Compositional Scheduling of Real-Time Embedded Systems

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CSF Theory
Compositional Scheduling Framework

Motivation

- Real-time embedded systems (RTS) are large-scale, complex and resource-constrained
- Existing component-based design frameworks cannot provide timing guarantees

Goals

- Develop compositional scheduling theory to support
  - Efficient compositional analysis of timing/resource properties
  - Safe and cost-effective component-based design

Approach & Results
Compositional Scheduling Framework (CSF)

Resource-aware Interfaces
- Abstract timing requirements of components into interfaces based on scheduling theory
- Efficient interface generation and composition
- Preserve optimality, schedulability, and compositionality

CARTS Tool
Tool Support for CSF Analysis

Motivation

Challenges
- Lack of system supports for CSF theory
- Virtualization enables integration of legacy systems, but cannot provide temporal isolation and real-time guarantees

Features & Supports
Features
- Editor for demand-supply XML files
- Tree representation of components and tasks
- Editing components/tasks in the tree
- Open architecture
- Extendable

Supports
- Task models
  - Periodic tasks, with jitter, offset, or resource sharing
- Interfaces
  - Periodic resource model
  - Explicit deadline periodic (EDP) resource model
  - Scheduling policies
    - DM, RM, EDF

Features
- Workload
- Resource Interface

Software Architecture

Approach & Results
Real-Time Xen

CSF Implementation using Virtualization

Motivation

Challenges
- Confederation of CSF and virtualization to provide
  - Architecture platform supports for CSF
  - Real-time guarantees in virtualization platforms

Features & Supports
Open source: http://rtg.cis.upenn.edu/carts

Periodic Server Design
- Purely Time-driven Periodic Server (PTPS)
  - If currently scheduled domain is idle, its budget is wasted
- Work-Conserving Periodic Server (WCPS)
  - If currently scheduled domain is idle, a non-idle lower priority domain is executed
- Capacity Reclaiming Periodic Server (CRPS)
  - If currently scheduled domain is idle, this idled budget is re-assigned to any other non-idle domain

ARINC-653 Case Study

Collaborators: Sisu Xi, Chris Gill, Chenyang Lu (Washington U)

Website: http://rtg.cis.upenn.edu/rtComp.php3

Collaborators: Insik Shin (KAIST), Arvind Easwaran (Honeywell)

Website: http://rtg.cis.upenn.edu/rtComp.php3

Website: https://sites.google.com/site/realtimexen