CPS: Synergy: Declarative Computing as Unified Platform for Three Components of Cyber-Physical Systems

Overview:

The August 2007 Report of the President's Council of Advisors on Science and Technology recognized the utmost importance and urgency of cyber physical systems (CPS) for US industrial competitiveness and hence designated CPS as one of the top priorities for federal research investment. A CPS is usually made of three components.

- Sensing unit in physical subsystems or physical environment
- Actuator unit that physically alter or interact with the subsystems
- Control unit that bridges sensing units and actuator units

In current CPS community, there is a keen need for a unified model to tie all these three components together, not physically, not in circuit, but through common abstraction, common design tool and/or techniques, common mathematical framework and foundation, such that critical requirements for CPS, including time constraints, adaptability, autonomy, efficiency, functionality, reliability, safety, and usability, etc., could be quantitatively and qualitatively modeled, measured, analyzed, and simulated.

We propose the declarative computing as the unifying substrate over which all three components are tightly coupled and can be modeled, analyzed, and reasoned quantitatively. Declarative networking has been proved to be effective approach to design, analyze, and code wireless sensor networks, which is the most common form of CPS sensing subsystem, and wireless actuator networks are, which is the most common form of CPS actuating subsystem. Furthermore, the declarative control has been successfully used in automatic control society for decades. Some of our students have simulated declarative sensor network via simulation.

Right now, we need a sample CPS application which has all these components of CPS, and better falls into one of three identified application domains of CPS: energy, transportation, and health care. Similar to sensor networks, robotics is another traditional tool technique in CPS. Several proposals on robot in medical fields have been funded by NSF CPS programs. If you could identify a similar application, we can write this proposal targeting the December 2015 submission. It will be a Synergy type with budget up to one million.