Underlying principles for hardware, software, and networking:

- Computer Architecture + Compiler + OS + Application

The necessary background for graduate students to pursue advanced study in the areas of computer engineering.
Architecture?
Architecture of a Computing Machine?

Source: http://cache.kotaku.com/assets/resources/2007/10/BRAIN.jpg

How Computer Architectures evolved?

What is the architecture of Intel ATOM and Why it is used in Notebooks?


Course Goals

1. To understand fundamentals of computer systems
   1. Computer Architecture: memory hierarchy, instruction scheduling and pipeline, virtualization, I/O
   2. Operating systems: interrupt handling, monitors, semaphores, protection mechanisms
   3. System software: compilers, linkers, loaders,
   4. System programming: C, assembly language, concurrent programming
   5. Networking: MAC layer, TCP/IP, network programming
   6. Embedded and Mobile Systems: Formal modeling/Verification
   7. Parallel, Distributed and Cloud Computing Systems

2. To learn the efficient way of programming:
   1. Data types, Security in coding, Computer Arithmetic
   2. Memory and I/O Matters
   3. Codes performance
Course Goals - Indirect

- To get you a high-paying job
- To enrich with new ideas
- To train you in systems oriented thinking
- To prepare you for research in computer systems
- To promote your programming skills by enabling you to:
  - Write programs that are more reliable and efficient
  - Incorporate features that require hooks into OS (e.g., concurrency, signal handlers)
Classes of Computer systems

- Cloud computing
  - Challenges: Virtualization, Energy minimization

- High performance computing
  - Challenges: Concurrent /Parallel programming, energy minimization

- Embedded systems
  - Challenges: Application specific softwares, software verification

- Sensor systems
  - Challenges: Limited resources (energy and computing)
Computer systems- Traditional design objectives and concerns

- Performance management
- Memory management
- Resource sharing
- Concurrent programming
Computer systems - recent issues/research directions

- Cyber physical design for critical mission systems
- Sustainability
  - energy consumption
- Safety
- Security
Research/technology trend
-Examples

- **Power-Hungry Devices** (A study by the Natural Resources Defense Council)

- **Cellphone Use Tied to Brain Changes** (Research by National Institutes of Health)

- **For Smartphones, Safeguards Against Swindlers**:
Why PS3 Uses Cell Processors?

Source: http://en.wikipedia.org/wiki/PlayStation_3

Why Multicore Architectures?

An AMD Athlon X2 6400+ dual-core processor

Source: http://en.wikipedia.org/wiki/Multi-core_processor

Why companies are very secretive about their Datacenter’s Architecture? And Why (Mega) Datacenters are situated near large electricity power plants?

Source: news.cnet.com/i/bto/20090123/Iowa.jpg

Source: eetdnews.lbl.gov/nl12/images/data-center.gif
Processor Virtualization

![Intel Virtualization Technology Diagram]

**Without Virtualization**
- OS
- Platform Hardware
- VMM
  - Layer of system software
  - Enabled multiple OS’s to share hardware
  - Vanderpool Technology can allow OS & Apps to run without modifications

**With Virtualization**
- Virtual Machine Monitor
- Intel Virtualization Technology
- Platform Hardware
- VMM
  - Virtualization Technology-enhanced hardware capabilities to facilitate virtualization
And Much More...

- Dynamic Scheduling: Tumasulo’s Algorithm
- Virtual Memory
- Protection and Synchronization Mechanisms
- Shared memory architectures
- Storage Architectures: RAID
How CSE Engineers Think and Master Complexity

- Abstraction: is a mechanism and practice to reduce and factor out details so that one can focus on a few concepts at a time. (wikipedia)
  - Control abstraction: abstraction of action
  - Data abstraction: abstraction for handling data in meaningful manner

- Layering – Layered Architecture
- Objects
- Components
- Interfaces
Layers of Data Transferring Abstraction

Source: Operating Systems by Tanenbaum
Layers of System Abstraction

Source: Operating Systems by Tanenbaum
Layers of Coding Abstractions

Source: Operating Systems by Tanenbaum
Layers of System Architecture

Abstraction

Source: Operating Systems by Tanenbaum
Layers of Hardware Abstraction

Bit-level components

- Logic Gates
  - AND, OR, NOT
- Transistors
- Atoms, Molecules

1-bit adder

Source: Operating Systems by Tanenbaum
H/W Abs: Multi-bit Components

Multi-bit Adder

Register File

4-bit adder

Source: Operating Systems by Tanenbaum
H/W Abstraction: CPU Controller

Source: Operating Systems by Tanenbaum
H/W Abstraction CPU
The agreed-upon interface between:
the software that runs on a computer and
the hardware that executes it.
The Instruction Set Architecture

that part of the architecture that is visible to the programmer
- instruction formats
- opcodes (available instructions)
- number and types of registers
- storage access, addressing modes
- exceptional conditions
# Example of different ISA

## Code sequence for $C = A + B$

<table>
<thead>
<tr>
<th>Stack</th>
<th>Accumulator</th>
<th>Register-Memory</th>
<th>Load-Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push A</td>
<td>Load A</td>
<td>Add C, A, B</td>
<td>Load R1,A</td>
</tr>
<tr>
<td>Push B</td>
<td>Add B</td>
<td></td>
<td>Load R2,B</td>
</tr>
<tr>
<td>Add</td>
<td>Store C</td>
<td></td>
<td>Add R3,R1,R2</td>
</tr>
<tr>
<td>Pop C</td>
<td></td>
<td></td>
<td>Store C,R3</td>
</tr>
</tbody>
</table>
A Major Part of Course is to Acquire System Oriented Mindset!
COURSE MECHANICS and policies
Course Books


Other reference books

- (CAQA) Computer Architecture: A Quantitative Approach, John L. Hennessy and David A. Patterson
- (OSC) Operating Systems Concepts, Silberschatz et al.
- (CPTT) Compilers’ Principles, Techniques, and Tools, Aho et al.
- (FMPC) Fundamentals of Mobile and Pervasive Computing, Adelstein et al.
Course Mechanics

- Homework and Programming Assignments (one every two to three weeks) : 40%
- Quizzes (every week), Midterm and Final Exam : 40%
- Term Project (20%)
  - Group
  - Proposal Topic – Select in consultation with me
  - Presentation
  - Report
A Note about “RAQ” Hazard

- RAQ = “Read After Quiz”
- Quizzes can be unannounced
- Meant to make sure you are in SYNC with the class
- Reduce some pressure for Exam preparation
- Read the material (book, slides, paper etc.) before coming to class
“No Distraction” Policy

- No Laptops/Netbooks/Cell Phone/News Papers etc.
- Laptops/Netbooks may be permitted – only with instructor’s permission
Cheating/Plagiarism Policy

- Strictly prohibited
- See University policy
- Minimum punishment – zero in the assignment
Class Format

- Quiz (10 min)
- Quiz review + Recap (5 min)
- Lecture (45 to 55 (when no Q) min)
  - Take Notes!
  - (If used) Slides will be posted after the class
- Discussion (10)
  - Take Notes!
- Assignment Qs/Next Class (5 min)
  - Take Notes!
Class Cyberpresence

- [http://impact.asu.edu/cen591.html](http://impact.asu.edu/cen591.html)
  - class assignments
  - Solutions
  - Slides
  - reference material
- Visit regularly for latest information
- Discussion board - If enough interest.
What can you expect from this course?

- Lots of in-class interaction
- Interesting and challenging assignments and exam questions
- Help/Tutorials by instructor/TA on difficult material
- And lot more!
Contacting Me or TA

Instructor
- Email: sandeep.gupta@asu.edu
  - Subject line: CEN591Fa11
- Office: BY 522
- Phone: 5-3806
- Office Hours: MW 3:15-4:30 pm
- Call me || come to my office hrs || Set up an appointment
- http://impact.asu.edu

TA: Zahra Abbasi
- Email: zahra.abbasi@asu.edu
- Office BY517
- Office Hours: TTh 3-4 pm or by appointment
What do I do when I am not teaching?
**IMPACT: Research**

**Use-inspired** research in pervasive computing & wireless sensor networking

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### ID Assurance

**Goal:**
- Protect people’s identity & consumer computing from viral threats

**Features:**
- PKI based
- Non-tamperable, non-programmable personal authenticator
- Hardware and VM based trust management

**Sponsor:**

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### Mobile Ad-hoc Networks

**Goal:**
- Protocols for mobile ad-hoc networks

**Features:**
- Energy efficiency
- Increased lifetime
- Data aggregation
- Localization
- Caching
- Multicasting

**Sponsor:**

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### Pervasive Health Monitoring

**Goal:**
- Pervasive Health monitoring
- Evaluation of medical applications

**Features:**
- Secure, Dependable and Reliable data collection, storage and communication

**Sponsor:**

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### Criticality Aware-Systems

**Goal:**
- Evaluation of crisis response management

**Features:**
- Theoretical model
- Performance evaluation
- Access control for crisis management

**Sponsor:**

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### Thermal Management for Data Centers

**Goal:**
- Increasing computing capacity for datacenters
- Energy efficiency

**Features:**
- Online thermal evaluation
- Thermal Aware Scheduling

**Sponsor:**

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### Intelligent Container

**Goal:**
- Container Monitoring for Homeland Security
- Dynamic Supply Chain Management

**Features:**
- Integration of RFID and environmental sensors
- Energy management
- Communication security

**Sponsor:**

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### Medical Devices, Mobile Pervasive Embedded Sensor Networks

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**BOOK:** Fundamentals of Mobile and Pervasive Computing, Publisher: McGraw-Hill Dec. 2004

CEN591 Fall 2011
What’s Next?

- Next Class: Fundamentals of computer system design
- Start reading
  - Chapter one from CSAPP
  - For truly motivated: Chapter one from CAQA
- Plan for next few lectures: Intro to Computer Arch. data representation and machine level representation of programs (CSAPP Ch 2 and 3),
“Have something to bring to the table, because that will make you more welcome.”

“You’ve got to get the fundamentals down because otherwise the fancy stuff isn’t going to work. “

“The brick walls are not there to keep us out. The brick walls are there to give us a chance to show how badly we want something. Because the brick walls are there to stop the people who don’t want it badly enough.”

“Be prepared. Luck is truly where preparation meets opportunity.”