Industrial Collaboration: Automotive Electronics

Edited and presented by
Alberto Sangiovanni-Vincentelli
UC Berkeley

Chess Review
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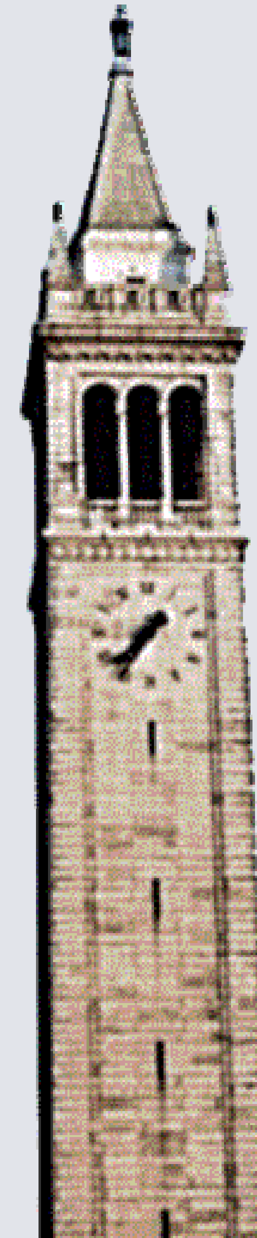
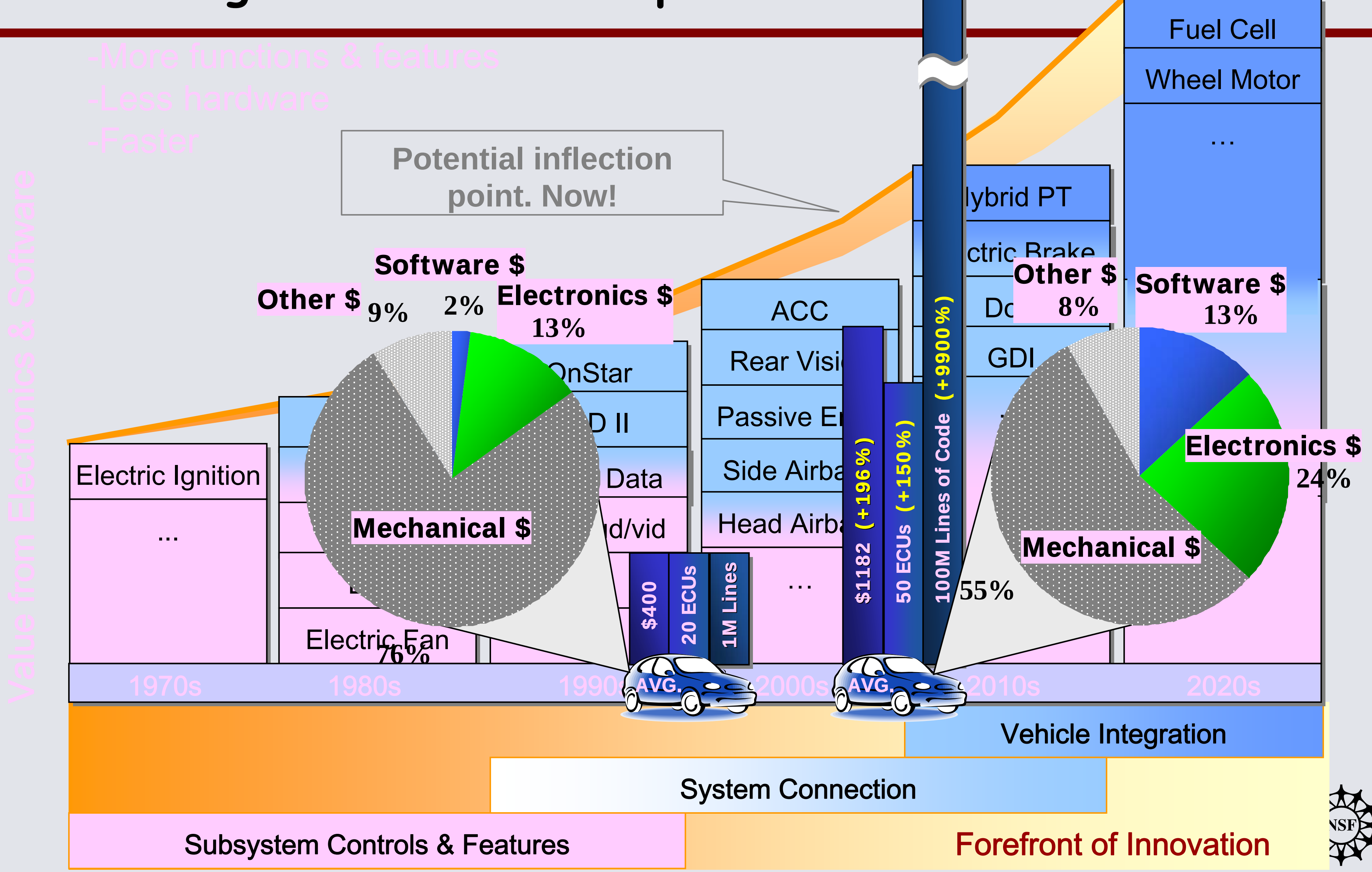


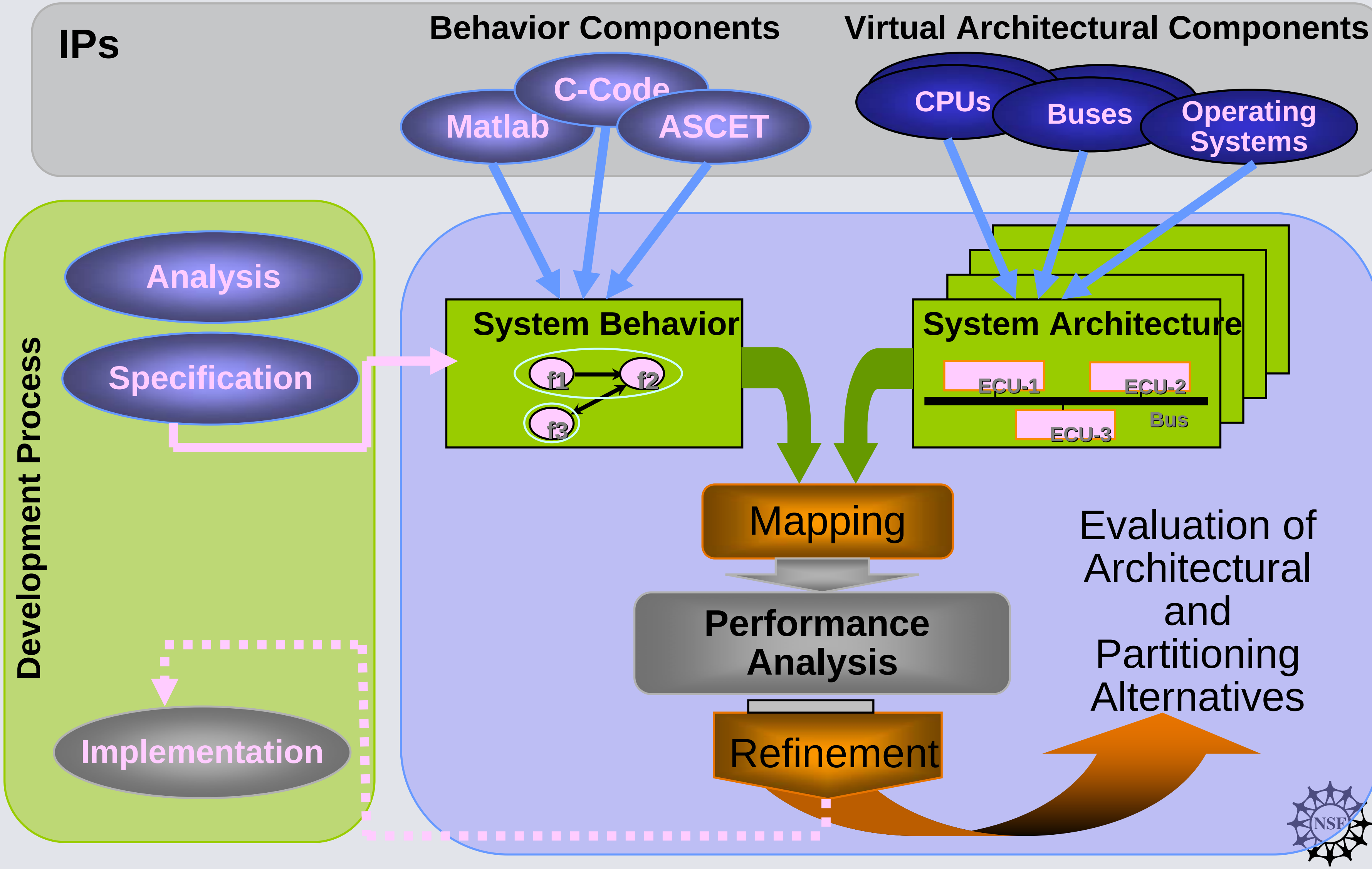
Automotive Collaborations

- 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

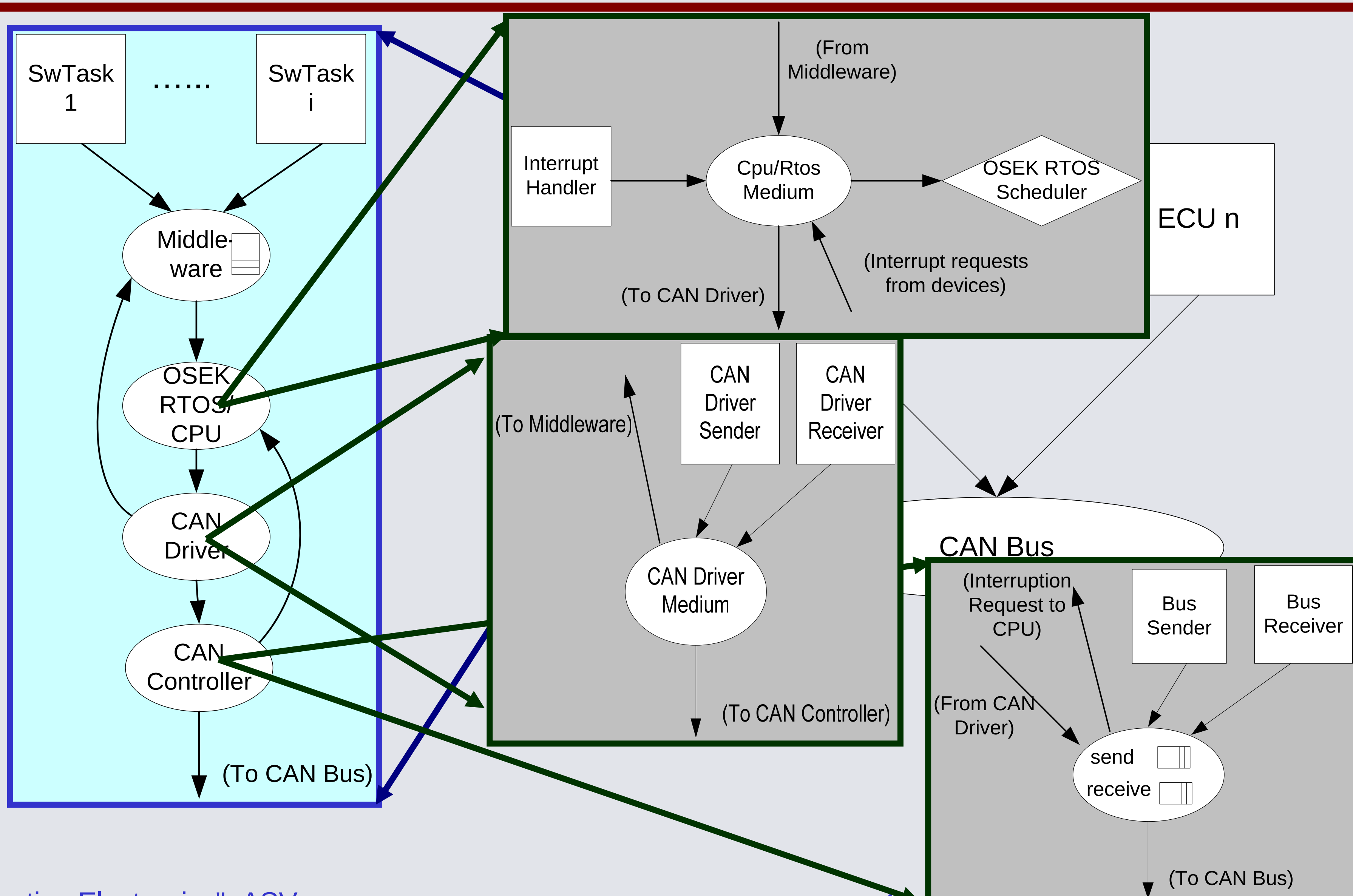
Electronics, Controls & Software is shifting the basis of competition in vehicles



Metro: Separation of Concerns

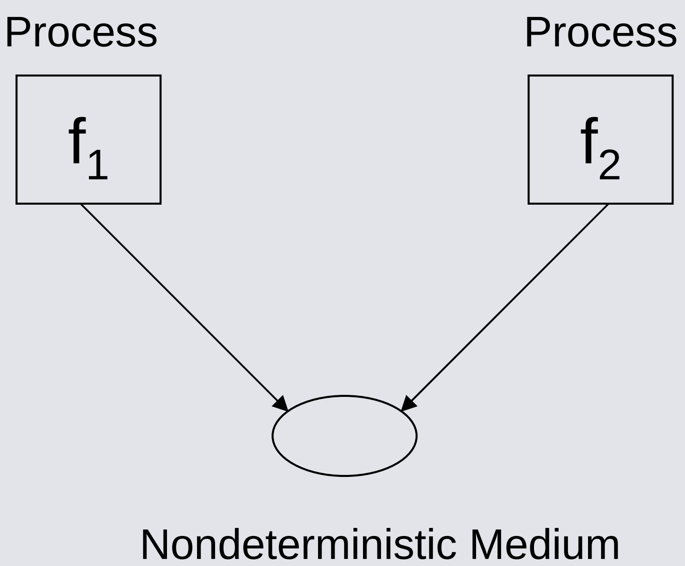


Architecture Model: Abstraction Levels



Matching Models of Computation

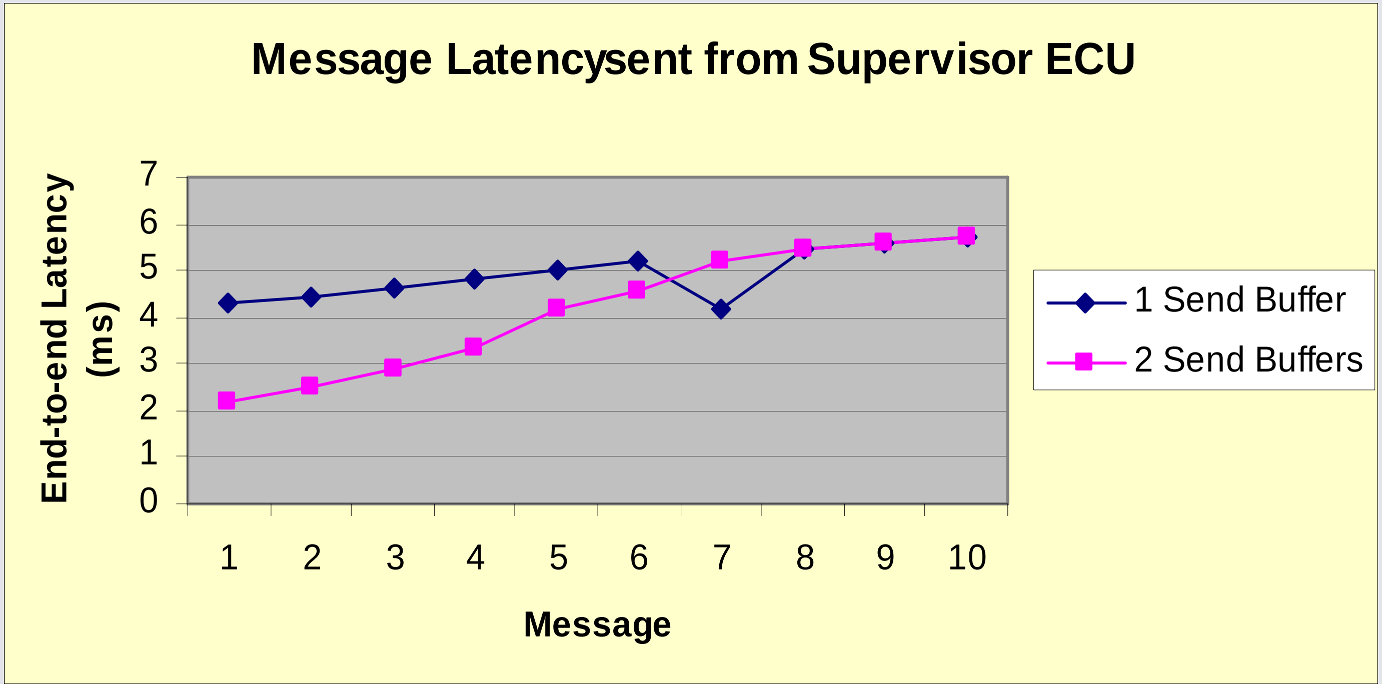
- The functional and architectural models should be described using the same model of computation
- Architecture Characteristics:
  - Network of processes connected by point-to-point FIFOs
  - Non-blocking reads and writes
  - Messages may be lost or duplicated within FIFO
- Functional Model
  - Functional 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



Functional Model

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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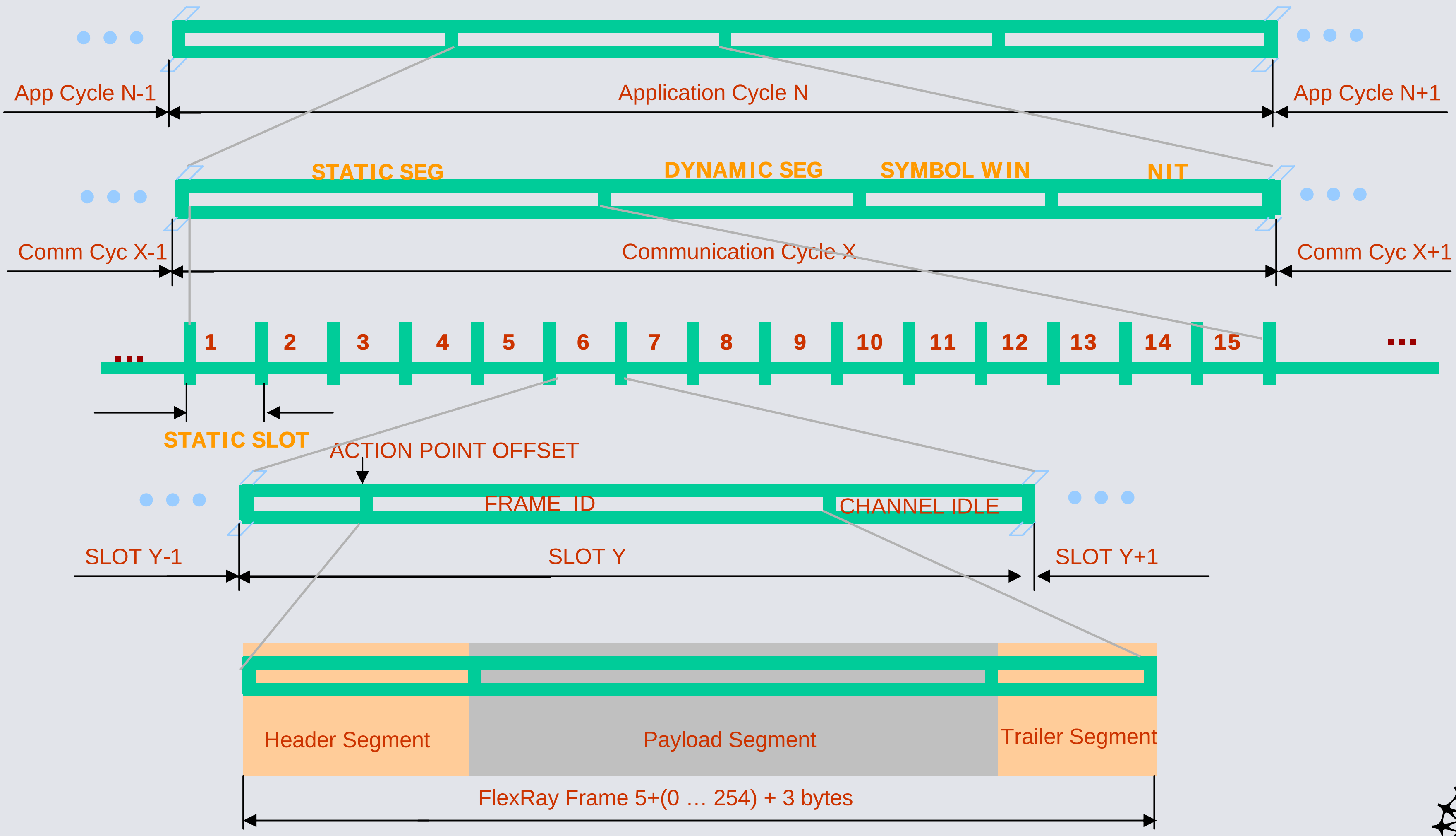
Project Background and Motivation

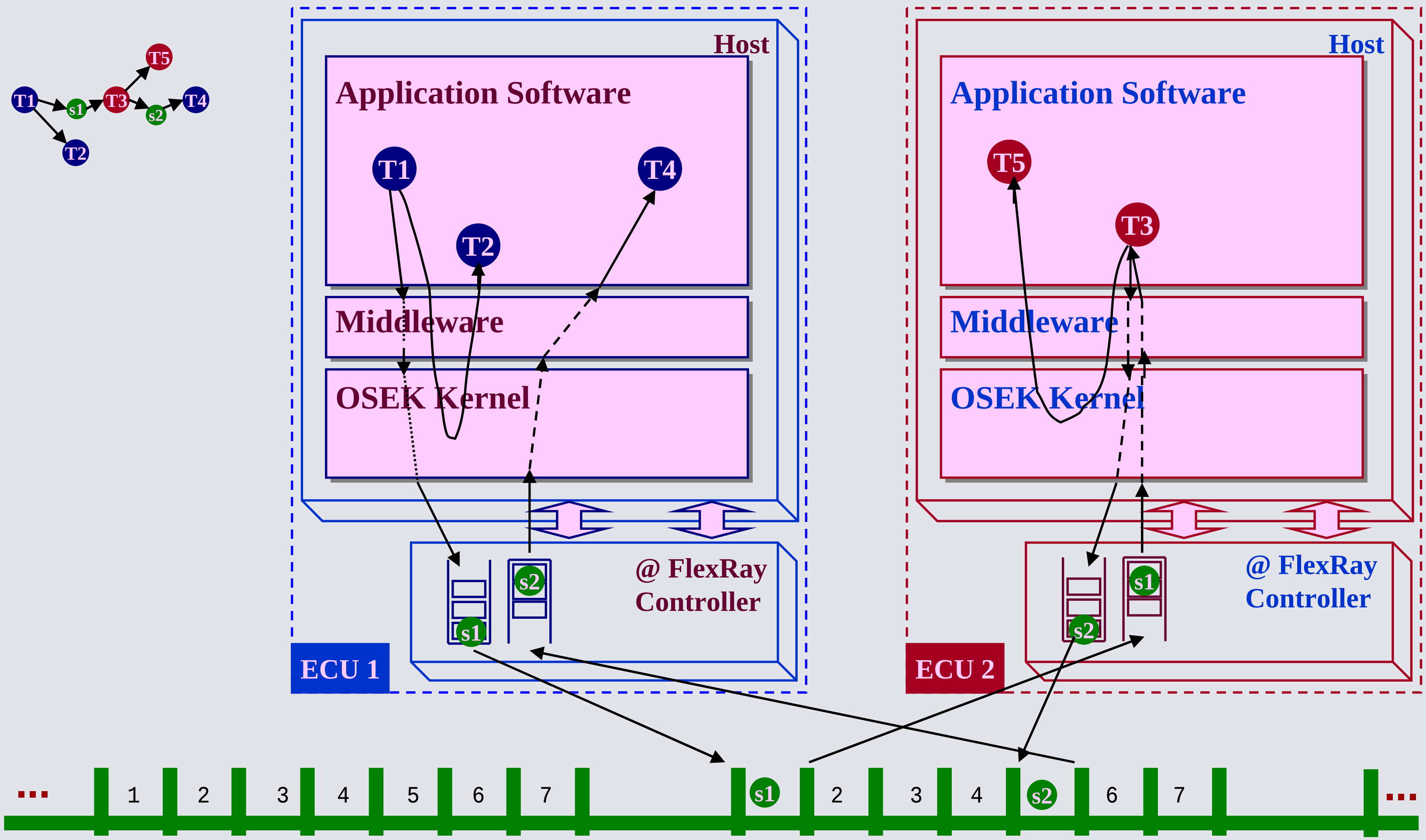
- GM has decided to choose FlexRay as the future communication system
- Importance of deciding the Communication Cycle Length, Slot Size and Slot Order in the FlexRay based system design.
- There is currently no technique to determine these parameters for FlexRay.
- Scheduling is currently done manually 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

FlexRay Timing Hierarchy

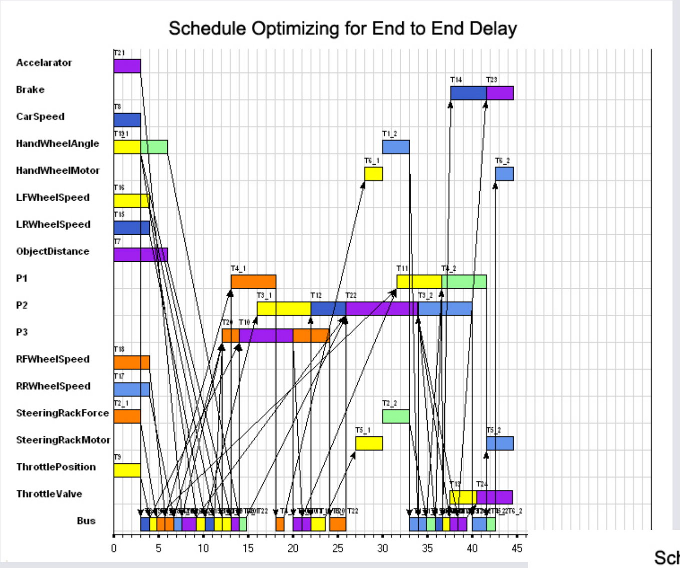


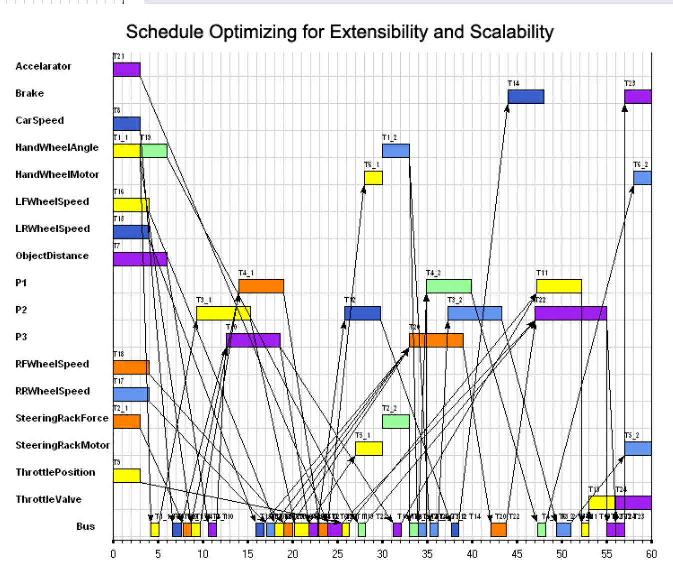
Source: FlexRay Specification 2.1

FlexRay Message Passing Mechanism



Comparison for scheduling





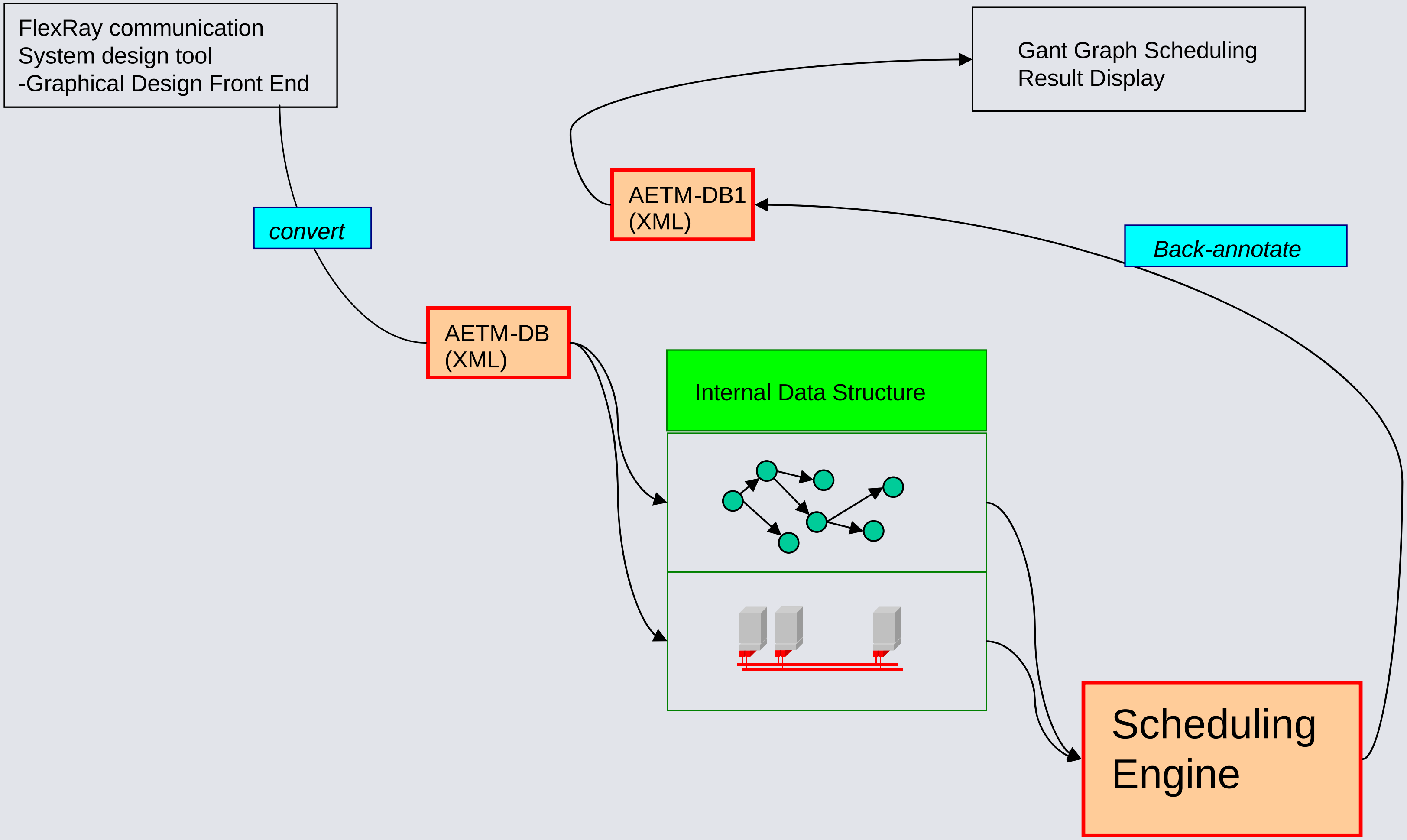
In Traditional Schedule:

Incremental changes impossible without full rescheduling

In Optimized Schedule:

A lot more porosity to accommodate new tasks and messages

Scheduling Tool Framework



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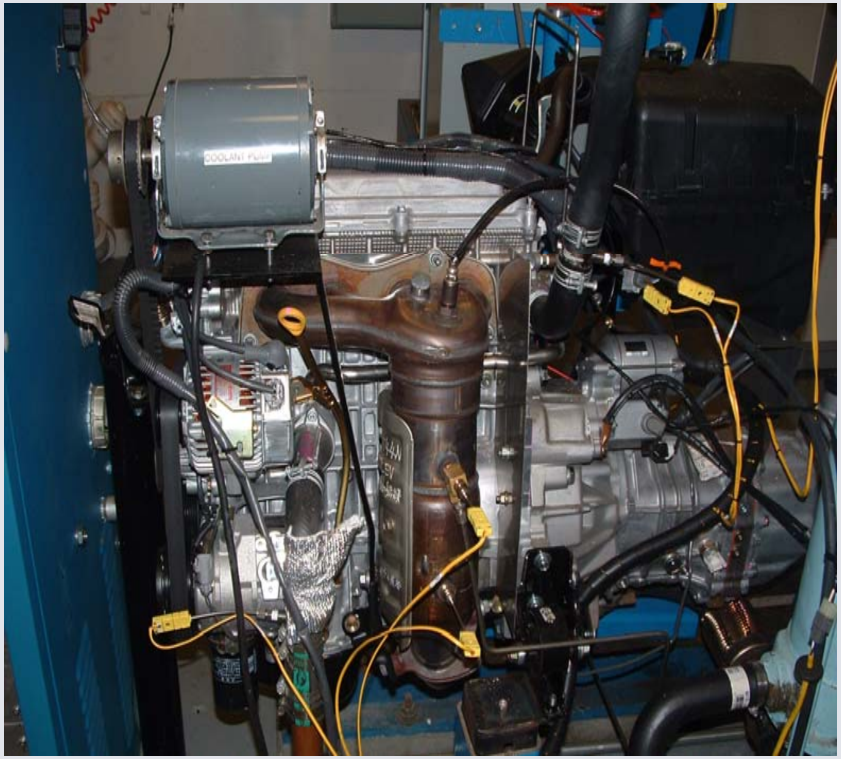
Toyota: Coldstart Engine Controller Design
(C. Zavala and K. Hedrick)

- 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

Transmission Control

Goal:

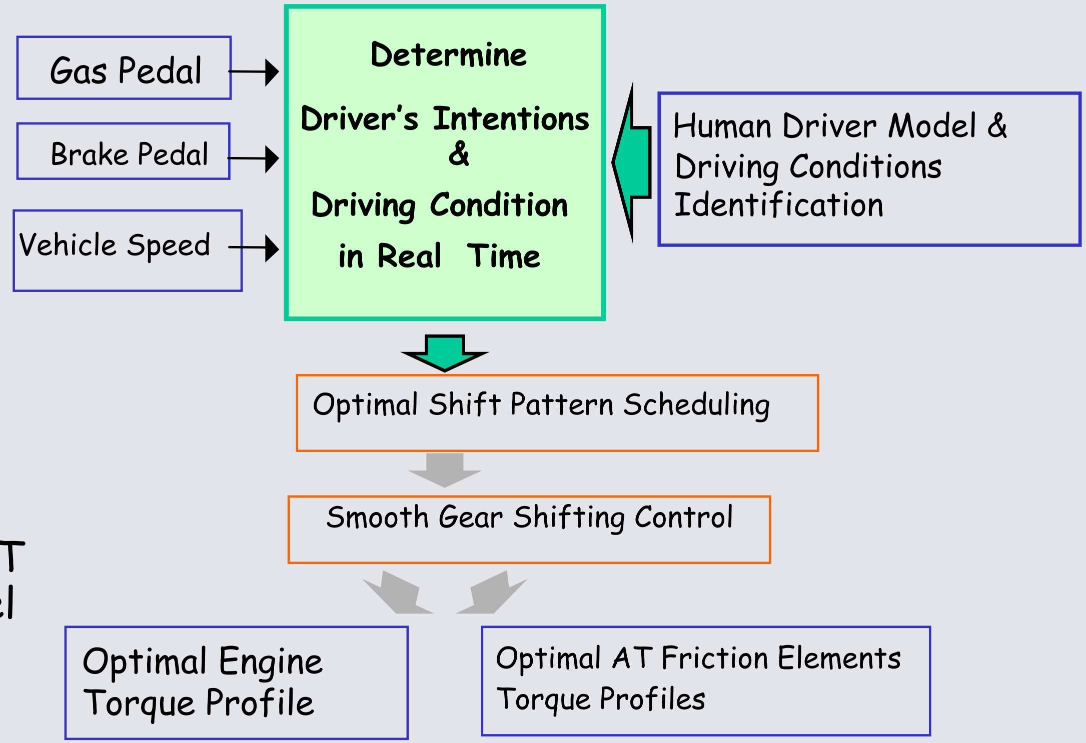
- Improve drivability and fuel efficiency by automotive control.

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

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