




Computer Systems and Networks

ECPE 170 – Jeff Shafer – University of the Pacific



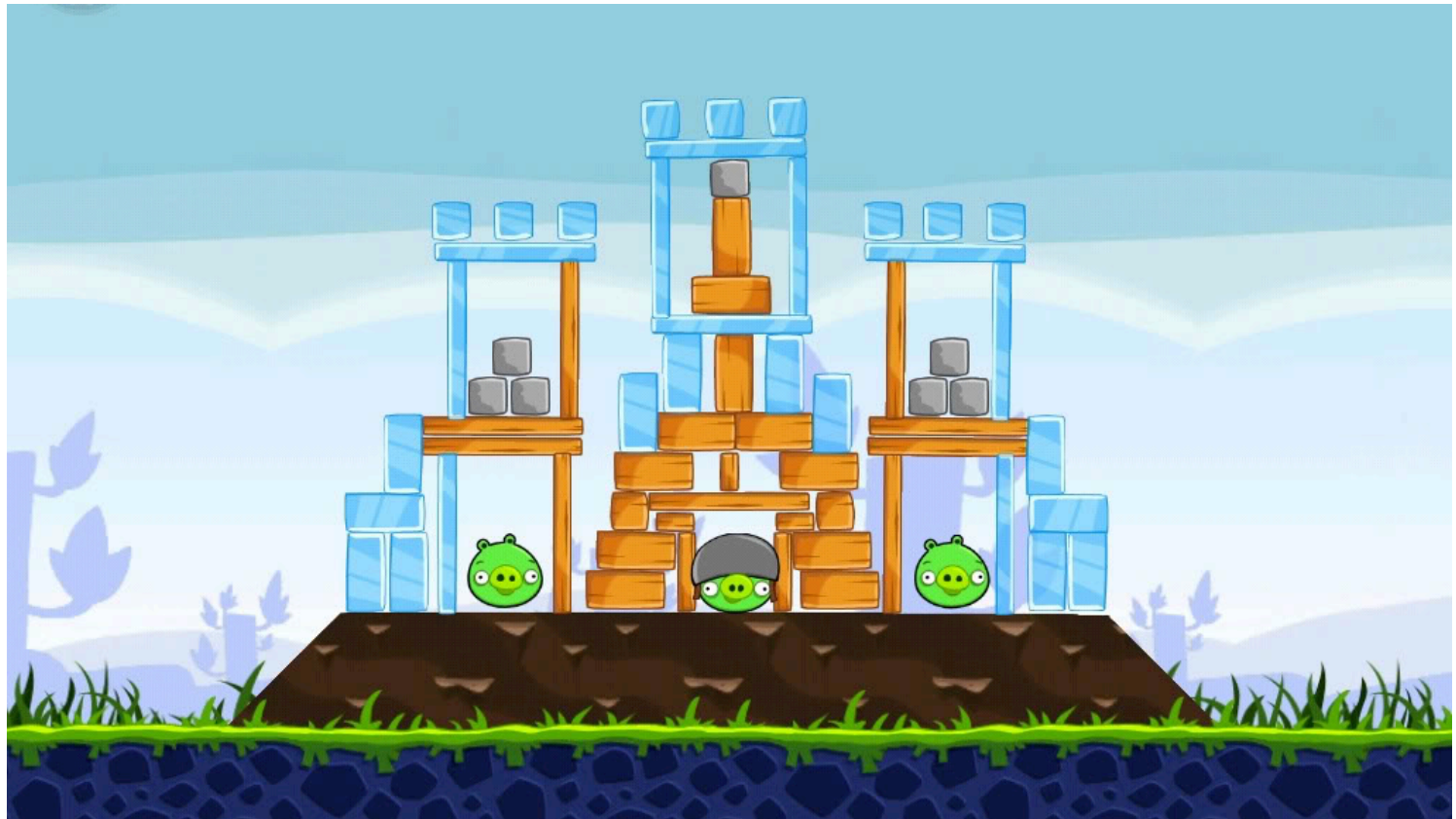
All-New
Version 2.0
for Fall'12!

Introduction

A Modern Computer



Applications



Application – Angry Birds

- Written in a high level language (Objective C)
- What **resources** does *Angry Birds* need to run? (i.e. what does the *Angry Birds* executable file need to execute?)
 - Hardware
 - Processor(s) – Run program, display graphics, ...
 - Memory – Store programs, store data
 - I/O – Touch screen, storage, network, 3-axis gyro, ...
 - Software - Operating system

Software - Operating System

- Apple iOS – Used in iPads, iPhones, iPods, Apple TV
 - Variant of Mac OS X operating system used on traditional Macs

- **What are some jobs of this operating system?**
 - Manage hardware
 - Manage applications (multitasking)

- Written in high-level languages
 - C, C++, Objective C (varies by component)
 - **Can we run this code directly on the processor?**

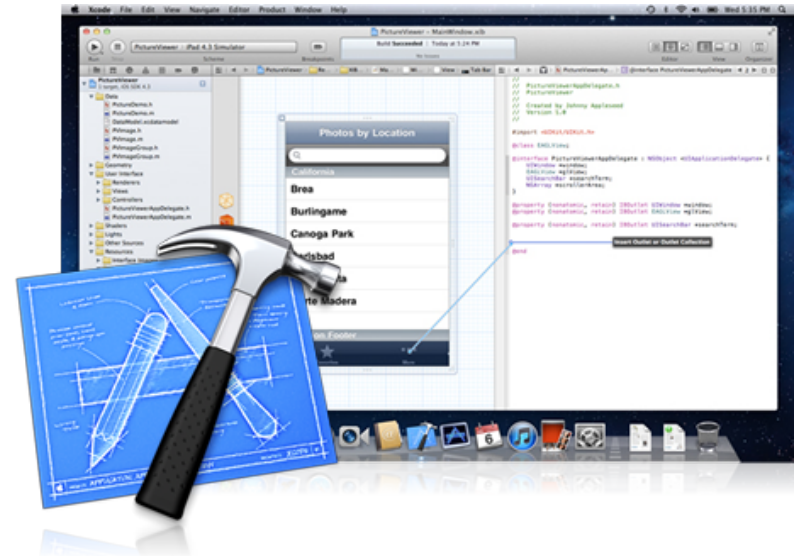
Software - Compilers / Interpreters

- These are programs that **build** other programs!
- Goal: Convert high-level languages into machine code that can be directly executed by hardware

- Examples

- Apple Xcode
- Microsoft Visual Studio

- **What's the difference between a compiler and interpreter?**



Hardware

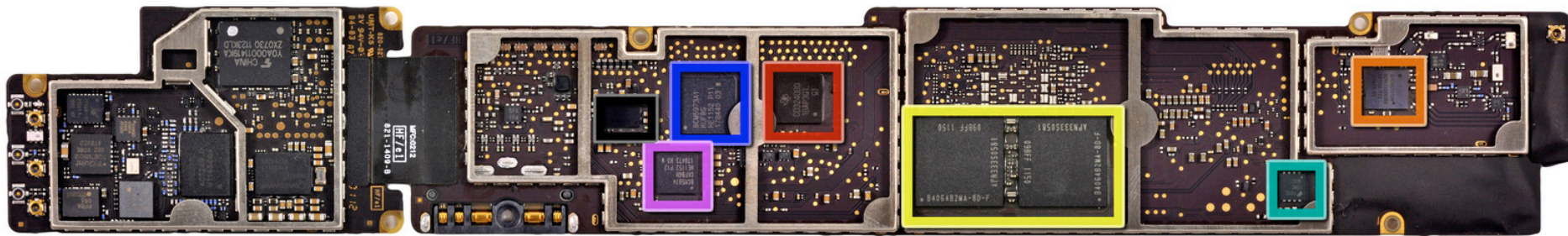


Hardware

Touchscreen controller
Wi-Fi / Bluetooth

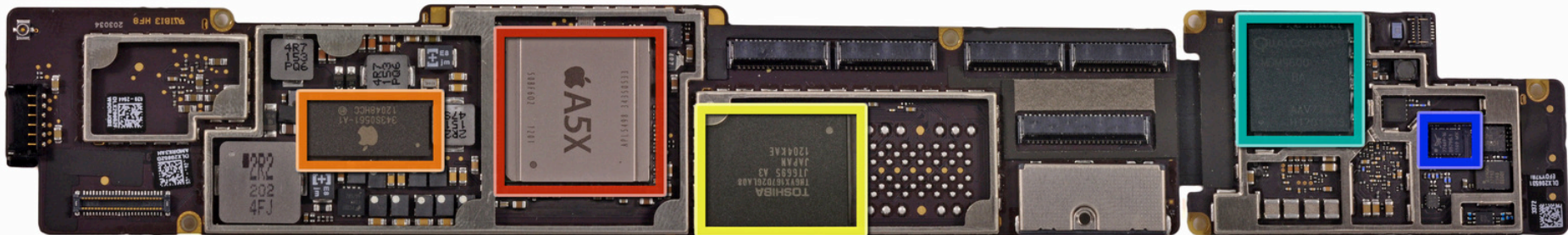
RAM
Power management

Touchscreen controller
Touchscreen controller



A5X Processor
Power management

Flash memory
3G / 4G Modem



iPad “3” Processor

- Apple A5X Processor
 - Clock speed – 1GHz
 - Quad core
 - 1GB RAM
- } What do these mean?
- **What does a processor do?**
 - Executes assembly language instructions
 - **Assembly language?**
 - **How does the processor execute the instructions?**

Microarchitecture



How Does It Work?

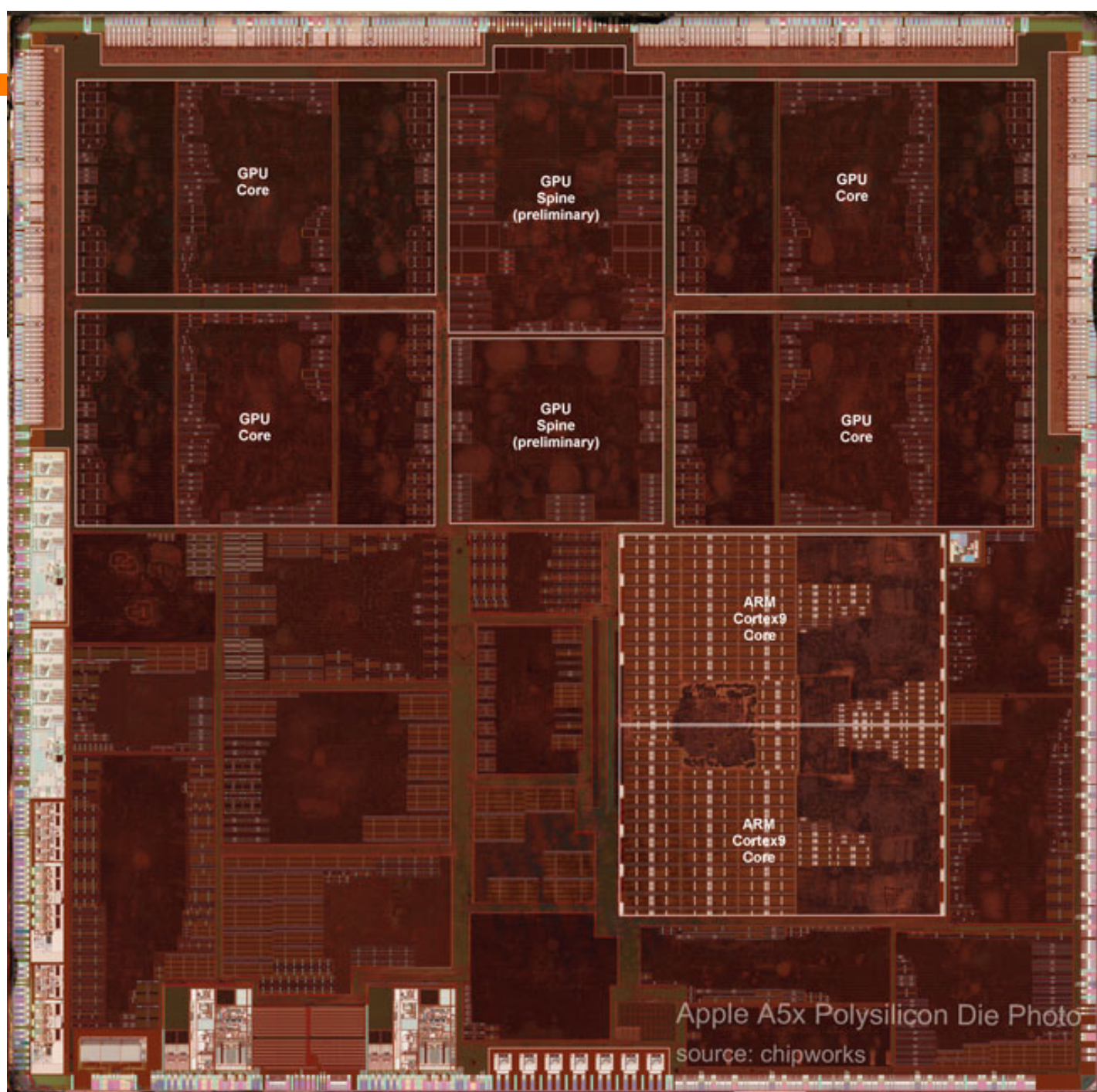
- Apple won't tell us – trade secret!
- Experts can dissolve (with acid), burn, or grind off outer protective layers of chip and then peer inside:
 - Need a *really good* microscope!
 - *Reverse Engineering in the Semiconductor Industry:*
<http://www.scribd.com/doc/53742174/Reverse-Engineering>



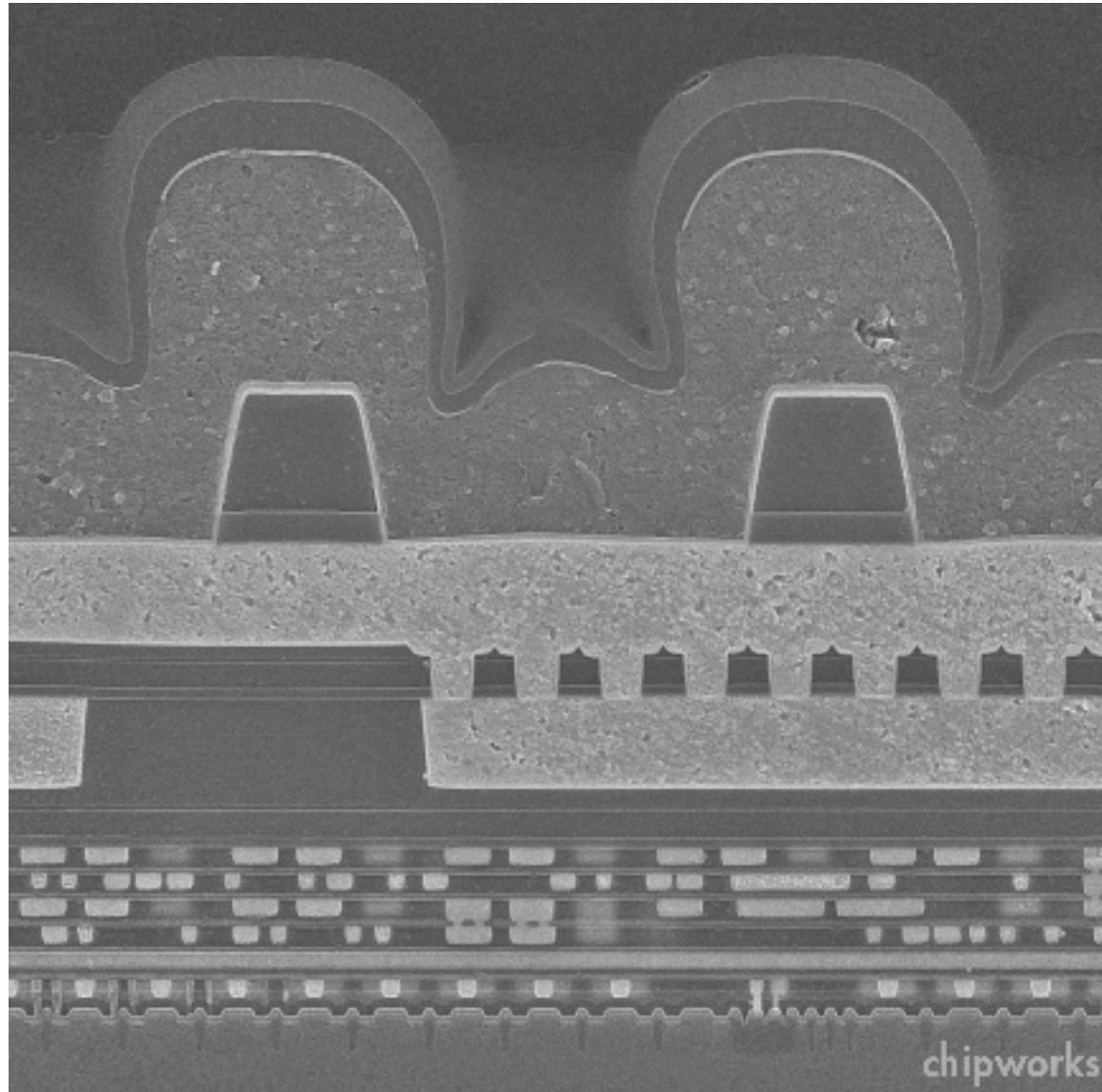
Can see this level of detail with your own eyes...

Divided into logic blocks with different functions:

- Processor
- Cache memory
- Memory Controller
- Video (GPU)



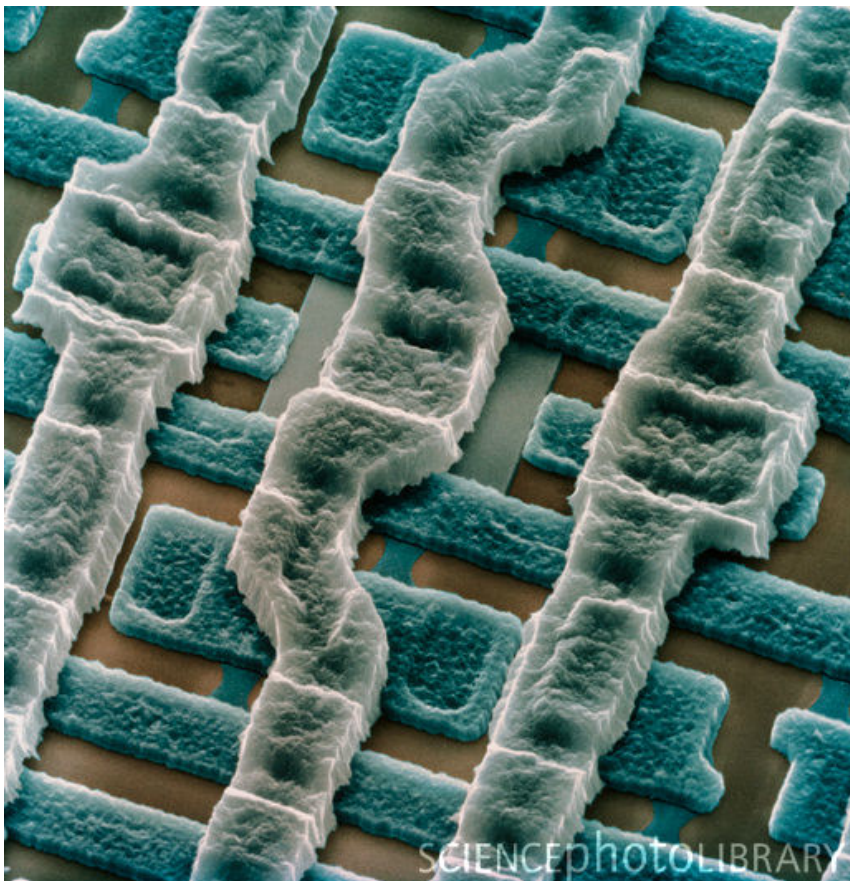
Apple A5x Polysilicon Die Photo
source: chipworks



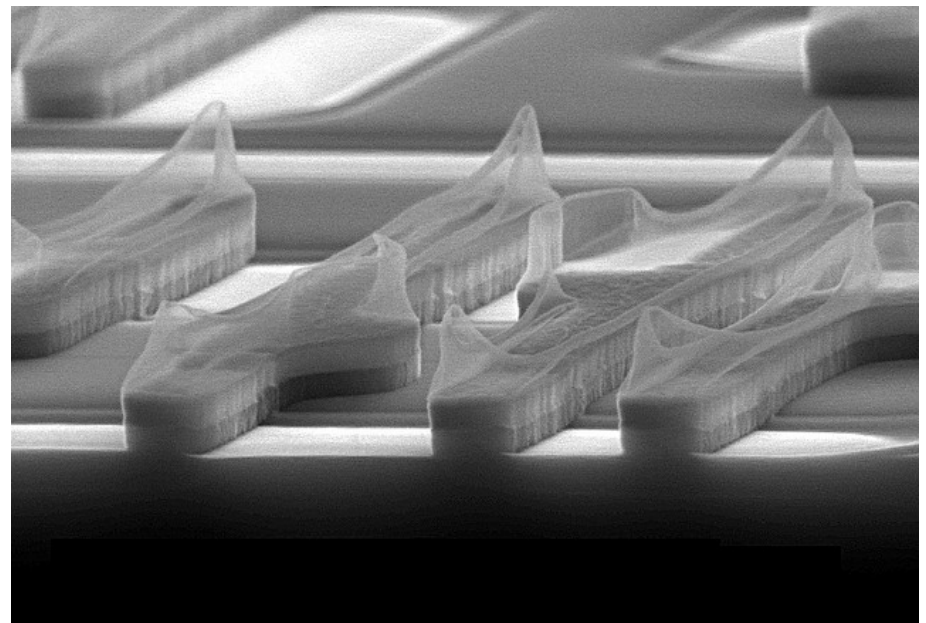
SEM Cross-Section of Apple A5

Digital Logic

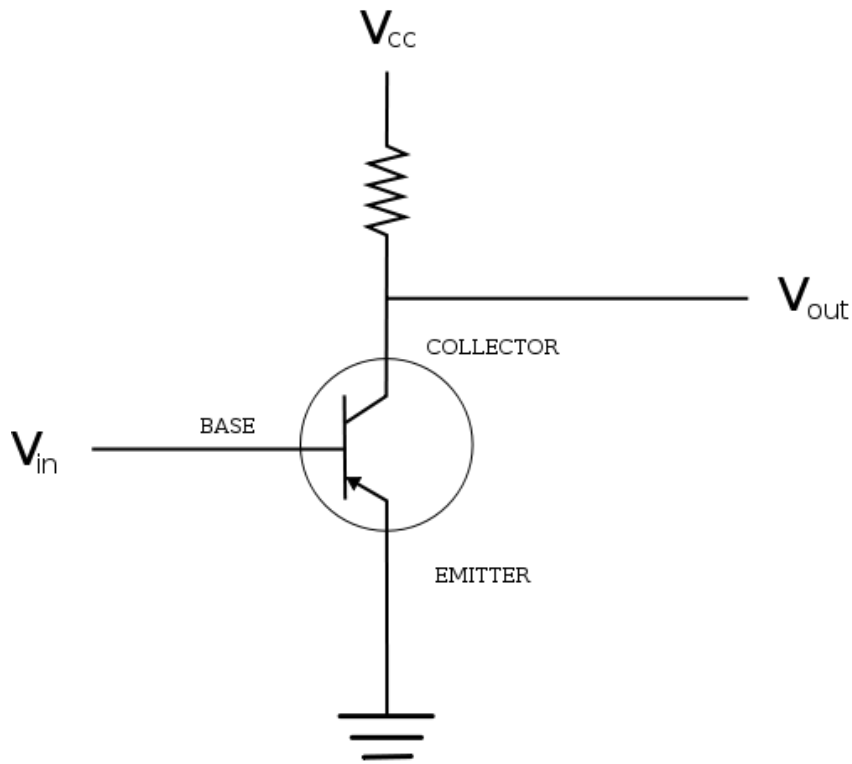
Memory cell



Transistor

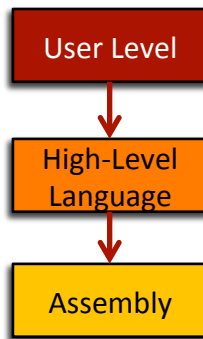


Transistors



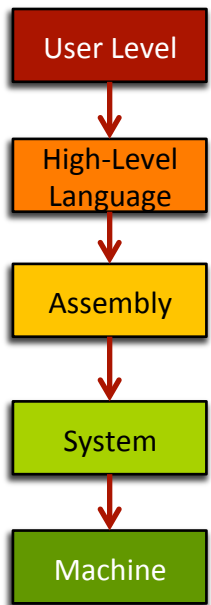
- You can still make assumptions at this level that the transistor is either “on” (1) or “off” (0)
- But below this is **analog circuits**

The Computer Level Hierarchy



- Level 6: The **User Level** – “Angry Birds”
 - Program execution and **user interface** level
- Level 5: **High-Level Language Level** – “Objective C”
 - Programming languages like C++, Java, Python, ...
- Level 4: **Assembly Language Level** – “ARM Assembly”
 - Program directly at this level, or ...
 - **Use a compiler/interpreter** to process/convert high-level code

The Computer Level Hierarchy



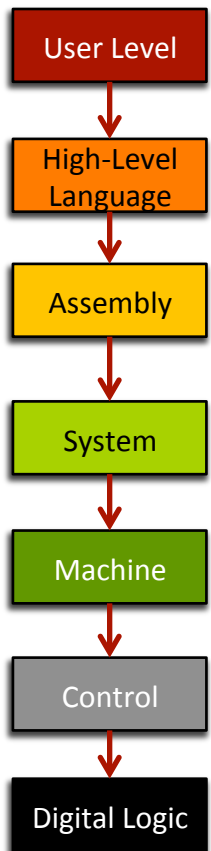
➤ Level 3: **System Software Level** - “iOS”

- Controls active programs and manages system resources
- Assembly language instructions often pass through Level 3 without modification

➤ Level 2: **Machine Level**

- Instruction Set Architecture (ISA) Level
- Instructions are particular to the architecture of the specific machine (i.e. Intel processors, ARM processors, IBM processors...)

The Computer Level Hierarchy



These levels are too hardware-oriented for ECPE 170...

➤ Level 1: **Control Level**

- Decodes and executes instructions and moves data through the system
- **ECPE 173 – Computer Organization & Architecture**

➤ Level 0: **Digital Logic Level**

- Digital circuits, gates and wires implement the mathematical logic of all other levels
- **ECPE 71 – Digital Design**
ECPE 174 – Advanced Digital Design

Course Overview



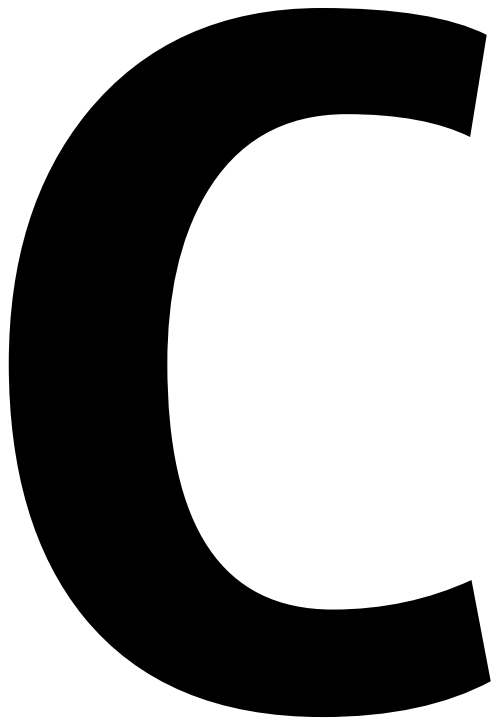
Motivating Question

- **What do you, as a programmer, need to know about the underlying system (software *and* hardware) to write more efficient code?**
 - Role of the tools
 - Compiler, assembler, linker, profiler
 - Role of the operating system and its efficient usage
 - Assembly programming (using the CPU efficiently)
 - Memory hierarchy and its impact on performance

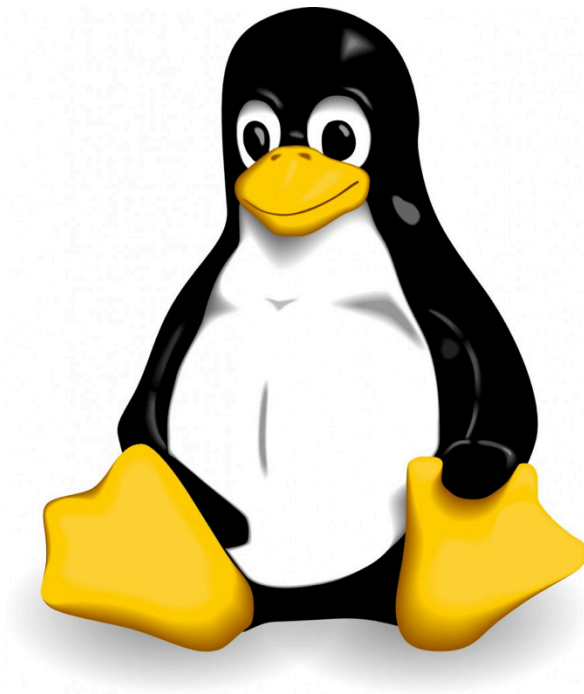
Course Goals

- Present a complete view of how computer systems are constructed
 - From the CPU assembly programming level to the user application level
- Understand the relationship between computer software and hardware
- Lay the foundation for future courses
 - Digital design / VLSI
 - Operating systems
 - Computer networking
 - Application development

C Programming Language

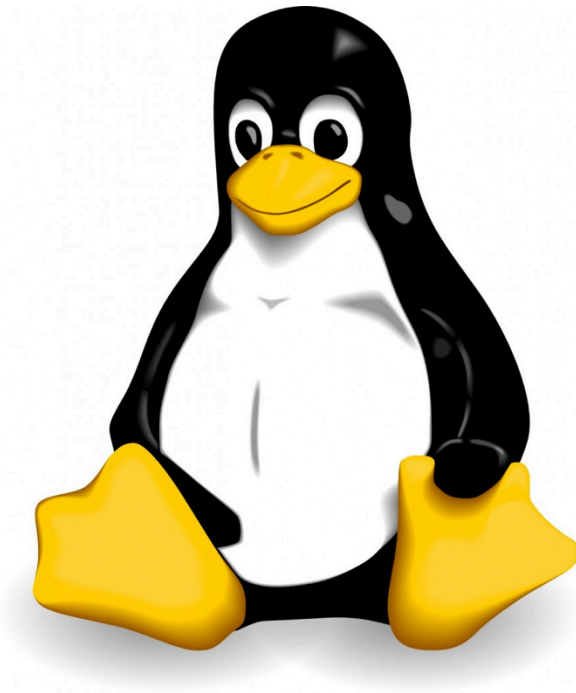


- **Why not Python, Java, Ruby, Perl, PHP, ...?**
- High-level languages (especially interpreted, managed code...) try to *hide* the underlying machine from you
- ECPE 170 wants to *reveal* the underlying machine to you!



- Course will be taught 100% in Linux
- *Did you have to choose Linux for ECPE 170?*
- No, not really, but...
 - Too many Pacific graduates were *escaping* without a working knowledge!
 - **Feedback from co-op employers and graduates: “More Linux/Unix skills please!”**

Linux



- **Who here has used a Linux desktop/laptop/server before?**
- **Who here has used a Linux “device” before?**
 - *I’d be surprised if it isn’t everyone...*
 - Android runs a Linux kernel
 - Amazon Kindle runs a Linux kernel
 - TiVO runs a Linux kernel

Discussion

- **What is open-source?**
- **What is an operating system *kernel*?**
 - **Is the kernel everything you need from an OS?**
- **What is Linux?**
- **What is Ubuntu Linux? (RedHat? Debian? ...)**
 - **→ Show family tree of distributions ←**

Virtual Machine



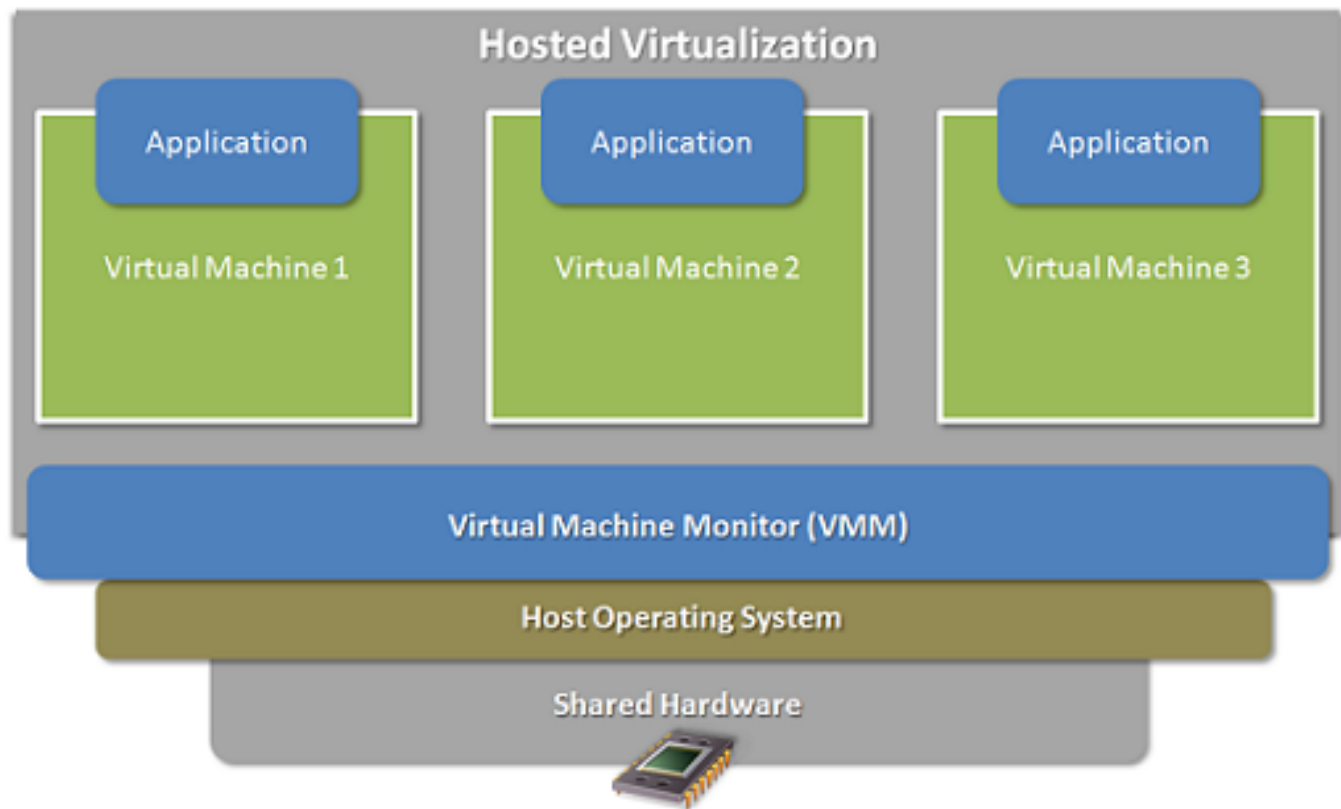
- **Course will be taught 100% from a virtual machine booting Linux that you install!**
- *Couldn't you just give us remote access to a server someplace that is already configured?*
- Yes, but...
 - By installing it yourself you will have the skills to use it again in the future
 - No mysterious "Professor Shafer" software configuration

Discussion

- **What is a Virtual Machine?**
 - Is this the same thing as a *Java* virtual machine?
- **How is it different from dual booting?**
- **Which comes first, the virtual machine, or the OS?**
 - Answer: It depends!
 - Typical desktop install: hosted virtualization
 - Typical server install: bare-metal virtualization

Recommended
technique for ECPE
170

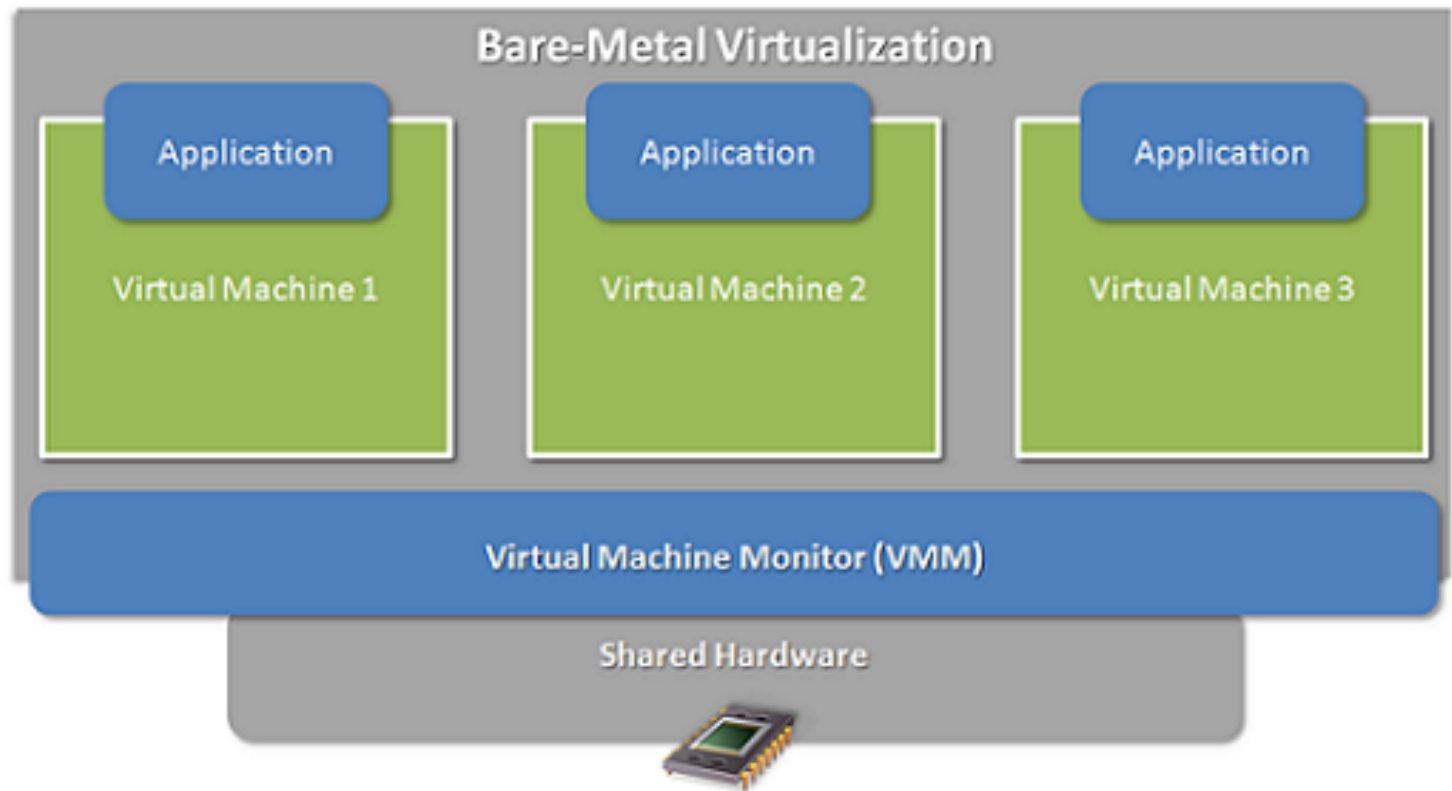
Hosted Virtualization



Bare-Metal Virtualization

More efficient, but not as easy to install.

The virtual machine monitor acts like an operating system itself!



Version Control



- **Course will use version control!**
 - Only way to get lab code or turn in assignments
 - *Did you have to mandate VCS for ECPE 170?*
 - No, not really, but...
 - Too many Pacific graduates were *avoiding* learning this on their own!
 - **Feedback from co-op employers and graduates: "Only n00bs work without version control!"**
 - Used everywhere: Source code of all kinds! (C++, Python, Matlab, VHDL/Verilog, ...)

Version Control



➤ **Who here has used a *version control system* before?**

- What system?
- Where at?
- What purpose?



Questions?

➤ Questions?

➤ Concerns?

Course Mechanics



Websites

Main website (syllabus, schedule)

- <http://ecs-network.serv.pacific.edu/ecpe-170>

Sakai website (gradebook)

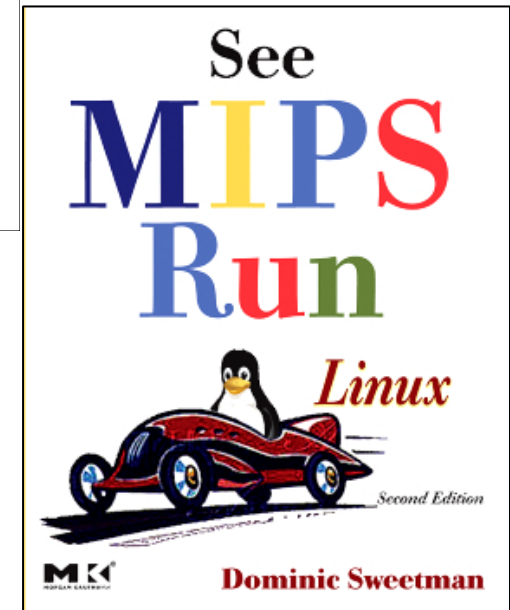
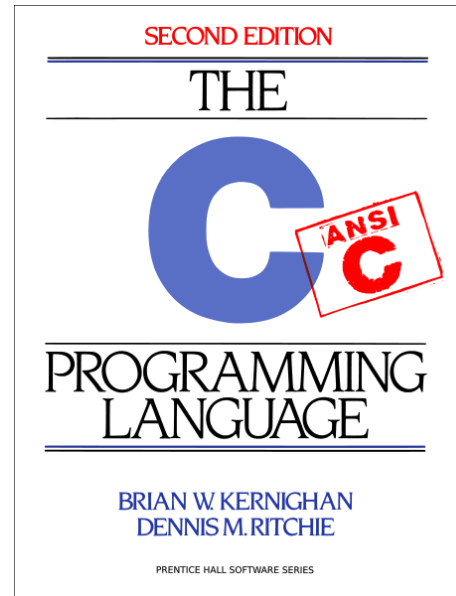
- <http://pacific.rsmart.com/>

Bitbucket.org (version control)

- <http://bitbucket.org>

Textbook

- **No official textbook**
- Optional reference books (useful for this class and beyond)
 - The C Programming Language, 2nd Edition
 - See MIPS Run, 2nd Edition
 - **Please suggest useful online or print references throughout the semester**



Grading

➤ 30% - Exams

- 15% - Mid-term exam
- 15% - Final exam

➤ 70% - Labs

- Pre-Lab activity (a.k.a. “homework”)
- In-class Lab activity
- Post-Lab activity (a.k.a. “homework” or “project”)
- *Points assigned to each activity will vary based on complexity*

Honor Code

- All assignments are submitted individually
- **Encouraged Activities**
 - Collaborating with your classmates
(asking questions, solving problems together)
 - Searching for solutions online
 - Provided code copied does not exceed 25% of total assignment length
 - Provided you clearly **document this copy** in your source code and lab report
 - What did you copy? Where did it come from?

Honor Code

➤ **Risky Activities**

- Having your classmates type on your computer or assignment file

➤ **Forbidden Activities**

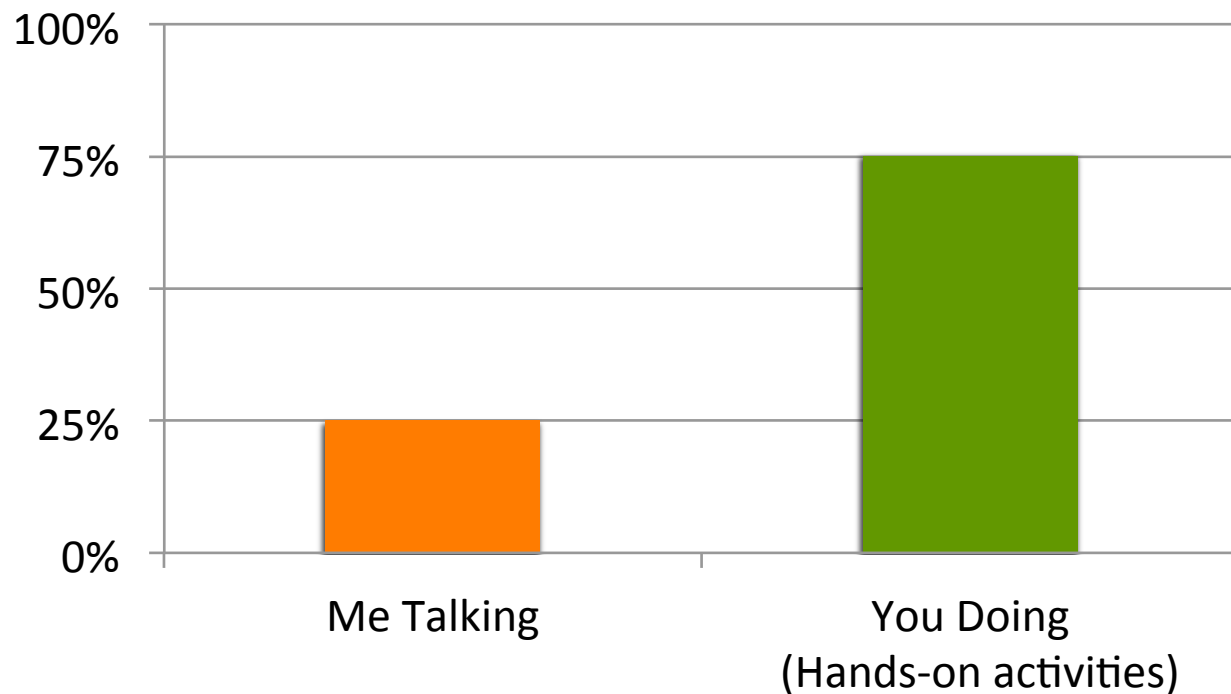
- Copying someone's work verbatim (classmate or otherwise)
- Copying someone's work and obfuscating its source

Lab Topics

1. Linux
2. Version Control
3. C Programming
4. Performance Measurement
5. Performance Optimization (Compiler and programmer techniques)
6. Performance Optimization (Memory systems)
7. Endianness
8. Assembly Programming 1 (MIPS)
9. Assembly Programming 2
10. Network Programming (Python)

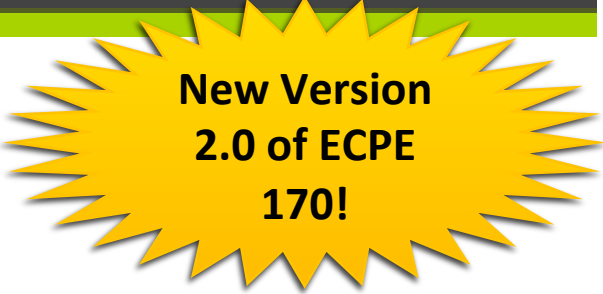
Class Time

➤ The goal* in designing this course:



* Actual time in any specific class may vary

Beta Testing Statement



**New Version
2.0 of ECPE
170!**

- **Class is > 95% new this year**
- **Pro:**
 - You get fun new labs and revamped content
- **Con:**
 - **You all are beta testers**
 - Errors, omissions, and unclear explanations in lab handouts are unavoidable
- **Ask questions and provide feedback so that I can make adjustments for future students**
 - **I'll be "flexible" in grading this semester, provided you are actively engaged in the class work**

Lab 1 - Linux



Homework

➤ **Before the next class**

1. **Skim “Virtual Machine Setup” tutorial instructions on website**
 - http://ecs-network.serv.pacific.edu/ecpe-170/tutorials/vm_setup
2. **Decide on what computer system you want to use for this class**
3. **Download all software**
 - Virtual machine installer (VirtualBox or VMWare Player)
 - Linux .iso image (installer)

Next Class - Linux Installfest

- Tutorial Day
- Objectives
 - Follow the “Virtual Machine Setup” tutorial from website to install Linux
 - Debug individual problems if needed
 - Verify OS works
 - **Email me screenshot as proof of success**

Next Class - Linux Installfest

- I want you to be comfortable as professionals working independently to solve problems
- If you complete the “Virtual Machine Setup” tutorial independently (and email me a screenshot by Thursday @ 8am), you don’t need to attend Thursday’s 8am class. Sleep in!
- I will still be here at 8am to answer all questions and solve problems

Next Class - Linux Installfest

- ➔ **Warning: Don't skip class Thursday, and then tell me next Tuesday at Lab #1 that your OS doesn't work!**

Lab 1 - Linux

- **The first lab is next Tuesday**
 - Topic: Linux
 - Crash course in command-line usage

- **Lab 1: Pre-Lab**
 - Show me the working command prompt in your Linux install. Hopefully you will have this done by end-of-class Thursday
 - **Pre-Labs are always due at the start of the lab (in this case, Tuesday)**

Bring Laptop!

Every class – bring your laptop



Bring Laptop!

Every class – bring your laptop!



Bring Laptop!

Every class – bring your laptop!!



(*) Maybe not this one, but you get the idea...

Bring Laptop!

Every class – bring your laptop!!

Just assume we'll do at least *some* lab activity in class unless it's been made crystal clear in advance that a day will be all lecture/discussion instead...

Bring Laptop!

- *I have a few old Pacific-owned tablets to loan if you don't have a laptop. See me after class...*

Questions?

➤ Questions?

➤ Concerns?

Computer History



Computer History

- **What is the first computer you remember using?**
- **What did you use it for?**

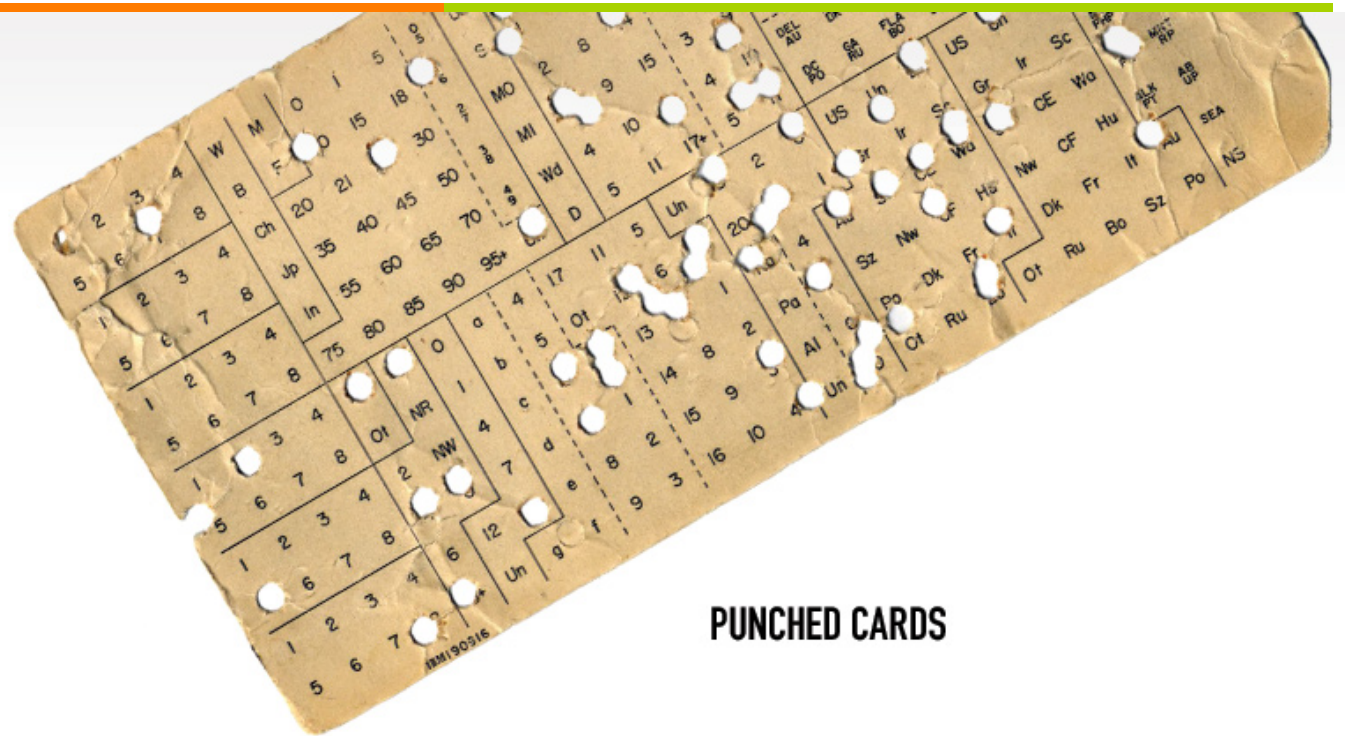




Computer History Museum

CALCULATORS

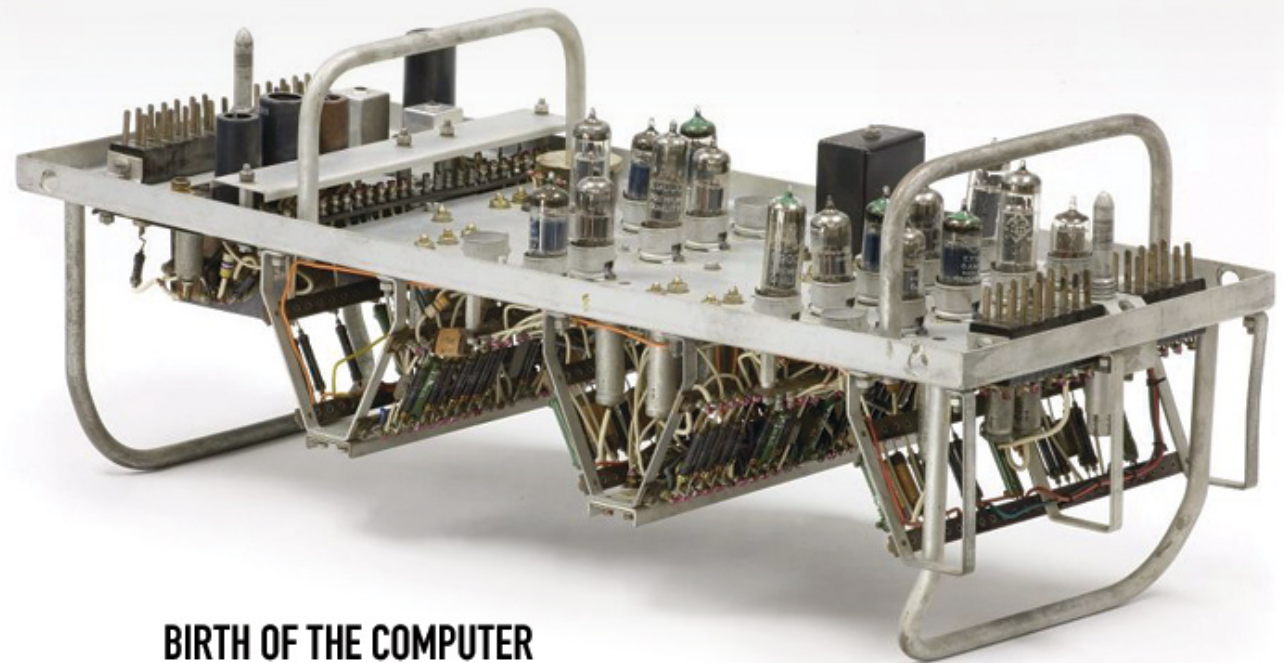




PUNCHED CARDS



ANALOG COMPUTERS



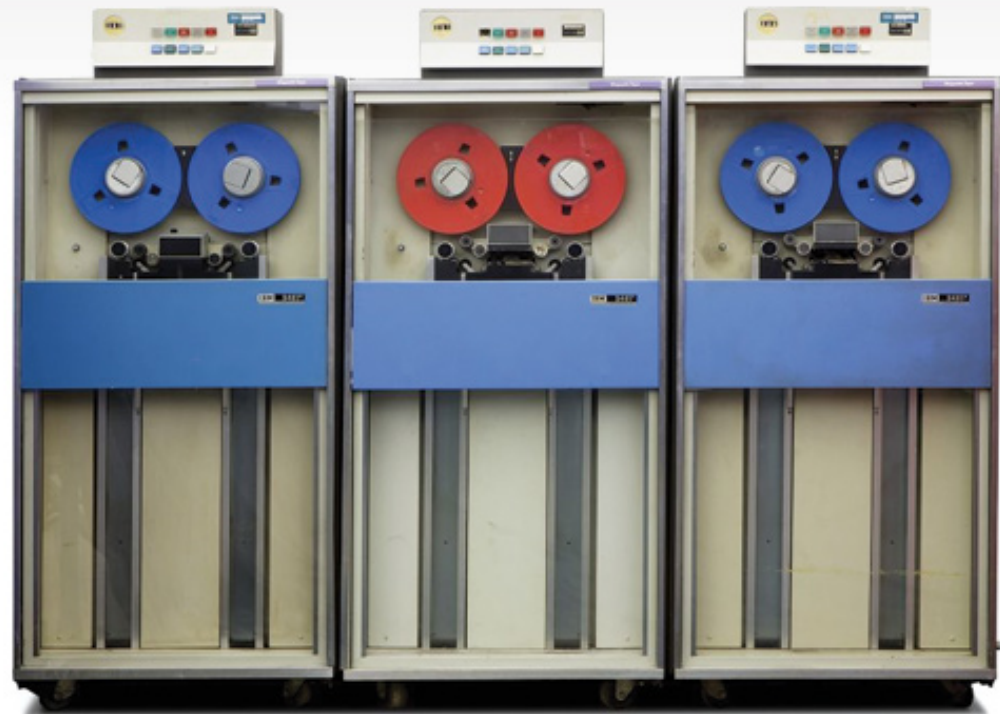
BIRTH OF THE COMPUTER



EARLY COMPUTER COMPANIES

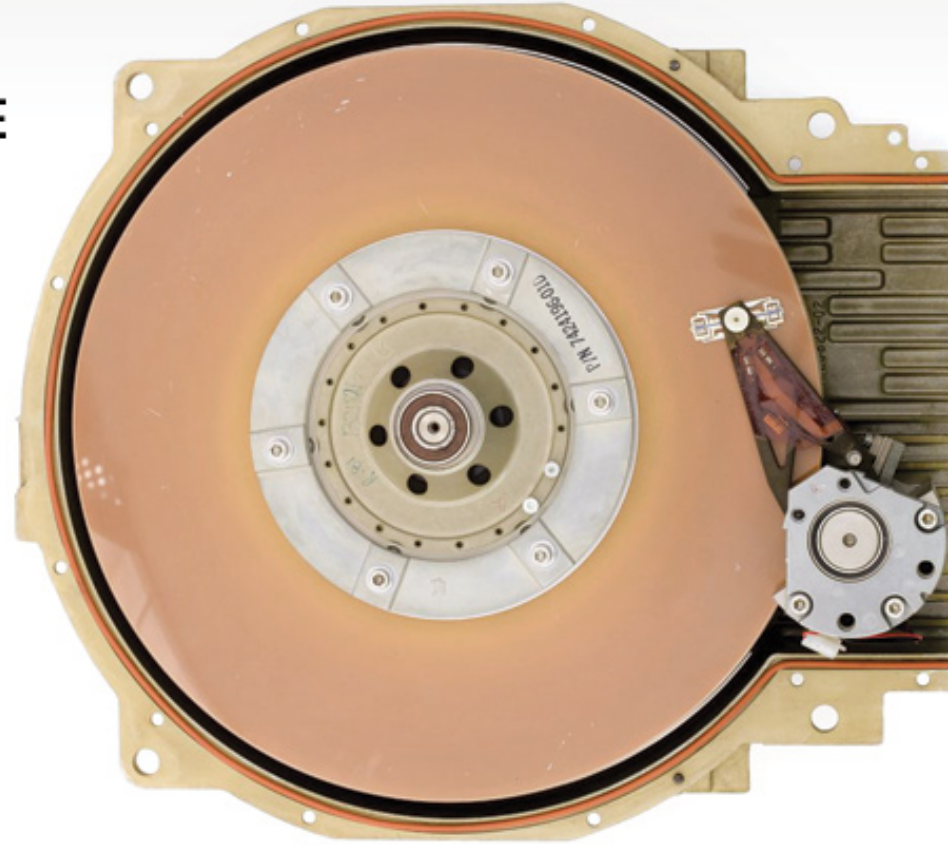


REAL-TIME COMPUTING

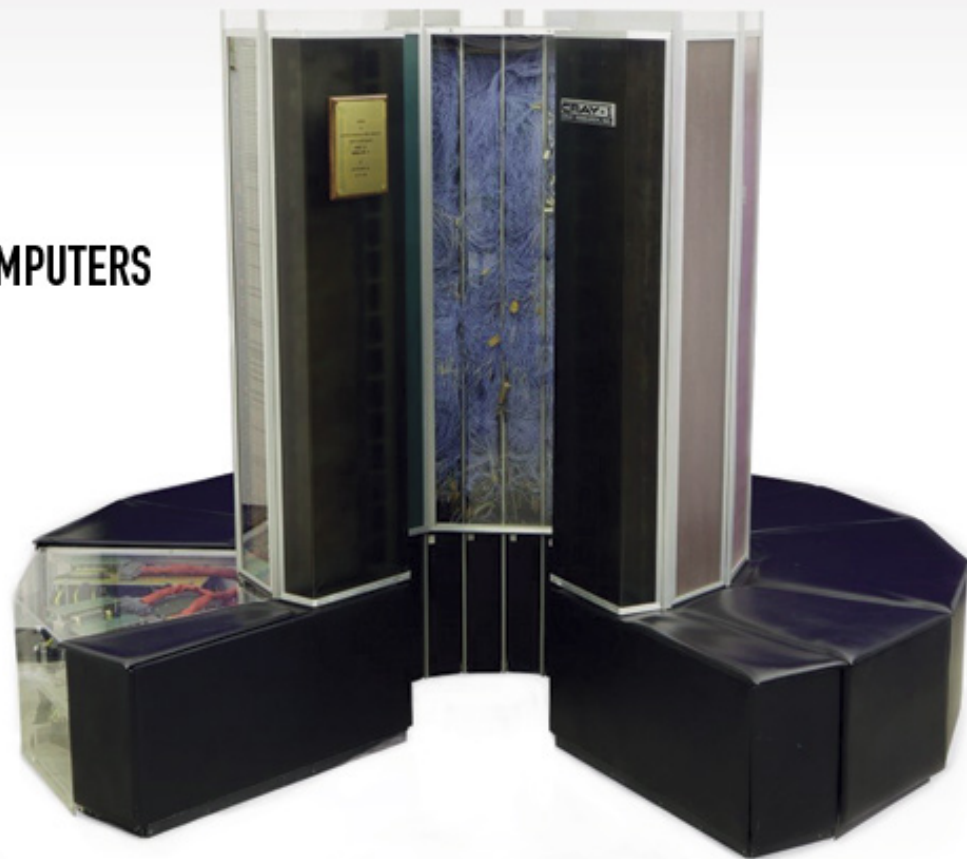


MAINFRAMES

MEMORY AND STORAGE



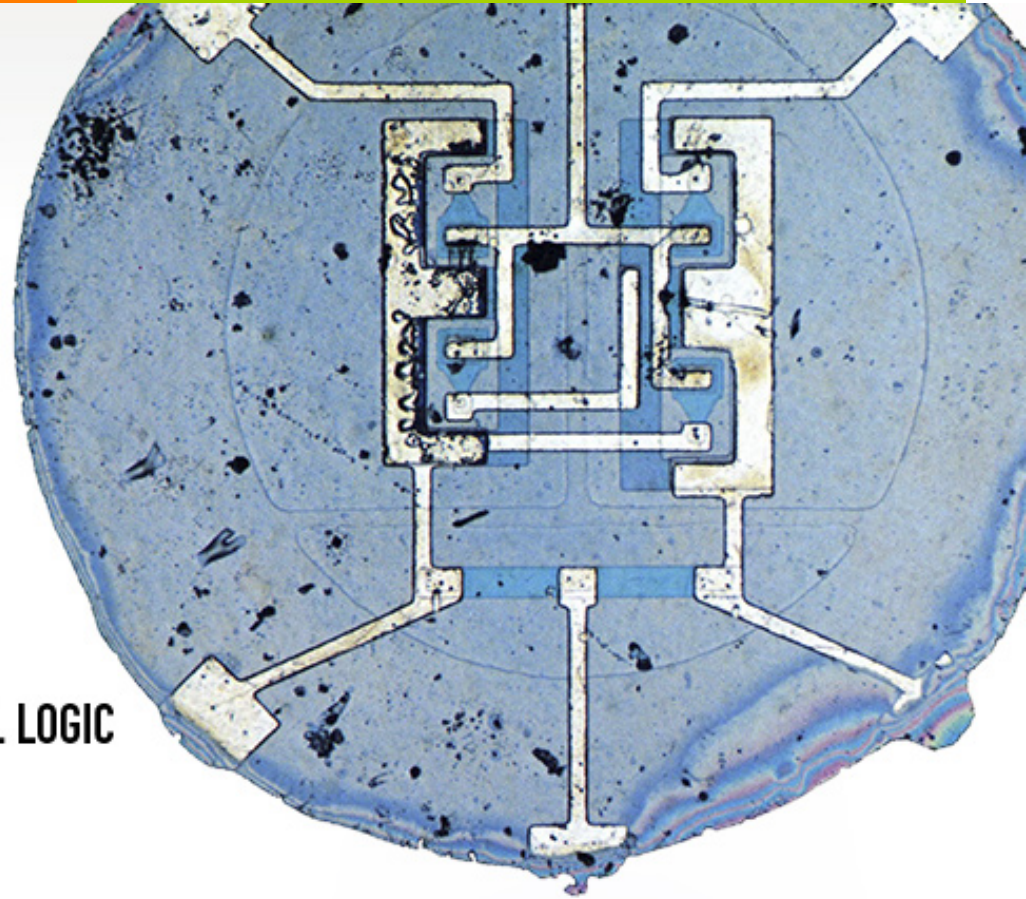
SUPERCOMPUTERS

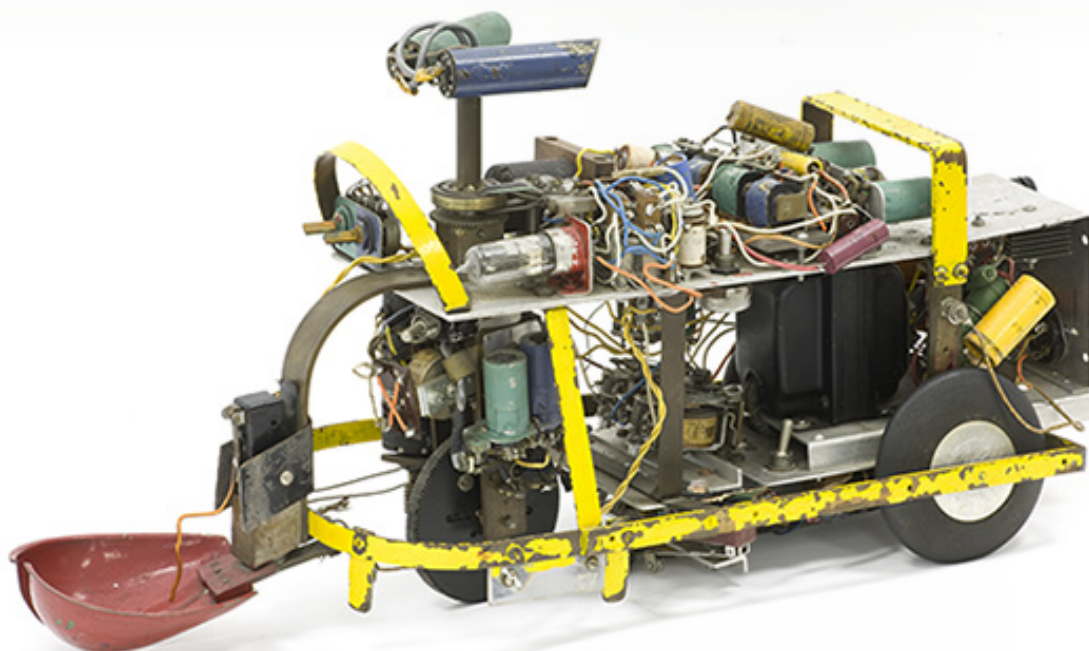


MINICOMPUTERS



DIGITAL LOGIC

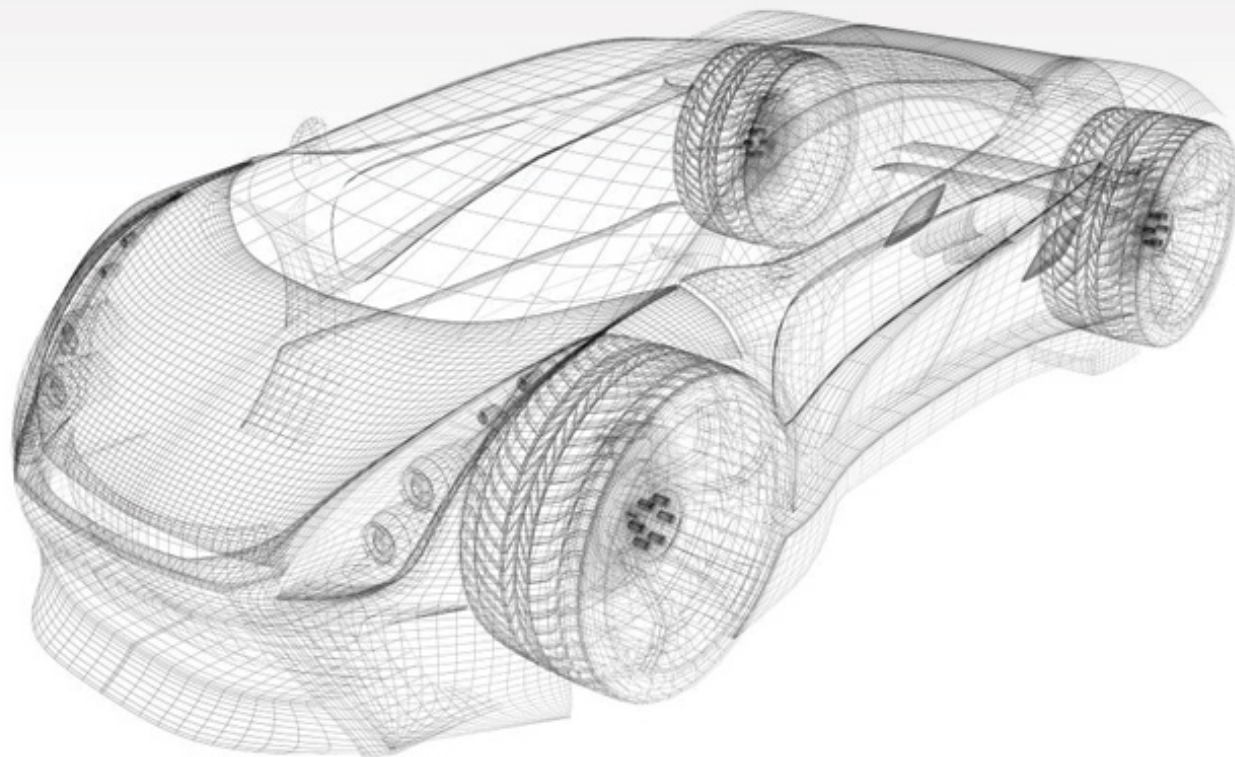




A.I. & ROBOTICS

INPUT & OUTPUT

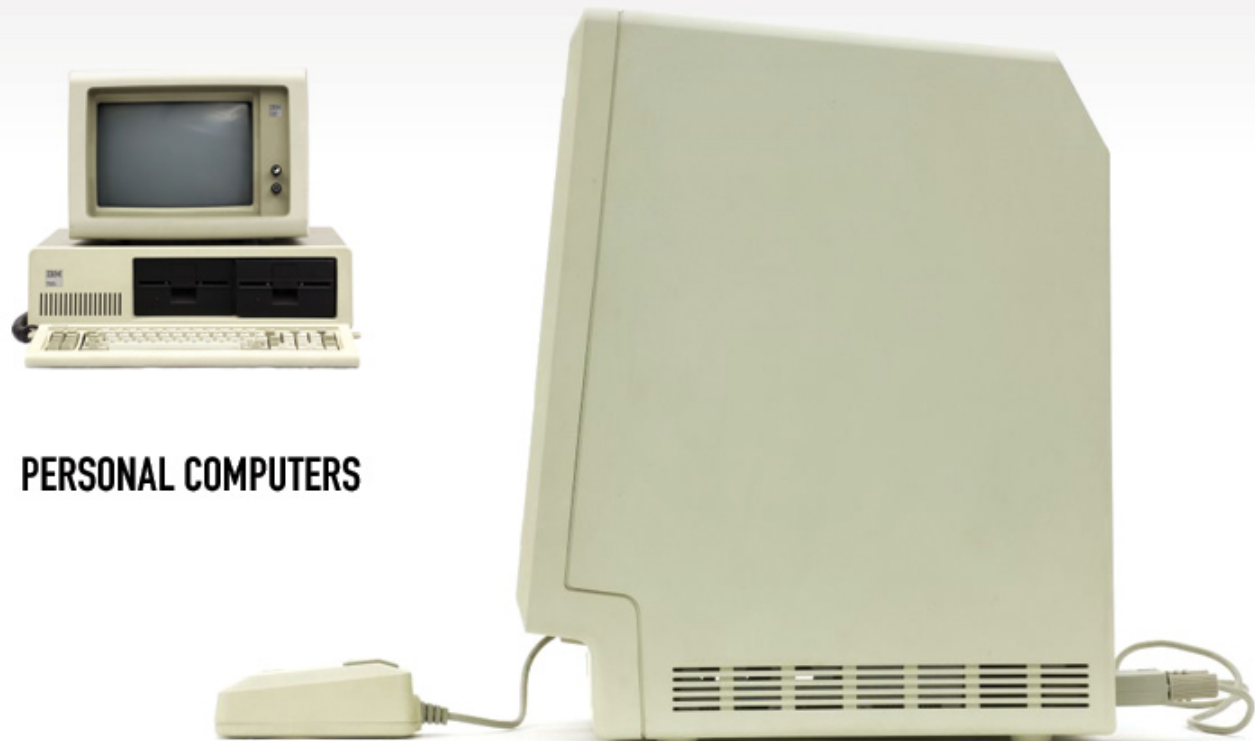




COMPUTER GRAPHICS, MUSIC, AND ART



COMPUTER GAMES



PERSONAL COMPUTERS



MOBILE COMPUTING



NETWORKING



Computer History Museum

Mountain View, CA