CPS: Medium: Timing-Centric Software

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The objective of this research is to define programming abstractions with temporal semantics for distributed cyber-physical systems. The approach is to create a coordination language for distributed embedded software that blends naturally with models of physical dynamics. The coordination language is a visual modeling language that is based on a rigorous discrete-event concurrent model of computation. The language will be used by system designers to construct models from which software implementations are synthesized via code generation. A small footprint runtime microkernel called PtidyOS is linked with the generated code to provide executable images that run on embedded processors. A program analysis framework capable of handling the concurrency in the model is being developed to accurately predict timing of program components and perform schedulability analysis. The objective is distributed software that, if it compiles for a platform, delivers precisely the temporal semantics specified in the model.

Intellectual merit: This project addresses the core abstractions of computing, which throughout the 20th century, have abstracted away time, and of physical dynamics, which have omitted software and network behaviors. For cyber-physical systems, both are inappropriate. This project will give new time-centric abstractions for software, programming models, analysis techniques, and integration of software and network models with physical dynamics.

Broader impacts: Besides the considerable economic and societal impact of CPS in general, the project will have considerable impact on engineering and computer science education. Its focus on engineering applications and on sound computer science methods will erode the boundaries between these disciplines that hamper competitiveness of our students. A generation of students will go on to dramatically improve our energy efficiency, manufacturing capabilities, transportation efficiency, instrumentation prowess (and hence, scientific knowledge), and infrastructure robustness. Because of the broad societal implications of the work, it will help attract to engineering and computer science a more diverse talent pool.