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-bitforUI
  - 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/sotware 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?