Software Engineering Institute | Carnegie Mellon

Cyber-Physical and Ultra-Large Scale Systems

Software Solutions Division

Scope of the Research

The design and analysis principles that govern smaller scale system behavior are necessary but not sufficient for larger scale systems. This is true because larger scale does not simply mean "lots of X" or "large along dimension Y." The notion of scale is subtle and multifaceted.

Cyber-physical systems (CPSs) are a natural consequence of the increased connectedness and autonomy of real-time embedded systems. Like real-time embedded systems, CPSs are characterized by a high degree of coupling between computations and physical processes. Because of this coupling safety and timeliness properties, among others, are critical. *However, increased distribution and scale make it much harder to guarantee such properties.*

Ultra-large-scale (ULS) systems are interdependent webs of software-intensive systems, people, policies, cultures, and economics. They are characterized by decentralization; inherently conflicting, unpredictable, and diverse requirements; continuous evolution and deployment; heterogeneous, inconsistent, and changing elements; erosion of the people/system boundary; and routine failures. *Despite such challenging characteristics, ULS systems must reliably demonstrate desirable behavior.*

The ULS systems notion has inspired us to ask new questions about software-reliant systems:

- What new quality attributes arise due to scale?
- What types of analyses are required to understand and design (at all levels) systems at scale?
- Are new architecture design principles needed?
- And generally, what new strategies are needed to control, predict, and bound the behavior of systems at scale?

The Cyber-Physical and ULS Systems (CP/ULS) Initiative strives to answer these questions and to develop principles and technology to understand, control, and bound the behavior of systems that exhibit characteristics of ULS systems. Specifically, we focus on cyber-physical systems and socio-adaptive systems.

How We Can Help

The CP-ULS team helps organizations to

- apply formal verification techniques and tools to assure critical system properties
- apply real-time analysis techniques to determine if critical system timing properties will be satisfied
- provide design and implementation guidance for real-time, cyber-physical systems

Related Web Sites

www.sei.cmu.edu/cyber-physical/
www.sei.cmu.edu/uls

For More Information

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