khamesi, Atieh R. and Agate, Vincenzo and Silvestri, Simone "A Reinforcement Learning Approach for User Preference-Aware Energy Sharing Systems" IEEE Transactions on Green Communications and Networking , v.5 , 2021

Khamesi, Atieh R. and Silvestri, Simone and Baker, D. A. and Paola, Alessandra De "Perceived-Value-driven Optimization of Energy Consumption in Smart Homes" ACM Transactions on Internet of Things , v.1 , 2020

Casella, Enrico and Khamesi, Atieh R. and Silvestri, Simone and Baker, D. A. and Das, Sajal K. "HVAC Power Conservation through Reverse Auctions and Machine Learning" 2022 IEEE International Conference on Pervasive Computing and Communications (PerCom) , 2022

Shin, Eura and Khamesi, Atieh R. and Bahr, Zachary and Silvestri, Simone and Baker, D. A. "A User-Centered Active Learning Approach for Appliance Recognition" IEEE International Conference on Smart Computing (SMARTCOMP) , 2020

Khamesi, Atieh R. and Musmeci, Riccardo and Silvestri, Simone and Baker, D. A. "Reproducibility of Survey Results: A New Method to Quantify Similarity of Human Subject Pools" IEEE Global Communications Conference (GLOBECOM) , 2020

Kahemsi, Atieh R. and Silvestri, Simone "Reverse Auction-based Demand Response Program: A Truthful Mutually Beneficial Mechanism" IEEE International Conference on Mobile Ad-Hoc and Smart Systems (MASS) , 2020

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PI: Simone Silvestri, University of Kentucky

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