CPS: Medium: Modular Power Orchestration at the Meso-scale

Submitted by Xuan Zhang on Fri, 01/05/2018 - 11:04am

Project Details

Lead PI:	Xuan Zhang
Co-PI(s):	Christopher Gill Humberto Gonzalez
Performance Period:	09/15/17 - 08/31/21
Institution(s):	Washington University
Sponsor(s):	National Science Foundation
Award Number:	1739643

Abstract: Energy storage and power distribution play an integral part in the engineered systems that play critical roles in people's everyday lives, including transportation, utility, health, and security. In today's cyber-physical platforms, however, the generation, storage, allocation, and distribution of energy among modules is often managed in a haphazard and rigid manner that is fixed at the system design stage. The limitations of existing power management methods are clearly evident in highly-integrated meso-scale systems, which range from mobile devices to large installations such as the International Space Station. The power semantics of these meso-scale systems fall in between those of macro-scale power grids and micro-scale on-chip power management, resulting in a significant solution void. This research project aims to fill that void by establishing an agile, yet resilient, framework to design and manage power distribution and energy storage in cyber-physical systems. The broader impacts of this project will not only transform power delivery capabilities in emerging technologies such as the next generation of electric and hybrid autonomous vehicles, but also enrich inter-disciplinary education by bridging hardware-oriented power electronics design with control, system software, and application development, through curriculum integration and outreach programs. This research will develop a principled approach towards two main goals: modularizing the management of power semantics in meso-scale cyber-physical systems, and orchestrating the power-related system-wide interactions among heterogeneous modules. We begin by introducing an innovative equivalence between the management of power distribution and the optimization of energy packet delivery. This new problem formulation allows us to re-imagine the power architecture by incorporating malleable power modules as smart energy routers, connecting and buffering bidirectional power flows between diverse functional components such as motors, processors, and sensors. This research will develop a novel approach to efficient delivery of energy packets, which will allow reasoning about optimality and trade-offs among power and performance semantics holistically. This project will also establish a new intelligent coordination framework based on formal methods, for off-line generation of on-line interfaces among power modules, aiming to orchestrate exchanges of power among modules at a full-system level, even in the face of variability and model uncertainty. This modular power flow orchestration framework is a step towards a theory of modular smart ubiquitous cyber-physical devices, empowering a paradigm shift in how next-generation systems with new semantic objectives such as long-term sustainable autonomy can be built.

Attachment	Taxonomy	Kind	Size	
CPS: Medium: Modular Power Orchestration at the Meso-scale	Washington University St Louis CPS-PI Meeting 2017 Poster 1739643 Posters (Sessions 8 & 13)	PDF document	1.18 MB	Download Preview

Related Artifacts

Presentations

- Modular Power Orchestration at the Meso-scale | Download

Posters

- Modular Power Orchestration at the Meso-scale | Download
- CPS: Medium: Modular Power Orchestration at the Meso-scale | Download

Publications

- Ivory: Early-Stage Design Space Exploration Tool for Integrated Voltage Regulators

---