
EEL 4783: Hardware/Software Co-design with FPGAs

Lecture 1: Introduction*

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* Partial material taken from NSU CS4722 slides

Overview

- What is an embedded system?
- Why HW/SW Co-design?
- Why take this course?
- Class mechanics
 - Administrative issues
 - Lecture topics
 - Assignment and projects

What is an Embedded System?

- ES from 10,000 Feet Above
 - a computer system designed for specific control functions within a larger system
 - often with real-time computing constraints
 - embedded as part of a complete device often including hardware and mechanical parts
- By contrast, a general-purpose computer
 - designed to be flexible and to meet a wide range of end-user needs

Embedded Computing Systems

- Obvious examples:
 - HDTV
 - Washing Machines
 - Microwave
 - Controllers for other household devices such as A/C
 - Digital watches
 - MP3 players
- Not-so-obvious examples:
 - Automobiles
 - Avionics / Flight control
 - Nuclear Power Plants
 - Medical devices

In-Depth Example: Mobile phones

- Multiprocessor
 - 8-bit/32-bit for UI
 - DSP for signals
 - 32-bit in IR port
 - 32-bit in Bluetooth
- 8-100 MB of memory
- All custom chips
- Power consumption & battery life depends on software



But ...

- Dual-core A5 chip
 - package on package (PoP) system-on-a-chip (SoC)
 - 45 nm Dual core GPU PowerVR SGX543MP2 clocked at 200 MHz
- 8MP camera and optics
- IOS 5 and iCloud
- Siri



In-Depth Example: Cars

- Multiple processors
 - Upto100
 - Networked
- Multiple networks
 - Body
 - Engine
 - Telematics
 - Media
 - Safety



Cars

- Function diversity
 - ABS: Anti-lock braking systems
 - Airbags
 - Efficient automatic gearboxes
 - Theft prevention with smart keys
 - Blind-angle alert systems
- Device diversity
 - 8-bit – door locks, lights, etc.
 - 16-bit – most functions
 - 32-bit – engine control, airbags

Little-Known Facts about Cars

- Car electronics is an increasingly important market, requiring new design flows
 - Software is important for value addition
- Comments by major manufacturers
 - Daimler Chrysler: More than 90% of the innovation is from the car electronics (and not from the mechanical parts!)
 - BMW: More than 30% of the manufacturing cost of a car is from the electronic components !
- Reliable/robust ES design flows needed !

ES Design Challenges

- Real-time and/or Reactive
 - Often combines hard and soft real-time
 - Timing constraints on the response
- Low power budget
 - Novel architectures etc.
- High code density
 - Aggressive Code compression possible
- Profile driven development all important

Hardware/Software Design Methodology

- System Modeling
 - Irrespective of which parts are implemented in hardware and which parts in software
 - various choices of Models of Computation for reactive real-time systems
- HW/SW Partitioning
 - HW: Can be reconfigurable (FPGA)
 - Soft core or hard core
 - Function blocks
 - SW: Run on micro-controllers or more complex processors.
 - Further allocation needed if multiple processing elements (PEs) are available.

Hardware/Software Design Methodology

- Compute Scheduling
 - After allocation of tasks to PEs
 - Determines order in which tasks allocated to the same PE will be invoked so that
 - Performance constraints (deadlines) are met
 - Any dependencies between tasks are preserved
 - Communication/context-switch overheads in execution are minimized if possible
- Communication synthesis
 - Simple: Replace shared var. names by appropriate locations
 - Complex: Design interfaces to enable communication among design components

Why This Course?

- Because it is FUN intellectually!
- Because HS-Codesign become increasingly more critical



Aerospace/Defense



Industrial/Scientific/
Medical



Broadcast



Wired communication



Consumer



Wireless communication



HPC and storage



Automobile

Class goal

- Learn about basic concept and techniques of hardware/software co-design, ...
- Hands-on class projects
 - Complete FPGA design flow to implement a “real” embedded computing system
 - Improve your HDL programming skills
 - Improve your Software programming skill
 - Learning by doing

Administrative issues

- Fill out the student info sheet
 - Name, status, reason of taking this class, expectations, prior knowledge, ...
- Pre-requisites
 - EEL 3342: Digital Logic Design
 - Course self-contained, but logic design and computer architecture knowledge helpful (EEL 4768: Computer Architecture)
 - Willingness to work hard
- Information distribution
 - Webpage: www.eecs.ucf.edu/~mingjie/EEL4783_2012/index.html

Lecture schedule

See Webpage:

www.eecs.ucf.edu/~mingjie/EEL4783_2012

Final issues

- Please fill out the student info sheet before leaving
- Come by my office hours (right after class)
- Any questions or concerns?