Industrial Collaboration: Automotive Electronics

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Automotive Collaborations

- **General Motors (ASV)**
  - Architecture Exploration Using Metropolis
  - FlexRay Scheduling
  - Cost Metrics
- **Toyota (K. Hedrick, E. Lee)**
  - Cold Start Engine Controller
- **Pirelli (ASV)**
  - Smart Tire
- **Daimler-Chrysler (all)**
  - Embedded Software design
Electronics, Controls & Software is shifting the basis of competition in vehicles.

- More functions & features
- Less hardware
- Faster

Potential inflection point. Now!

Value from Electronics & Software
- More functions & features
- Less hardware
- Faster

Vehicle Integration

Subsystem Controls & Features

Forefront of Innovation

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Chess Review, Nov. 21, 2005
Metro: Separation of Concerns

IPs

- Analysis
- Specification
- Implementation

Development Process

Behavior Components

- C-Code
- Matlab
- ASCET

Virtual Architectural Components

- CPUs
- Buses
- Operating Systems

System Behavior

System Architecture

Mapping

Performance Analysis

Refinement

Evaluation of Architectural and Partitioning Alternatives

Metro: Separation of Concerns

"Automotive Electronics", ASV

Chess Review, Nov. 21, 2005
Architecture Model: Abstraction Levels

SwTask 1  ……  SwTask i

Middleware

OSEK RTOS/ CPU

CAN Driver

CAN Controller

(To CAN Bus)

Interrupt Handler

Cpu/Rtos Medium

OSEK RTOS Scheduler

(From Middleware)

(Interrupt requests from devices)

(To CAN Driver)

CAN Driver Sender

CAN Driver Receiver

(To Middleware)

CAN Driver Medium

(To CAN Controller)

(From CAN Driver)

Send

Receive

(To CAN Bus)

Bus Sender

Bus Receiver

(To CAN Bus)

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Matching Models of Computation

- The functional and architectural models should be described using the same model of computation
- **Architecture Characteristics:**
  - Network of processes connected by point-to-point FIFOs
  - Non-blocking reads and writes
  - Messages may be lost or duplicated within FIFO
- **Functional Model**
  - Functional blocks operate concurrently
    - Single rate
    - No synchronization across processes
  - Non-blocking read, non-blocking write communication semantics
- **Mapping: intersection of behaviors**
  - Before mapping, nondeterministic loss and/or duplication of messages in functional model
  - After mapping, functional loss/duplication follows architecture
Results

- **Functional Model**
  - 14 functional processes
  - 48 signals

- **CAN controller configurations:**
  - Number of send buffers

- **Metric**
  - Message End-to-end Latency

- With 1 send buffer:
  1. Priority inversion: Message 7 < Message 1~6
  2. Average message latency = 4.936ms

- With 2 send buffers:
  1. No priority inversion
  2. Average message latency = 4.165ms
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Project Background and Motivation

- GM has decided to choose FlexRay as the future communication system.

- Importance of deciding the Communication Cycle Length, Slot Size, and Slot Order in the FlexRay based system design.

- There is currently no technique to determine these parameters for FlexRay.

- Scheduling is currently done manually in GM, which is time consuming and error prone.

- Need an incremental scheduling tool for FlexRay system which supports any form of automated bus/task schedule.
Comparison for scheduling

In Traditional Schedule:
Incremental changes impossible without full rescheduling

In Optimized Schedule:
A lot more porosity to accommodate new tasks and messages

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Scheduling Tool Framework

FlexRay communication
System design tool
-Graphical Design Front End

convert

AETM-DB1
(XML)

Gant Graph Scheduling
Result Display

Back-annotate

AETM-DB
(XML)

Internal Data Structure

Scheduling Engine

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Toyota: Coldstart Engine Controller Design
(C. Zavala and K. Hedrick)

• Objectives:
  – Minimize the HC emissions of cold-start
  – Reduce design-to-implementation controller cycle time.

• Challenges
  – Sensors not active, poor combustion, keep development cost low.

• Strategies
  – Design of AFR and HC observers, use of design of automated tools, use of modern controller design techniques

Experimental facilities

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Transmission Control

Goal:
- Improve drivability and fuel efficiency by automotive control.

Approach:
- Utilize dynamical model-based analysis and controller design.

Control Strategy:
- Multi-tiered approach to achieve shock-free gear shifting by smooth gear shifting control with engine/AT collaboration balancing between fuel economy & performance by optimal shift pattern scheduling.

Prospected control structure for intelligent shifting

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Hybrid Systems Modeling

Objectives

- **Hybrid System Analysis**: study of a general semantics for simulator engines to execute hybrid system models.

- **Study of representations of discontinuities and interactions** between continuous-time dynamics and simultaneous discrete events.

- **The code generation project aims** to produce application code automatically from graphical models in Ptolemy II.

If an outgoing guard is true upon entering a state because of the triggering semantics of transitions, the time spent in that state is identically zero. This state is called a "transient state."