Hardware Virtualization for Pre-Silicon Software Development in Automotive Electronics

Frank Schirrmeister, Filip Thoen
fschirr@synopsys.com
Synopsys, Inc.
Market Trends & Challenges

Growing electronics content & complexity
- Multi-node, networked ECU architecture typical
  - Complex intra-ECU behavior & inter-ECU interaction
  - Meeting quality & reliability requires analysis & diagnosis of complex hardware/software problems
- Dramatic increase in software content & complexity
  - 40% of vehicle cost is attributed to electronics & software cost
  - 50-70% of ECU development cost is due to software

Need to reduce design cycle times & cost
- While satisfying global regulations on passenger safety, emissions & fuel economy
- While guaranteeing high quality & reliability

Software & hardware are focused on reliability & quality
- Both for safety-critical functionality and to control warranty costs

Competitive OEM market, complex dynamic of cost & reliability
- Compete heavily in terms of safety, fuel efficiency & new features
- But at competitive cost & with high reliability!
Growing Complexity in Car Software

Source: BMW

Source: Toyota
#1 Automotive Challenges
Cost Reduction & Supply Chain Collaboration

**Cost Reduction** cited as #1 challenge facing the Automotive Design and Engineering Community (32% of users)!

Source: Dupont, 2008

53% of users think an increase in **collaboration** across the value and supply chain is needed to strengthen the automotive industry!

Source: Dupont, 2008
HW/SW Challenge #1: Late Bugs

Relative costs to repair embedded software defects by development phase
HW/ SW Challenge #2: Late Start

Software has to wait for hardware => Semi cannot sell silicon and bugs are found late
Virtual Platform Example
Fast Transaction-level Models - Technology Details

- User Interface Emulation
- Emulation of system I/O
- High-speed (SystemC™)

Comprehensive virtual platform featuring:
- Cockpit
- Peripheral Models
- Device Board(s)
- Virtual I/O
- Mem
- CPU Model
- Bus Model
- Simulation Infrastructure
- Transaction-level Interfaces
- Graphical Hardware Models
- Fast Instruction-set Simulators
- Emulation of system I/O
- Sensor(s)
- Actuator(s)
- User Interface Emulation
Virtual Platform Demo
ECU in Innovator

ECU in Innovator
Software Debugger
Module Authoring
Module Authoring
Electronics in the Car
A Distributed Embedded System

Today: More than 80 microprocessors and millions of lines of code!

Transaction-level Modeling Abstraction Levels
What Synopsys offers in TLM space

- 80+ MIPS: Application Development
- 40-60 MIPS: Pre-silicon Software Development & Integration
- 1-10 MIPS: Architectural Exploration & Real-Time SW Development (Profiling)
- 1-100 KIPS: System Verification & Timing Validation

- Functionally Accurate: App View TLM (AV)
- Cycle Approximate: Prog. View TLM (PV)
- Cycle Accurate: PV with Timing TLM (PVT)

Speed

- Automotive Area:
  - Information Systems
  - Body Functions
  - Body Electronics

Accuracy

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Modeling Styles

Use cases
- Software development
- Software performance
- Architectural analysis
- Hardware verification

TLM-2 Coding styles
- Loosely-timed
- Approximately-timed

Mechanisms
- Blocking interface
- DMI
- Quantum
- Sockets
- Generic payload
- Phases
- Non-blocking interface
Loosely Timed Synchronization
Approximately Timed Synchronization

- Process 1
- Process 2
- Process 3

Annotated delays

Timeline:
- 0
- 10
- 20
- 30
- 40
- 50
The Automotive Supply Chain

Companies

Software IP / Software Suppliers

Independent Software Developers:

Operating Systems: WindRiver, Linux, ecos, Itron
Development Tools: WindRiver, Lauterbach, Greenhills, Etas, DSpace

Hardware IP

Processors: ARM, MIPS, PPC, X86, Tensilica, ARC, MeP, CEVA
Interconnect: Arteris, Sonics, Silistix
Peripherals: Synopsys, Denali

Semiconductor

ST
Freescale
Infineon
...

Subsystem Suppliers

Bosch
Continental
Magneti Marelli
Denso
Delphi
Visteon

System Integrators

BMW
Toyota
Honda
GM
Chrysler
Ford

Users

Processor & Subsystem & IP Developer

Hardware Developers
Programmers
Value Proposition:
Design Cycle Reduction

- **Software IP / Software Suppliers**
  - Validate architecture(s) & select semi supplier
  - ECU software

- **Subsystem Suppliers**
  - Software integration
  - Software development

- **Semiconductor**
  - Device drivers,
  - OS

- **Hardware IP**
  - Device drivers,
  - OS

- **Companies**

- **System Integrators**
  - Software integration
  - Software development

- **Part Design**
  - Proto

- **System Design**
  - Bench / Proto

- **Virtual Platform**

- **Firmware**
  - Drivers

- **Drivers**
  - System SW

- **Testing**

**Value Proposition:**

- **Reduced design cycle**
- **Develop SW early, find issues early**
The Automotive Supply Chain
Concerns, Responsibilities, Value of Virtual Platforms

Actual Platform usage (wireless example)

Virtual Platforms as Collaboration Tool

Software IP / Software Suppliers

- Device drivers, OS
- Validate architecture(s) & elect semi supplier
- ECU software

Companies

Hardware IP

Semiconductor

Subsystem Suppliers

System Integrators

- Software integration
- Software development

Companies

Software Responsibility

Semiconductor

- Device drivers, OS

Subsystem Suppliers

- Validate architecture(s) & elect semi supplier
- ECU software

System Integrators

Software Responsibility

Virtual Platforms as Collaboration Tool

Actual Platform usage (wireless example)
Value Proposition:
Design Cycle Reduction

Virtual Platforms as Collaboration Tool

Actual Platform usage (wireless example)
Value Proposition:
Higher Quality & Reliability, Lower Cost

Companies

Technical Concerns
- Architecture analysis
- Feature definition, get designed in by semiconductor house

Software Responsibility
- Early supplier feedback
- Architecture trade-offs

Virtual Platform Value
- Device drivers,
  - OS

Hardware IP
- Architecture analysis
- Feature definition, get designed in by semiconductor house

Semiconductor
- Early supplier feedback
- Improve software productivity
  - Architecture trade-offs

Subsystem Suppliers
- Reduce cycle time
  - Improve quality
    - More time to test
    - Systematic test methodology
  - Improve software productivity
  - Reduce cost
    - Less bench time
    - Reduce need for prototype

Software IP / Software Suppliers
- Architecture analysis
- Feature definition, to get designed in by parts suppliers

- Software development productivity
- Quality & reliability

- Validate architecture(s)
- ECU software
- Software integration
- Some: Proprietary OS plus all development

System Integrators
- Early access
- Reduce cycle time
- Improve quality
  - More time to test
  - Systematic test methodology
- Improve software productivity
- Reduce cost
  - Less bench time
  - Reduce need for prototype

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Summary
Virtual Platforms Address Automotive Challenges

Model-based design for software development
- “Front load” the design & reduce cycle time
- Foster supply chain collaboration
- Higher quality & reliability, lower cost

Synopsys offers tools, libraries & services to enable virtual platforms