CSE477 – Digital System Design

- Welcome to CSE 477 - Computer Engineering Capstone Design
  - Instructors: Gaetano Borriello and Ross Ortega
  - TA: Tony Wiegering
- Some basics
  - what is a system?
  - what is digital system design?
- Objectives of this class
  - embedded systems: hardware and software
  - interfacing and communication
  - projects
- Class administration and logistics

What is a system (in our case, mostly digital)?

- A collection of components
  - that perform a specific function
  - judiciously chosen to meet some constraints
    - cost, size, power consumption, safety
  - communicates with its environment
    - human interaction
    - communication with other systems
- One person's system is another's component
  - no universal categories of scope/size
  - subsystems need to be abstracted
- How is it documented?
  - how much does one have to know about the internals to use it?
  - how easily can it be altered/re-configured? along what dimensions?

What is digital system design?

- Encompasses all computing systems
  - general-purpose
  - embedded or task-specific
- Encompasses many digital (and mixed digital/analog) technologies
  - combinational and sequential logic
  - programmable components (e.g., PLDs and FPGAs)
  - processors
  - interfaces to analog world
  - input/output devices
  - communication links to environment (wired and wireless)
- To create a physical device capable of solving a problem or performing a task that is useful to someone

Trends in digital system design

- Forces
  - cost (cheaper)
  - size (smaller)
  - weight (lighter)
  - power (lower)
  - time-to-market (shorter)
  - upgradeability (in-the-field)
  - recyclability (reusable parts)
  - ubiquity (anywhere, everywhere, and highly task-specific)
  - standardization of interfaces (leverage)
- Effects
  - increased use of high-level languages
  - high-level specifications
  - automatic synthesis tools (hardware and software compilers)
  - programmable hardware (quick to prototype, reconfigurable)

Examples of embedded systems

Programmable hardware

- Programmable logic devices (e.g., PLDs, FPGAs)
- Microprocessors and microcontrollers
  - integration of surrounding logic onto processor chip
    - interrupt subsystem (priorities and vectoring)
    - timer co-processor (real-time measurements in parallel with processor)
  - faster instruction cycle time
    - processors can now do many things for which custom hardware was previously required
    - parallelism in software
  - integrated memory (RAM, ROM, EPROM, cache, flash)
    - less parts but sensitivity to program/data size
  - processor cores with custom logic
    - optimized to specific application
    - even application specific instruction sets (e.g., DSP processors)

CSE 477

- Computer engineering capstone design course
  - serves to tie together curriculum with an intensive design experience
- For computer engineering
  - programming, data structures, operating systems
  - electronics, logic design, computer design
  - communication skills (oral and written), documentation of designs
  - group effort (1-2 persons in our case), interaction with users (customers)
- Project experience must have most of these elements
  - connecting thread through the discipline
  - invaluable opportunity to add to student portfolio
  - just what employers want to hear about
  - independently motivated experiences grad schools like to hear about

Course rationale

- Assignments and exams
  - reinforce concepts presented in lecture
  - serve to create infrastructure for possible use in projects
  - opportunity to evaluate individual creativity and understanding
  - gain familiarity with laboratory equipment and software
- Embedded system design project
  - wide variety of possibilities in a chosen domain
  - design reviews of other projects (learn from others' experience)
  - must be possible to complete in 10 short weeks
  - presentation and documentation
    - in-class presentations
    - web-based documentation

Project scope

- Groups of one or two students will construct a self-contained mostly-digital subsystem whose complexity is mostly in its control structure rather than data computation (i.e., a small embedded system)
- All projects will be in the domain of wearable/pocketable computing
  - investigate cross-project communication issues
  - tie projects together into a single story (for video later in the year)
- Characteristics
  - interfacing multiple components
  - based around a PC or PDA
  - analog/digital interfacing
  - reactive, real-time interactions
  - wired or wireless communication between components or other systems
  - exploit high-degree of integration
  - effective use of microcontrollers and software development environments

Course outline

- Introduction
- Microprocessors and microcontrollers
- Interfacing techniques
- Communication methods
- Software issues in embedded systems
- Case studies from industry
- Project design reviews and presentations (videotaped)
- Project demonstrations on 20 March
  - early demonstrations for Industrial Affiliates Meeting on 26/27 February

Course schedule

- First half
  - lectures
  - laboratory assignments
  - midterm exam
  - definition and initial design of project
- Second half
  - construction and debugging of project
  - design reviews
  - project presentations and videotaping for later critique
  - project documentation on web
  - review of industry case studies
- Planning meeting during 2nd, 3rd, and 5th weeks
  - each team assigned to one of instructors as primary project manager

Background (prerequisite) material

- Logic design (de-emphasized this quarter)
  - combinational logic
  - sequential logic
  - control/data-path
- Computer architecture
  - assembly language programming
  - computer organization
  - memory hierarchy
  - interrupt mechanisms
- Programming skills (re-emphasized this quarter)
  - basic programming
  - data structures
  - facility with imperative programming languages

Refreshers

- Courses
  - CSE370 – Introduction to Logic Design
  - CSE467 – Advanced Digital Design
  - CSE378 – Machine Organization and Assembly Language Programming
  - CSE451 – Introduction to Operating Systems
- Find the your textbooks and notes from these courses
  - review chapters and lecture notes as topics come up
- Review written assignments and any projects
  - make sure they are fresh in your mind
  - get close to the point you were at when you completed these courses

Project ideas

- 3-D ultrasonic mouse
- MIDI flute synthesizer
- CCD camera
- Hand-held logic analyzer
- Mobile robots
- Talking toaster
- Some examples from last year . . .
- Some ideas for this quarter . . .
  - meet Tuesday 4:30-6:30 to review videos
  - pizza/drinks will be provided

Support for CSE477

- Philips Multimedia Center
- Motorola Mobile Data Systems
- Xerox Palo Alto Research Center
- Texas Instruments
- Rob Short

Goals for CSE477

- Lots of fun getting projects done
  - cool devices
  - amaze friends, family, and Ed Lazowska
- Lots of learning in the process
  - great way to end your undergraduate career
  - killer interview material
- Produce a great new video
  - highlight the program and department
  - demonstrate that education can be at leading edge
  - help us get more industry support for our educational programs
  - win another video award (the previous two videos both did)