## The Emerging Trends in Electrical and Computer Engineering

### Hosting instructor: Prof. Jimmy Zhu; Time: Thursdays 3:30-4:20pm; Location: DH 2210

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Electrical and Computer Engineering
The Forefront of New Paradigms in Technology

Ed Schlesinger
Professor and Head, Electrical & Computer Engineering
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Overview

• **ECE Technical Spectrum**
• **Some Example Work in ECE**
• **Some “trends”**
• **ECE Curriculum**
• **ECE Faculty**
• **ECE Students**
The ECE Technical Spectrum

Computer Hardware
Computer Software
Computer Systems
Signals & Systems
Electrical Circuits
Applied Physics
Applied Physics

Semiconductor Devices

MEMS

Integrated Circuit (IC) Manufacturing

Sensors

Wireless transmission
Signals & Systems

Digital Communication

Image Processing

Control Systems

Robotics
Computer Systems

Computer Networks

Data Storage Systems

Computer Security
Computer Software

Embedded Systems

Middleware

Remote Control

Video Streaming

RPC component

QoS Negotiator

SMART Kernel

PC-based DB

Badge-polling

Video Preview

Video Transcoding

QoS Negotiator

QoS Adaptor

SMART Kernel
Computer Hardware

Processor Architectures

Embedded Systems
The ECE Technical Spectrum

- Computer Hardware
- Applied Physics
- Electrical Circuits
- Computer Software
- Signals & Systems
- Computer Systems
How many computers are in a car seat?
Car Seat as Computer and Communications Network

- Low speed network to connect seat motion control nodes
- This is a distributed embedded system
  - Front-back motion
  - Seat tilt motion
  - Lumbar support
  - Control button interface
CMU – GM Collaborative Research Lab

- **Face/Eye/Hand Tracking**
  - Driver-vehicle interfaces
  - Cognitive overflow study
- **Driver ID and Encryption**
  - Security
  - Safety
  - User Preference
- **Airbag Deployment Control**
  - Mirror, wheel, panel, seat
Imaging Arrays
CMOS MEMS at CMU

- Moving capacitor in 0.35 µm CMOS
- Dense comb array provides variable capacitance

Information Storage Technology

Seagate Barracuda ATA II

Courtesy Read-Rite
What is 1 Tbit/in²?

At 1 Tbit/in² you can save a picture of every man, woman and child on earth on a disk the size of a Compact Disk.

Individuals will own libraries of information.

Courtesy: T. Rausch
How long can physical limits on scaling be avoided?

90 nm lithography

Gordon Moore ISSCC 2003
Extreme Ultraviolet Lithography
Moore’s Law (Original)

Relative Manufacturing Cost per Component

Number of Components per Integrated Circuit
Problems in the IC Industry

- $30 M/tool today
- $250 M/tool in ten years
- $1 B/tool in twenty years!

Moore’s “Law” is all about cost reduction not density

*Fabs cost 100x the tool cost

The late economist Herb Stein said "anything that can't go on forever, won't."
Memory Trends

Itoh, Hitachi
HDD Density Trends

- Longitudinal Demonstrations
- Longitudinal Products
- Perpendicular Demonstrations
- Perpendicular Products

Areal Density (Gbits/sq. inch)


- >100% Per Year
- 100% Per Year
- 30% Per Year

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Carnegie Mellon
Human Cytomegalovirus (CMV)

200,000 base pairs
Nucleocapsid ~ 100 nm diameter

Information storage density \(4 \times 10^5 \) bits per \(\pi (50 \times 10^{-9})^2 \) m\(^{-2}\)

or about \(3 \times 10^{16}\) bits/inch\(^2\)

A factor of \(10^5\) times today’s state-of-the-art

or equivalent to > 30 years of development
Relative Sizes

Genetic material of virus

CD

1.6 µm minimum

0.83 µm minimum

DVD

0.74 µm minimum

0.4 µm minimum
Heavier than air flight is possible.....

Bald Eagle in flight

F-15 Eagle in flight
This technology integrates memory and processing technology, is able to tolerate defects and irregularities, and is reconfigurable in the field and most importantly allows IC systems to move beyond CMOS and its scaling paradigm.
The ECE Curriculum: Core Courses

18-202 Engineering Mathematics
18-220 Fundamentals of Electrical Engineering
18-100 Introduction to Electrical and Computer Engineering
21-127 Concepts of Mathematics

Freshman year

ECE Breadth, Depth, Design Courses
**ECE Breadth Areas**

- **Applied Physics**
  - Solid State Magnetics
  - Fields Optics etc.

- **Signals And Systems**
  - Signals Linear Sys. Control DSP etc.

- **Circuits**
  - Analog Digital IC Design etc.

- **Computer Hardware**
  - Logic Design
  - Comp. Arch. Networks etc.

- **Computer Software**
  - Programming Data Struct.
  - Compilers Operating Sys. etc.

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**Requirements**

- **breadth**: one course from three different areas
- **depth**: a two-course sequence in one area
- **coverage**: two additional ECE courses

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**Electrical and Computer Engineering**

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Capstone Design Courses

18-517  Data Storage Systems Design
18-523  Analog Integrated Circuit Design
18-525  Integrated Circuit Design Project
18-544  Network Design and Evaluation
18-545  Advanced Digital Design Project
18-549  Distributed Embedded Systems
18-551  Digital Communications and Signal Processing Systems
18-575  Control System Design
18-578  Mechatronic Design
Courses and Course Trees

http://www.ece.cmu.edu/users/shared/primer/appendix/currlist.php
ECE Faculty

• Cover the complete ECE technical spectrum

• ~90 faculty members - including research, adjunct, and courtesy faculty

• Over 20 IEEE Fellows
  (The Institution of Electrical and Electronics Engineers is the world's largest professional society)*

• 6 Members of the National Academy of Engineering

* All ECE sophomores receive a free IEEE membership!
ECE Students

• 140-160 per class (soph-senior)
• Many continue for an MS through our IMB program
  IMB = Integrated Masters Bachelors
• Many double majors (CS, Engineering & Public Policy, Biomedical Engineering, Economics, etc.)
• Some employers of 2005 graduates
  – Semiconductor companies
  – Consulting companies
  – Software developers
  – Aerospace companies
  – Investment/finance industry
  – Government agencies
More Information:
http://www.ece.cmu.edu/
ECE Sophomore Welcome Reception

Thursday, September 1
4:30 to 6:30 p.m.
Singleton Room,
Roberts Engineering Hall

Network with Peers
Meet Your ECE Advisor
Enjoy Plenty of Great Food