Lecture 7: Embedded System Design

First need to know:

- -Interface requirements: ports, sockets, I/O rates
- -Memory requirements: size, thru-put, bus limitations (PCI, VME, etc)
- -System requirements: ADCs, DACs, sensors, I/O devices
- -Physical requirements: storage space, safety issues, climate, cost
- -Interrupt requirements: external event rate, polling, monitoring
- -hard or soft real-time application

Design tips:

- -h/w devices are intimately connected to s/w drivers
- -can't separate h/w and s/w teams as independent entitites
- -unit testing and integration testing apply to h/w as well as s/w embedded design
- -first use startup code and executable shell to play with each h/w item separately
- -enable CPU memory first
- -create simple and independent ISRs to drive each h/w device
- -create h/w and/or s/w monitor for each device to analyze response data
- -ICEs, scopes, logic analyzer come in handy
- -transmit single characters or bytes to h/w device via s/w driver, then receive them
- -build s/w drivers independently
- -successively re-iterate versions of the s/w drivers to make them more efficient

Memory needs: roms, proms, eproms, eeproms, dynamic/static ram, continuous/volatile/virtual memory

- -roms: easy to use, low cost, memory burned into device, switching matrix design
- -proms: electronically alterable rom
- -eproms: erasable proms using ultraviolet
- -static rams: flip-flop device for storing fixed information, fast, expensive, used for cache
- -dynamic rams: capacitance device, slow (2 msec discharge time), scalable, allows large data movement, cheaper, registers accessed by address, real-time reliability poor
- -sdram: synchronous drams (input/output signals synchronized to the system board clock so that uprocessor continues executing while RAM is retrieving data)
- -nram: nanotube storage ram where bits are stored as 1nm tubes of carbon atoms (discovered in 1991 by Sumio Iijima) in conducting or semiconducting graphite
- -mram: magnetoresistive ram (bits stored based on electron spin direction of ferromagnetic materials separated by insulation for electrical and power protected memory
- -nonvolatile continuous memory: memory not lost when power is removed
- -volatile memory: memory is lost when power is removed
- -virtual memory: all memory available to the CPU from the system (ram, rom, harddisk, etc)
    - -disk storage space becomes extension of main CPU memory
    - -CPU makes logical assignment to a physical address
    - -major source of execution time uncertainty (could take msec to retrieve info)
- -main memory: CPU memory (8MB) where instruction code is executed (100nsec access time)
- -cache: fast static RAM used by CPU for quick retrieval of memory or instruction code
    - -major source of real-time uncertainty, sensitive to bottlenecks
    - -management of cache usage will define CPU efficiency
    - -access time is fast (10 to 15 nsec), but is small (up to 512 KB at most)
- -storage (hard)disk considerations: magnetic or optical, 10 usec access time, >1GB needed

Digital design needs: decoders, priority encoders, multiplexers, flip-flops, comparators, adders, registers, latches, counters, 3-state buffers => simulation tools: PLDs, FPGAs, DSPs, VHDL

Kinds of embedded systems:

- -distributed: slow (1 Mb/sec), cheap, several CPUs handling components (elevators, trains, A/C)
- -mission critical: fast (10 Mb/sec), redundancy built-in, reliable (Jet engines, nuclear power)
- -signal processing: very fast (~gb/sec), large memory, expensive (radar/sonar, video imaging)