COMP273
Introduction

Course Lecture Outline

- Topics include
  - Boolean Algebra/Digital Circuit Design
  - Number Representation
  - Assembly Programming (MIPS)
  - Floating Point
  - I/0 & Interrupts
  - Caches
  - Virtual Memory
  - CPU Organization

Course Format

- Section 001 Monday and Wednesday 11:30 am to 1:00 pm
  - Formal lecture, with interactive Q&A throughout, recorded on zoom
- Section 002 Monday and Wednesday 2:30 pm to 4:00 pm
  - Inverted classroom... bring your questions!
  - Tutorials, live coding, problem solving, etc.
  - Not always recorded!
- Prof Hsiu-Chin Lin teaching up to reading week
- Prof Paul Kry teaching after reading week

Course Information – Pre-requisites

- COMP-206: Introduction to Software Systems.
- Anyone who has not taken COMP-206 (and is not taking it this term) will be automatically deregistered from COMP-273.
- This policy will be followed without exception.

Course Information - Assignments

- Assignments
  - Four assignments, covering logic, numbers, circuits, MIPS programming
  - Show your work (i.e., circuit design, comments in assembly programs)
  - A1 and A3 worth 10%, A2 and A4 worth 15%
  - **Do your own work**
  - **Must be correctly submitted to MyCourses**
  - **Late deadline is 3 days after due date, with penalty is 10%**
  - **Penalty can be waived once (request this in a README.txt file)**
    - **Use for any personal reason, sickness, etc.**

Course Information - Evaluation

- **Assignments: 50%**
- **Mid-term Examination: 20%**
- **Final Examination: 30%**

- No make-up tests or make-up assignments
- Supplemental exam weight is 30% (i.e., same as the final)

Course Information - Resources

- MyCourses
  - Discussions on material
  - Questions with respect to assignments
  - Assignment submission
  - Course outline (in course content)
  - Office hours (posted in my courses calendar)

Course Information - Textbook

- Patterson and Hennessy "Computer Organization and Design: The Hardware/Software interface"
  - The 4th or 5th edition (6th edition is probably OK too)
- Available at the bookstore, e-book on reserve in library.
- This is the main textbook for the course (recommended that you buy a copy)
- Also available as an interactive online zyBook!
- Lecture notes and other handouts will be made available on MyCourses

Teaching Assistants
Office Hours and Tutorials

- Teaching Assistants
  - Names and email and listed on course web page
  - Office hours to be announced on MyCourses

Meet the TAs

- Jiahui Peng
- Jifeng Wang
- Jiyi Wang
- Kaixiang Xie
- Linghang Liu
- Luca Zarow
- Richard Olaniyan
- Ruoyu Wang
- Wing Hang Ho
- Xiru Zhu
- Yanan Wang

Who to contact and when

- Problems with marking?
  - Contact TA who graded your assignment
  - If not satisfied with TA response, then email prof
- Problems with course content
  - Check for answers on MyCourses
  - Post your questions on MyCourses
  - Visit TAs or prof during the office hours
- Personal Issues
  - Visit the prof during the office hour
  - Email the prof with a clear subject prefix [COMP273]

In case you didn't already know...

McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures. See www.mcgill.ca/integrity for more information, as well as www.mcgill.ca/integrity/studentguide, the Student Guide to Avoid Plagiarism.

It should be noted that, in accordance with article 15 of the Charter of Students' Rights, students may submit examination answers in either French or English.

According to Senate regulations, instructors are not permitted to make special arrangements for final exams. Please consult the Calendar, section 4.7.2.1, General University Information and Regulations at www.mcgill.ca. Special arrangements in emergencies may be requested at your Student Affairs Office. If you have a disability, please advise the Office for Students with Disabilities (398-6009) as early in the term as possible so that we can provide appropriate accommodation to support your success.

In the event of circumstances beyond the instructor's control, the evaluation scheme as set out in this document might require change. In such a case, every effort will be made to obtain consensus agreement from the class.

Additional policies governing academic issues which affect students can be found in the Handbook on Student Rights and Responsibilities, Charter of Students' Rights.

Be sure your name and student number is included in your circuit or the top comments section of each of your source files. Submit your source code as a zip file via MyCourses unless otherwise specified. If you have comments about your solution, include a readme.txt or readme.pdf file with your comments. Be sure to check that your submission is correct by downloading your submission from MyCourses. You can not receive any marks for assignments with missing or corrupt files! Note that you are encouraged to discuss assignments with your classmates, but not to the point of sharing code and answers. All code and written answers must be your own.

Do not share your code. Using version control is a good idea, but using a publicly accessible repository is not acceptable.

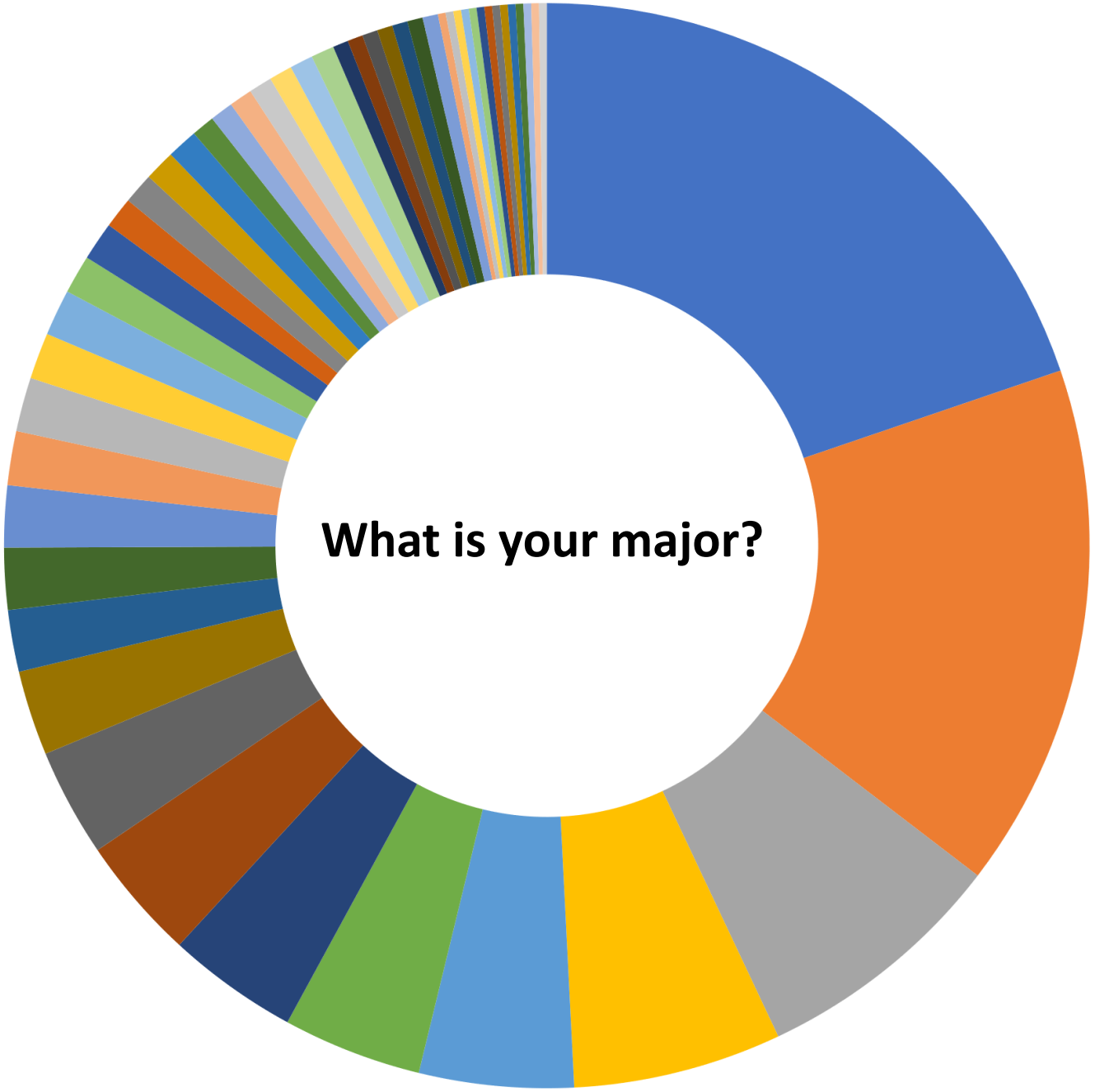
ALL WORK MUST BE SUBMITTED ON MY COURSES. DO NOT EMAIL YOUR WORK TO THE PROF OR TAs.

ALL DEADLINES ARE HARD!!! DO NOT WAIT TO THE LAST MINUTE TO SUBMIT YOUR WORK!

Question

- What can you do if you are having trouble?

About you



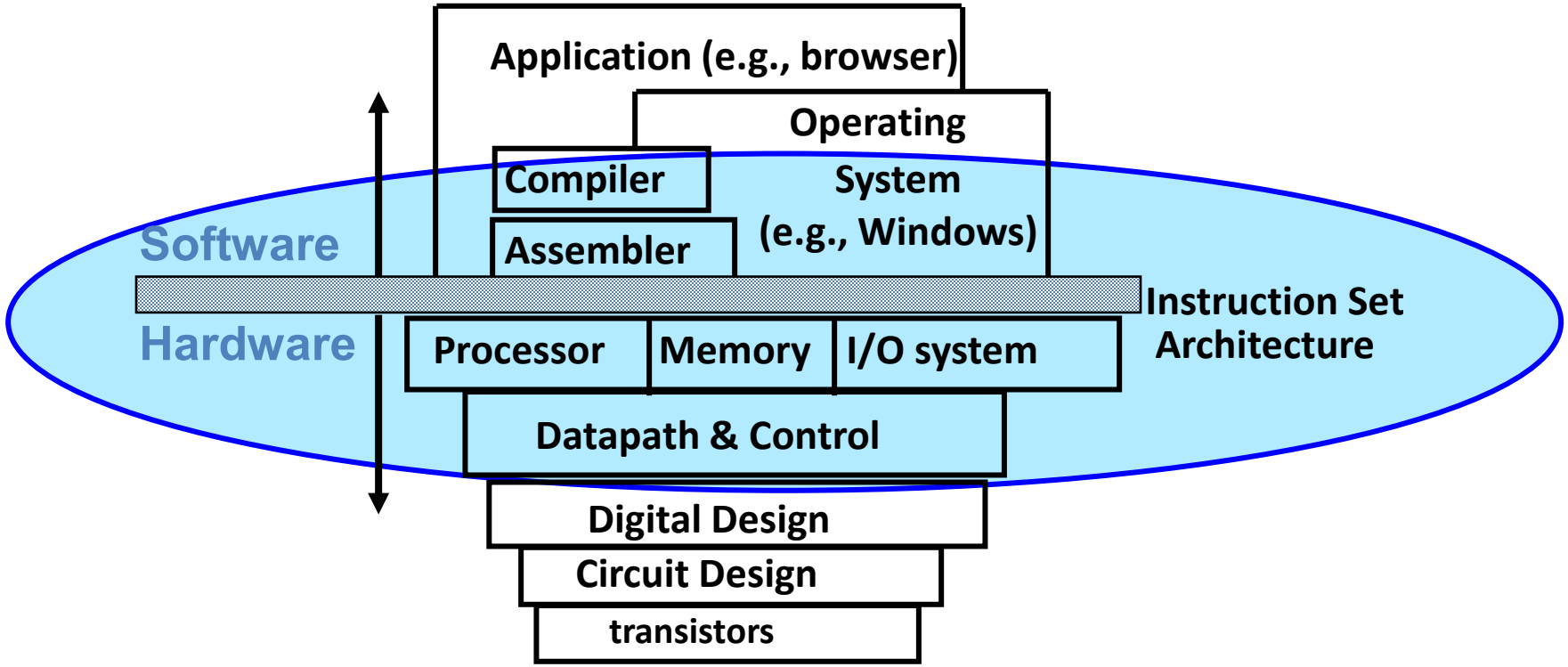
- Computer Science
- Computer Science -Con
- Software Engineering
- Stats & Computer Science
- Math & Computer Science -Hon
- Economics -Con
- Math & Computer Science
- Computer Science -Hon
- Mathematics
- Freshman Program
- Computer Science and Biology
- Undeclared
- Finance
- Mechanical Engineering
- Cognitive Science
- Biochemistry
- Physics & Computer Sci -Hon
- Microbiology & Immunology
- Psychology
- Biology
- Physiology
- Computer Science -CSC
- Geography (AR)-Con
- ComputerScience & Biology -Hon
- Chemistry
- Political Science -Con
- Linguistics -Con
- English -Con
- Physics
- Neuroscience
- Statistics
- Intnl Development Studies -Con *
- Sustainability, Sci & Soc
- Bioengineering
- Chemical Engineering
- Anatomy and Cell Biology
- Pharmacology
- Accounting
- History -Con
- Environment
- Biology & Mathematics
- Urban Systems
- Co-op in Mining Engineering
- Performance Jazz
- Bioresource Engineering
- Strategic Management
- Probability & Statistics
- Civil Engineering
- General Management
- Applied Mathematics -Hon
- Sociology

About the instructors

- Brief research overviews…

What is inside a computer?

What are “Machine Structures”?



* Coordination of many *levels of abstraction*

Below Your Program

- High-level language program (in C)

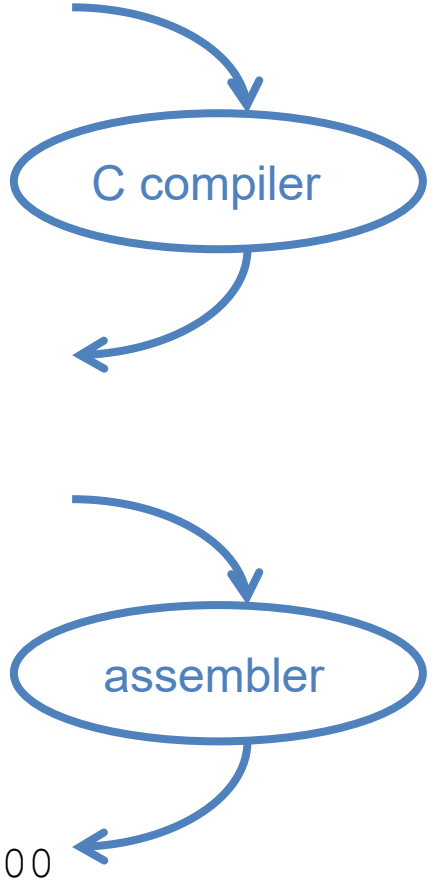
```
swap (int v[], int k) {
    int temp = v[k];
    v[k] = v[k+1];
    v[k+1] = temp;
}
```

- Assembly language program (for MIPS)

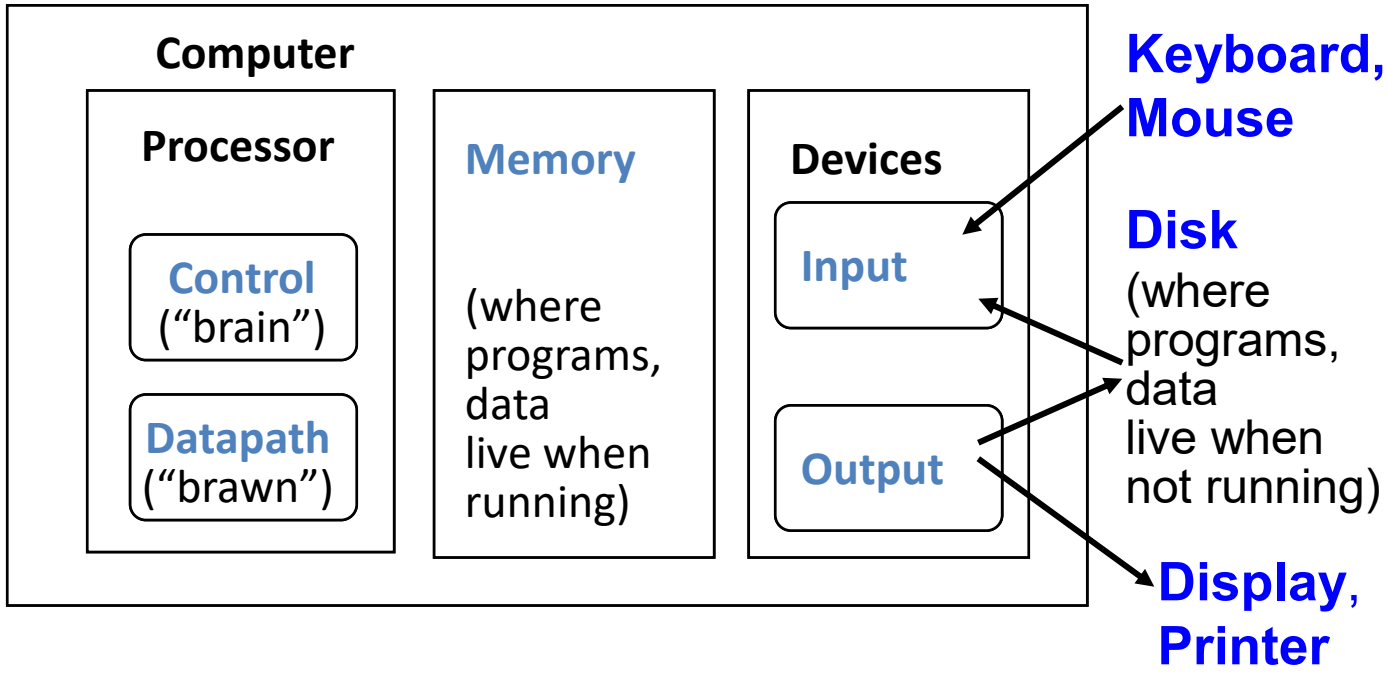
```
swap:   sll     $2, $5, 2
        add     $2, $4,$2
        lw      $15, 0($2)
        lw      $16, 4($2)
        sw      $16, 0($2)
        sw      $15, 4($2)
        jr      $31
```

- Machine (object) code (for MIPS)

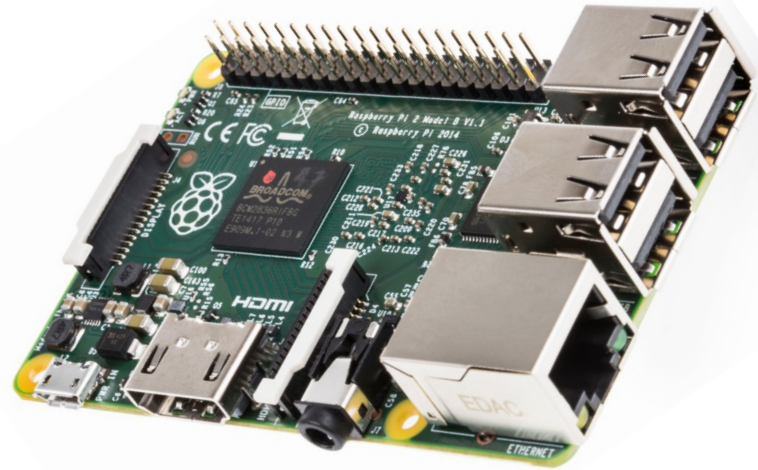
```
000000 00000 00101 0001000010000000
000000 00100 00010 0001000000100000
 . . .
```



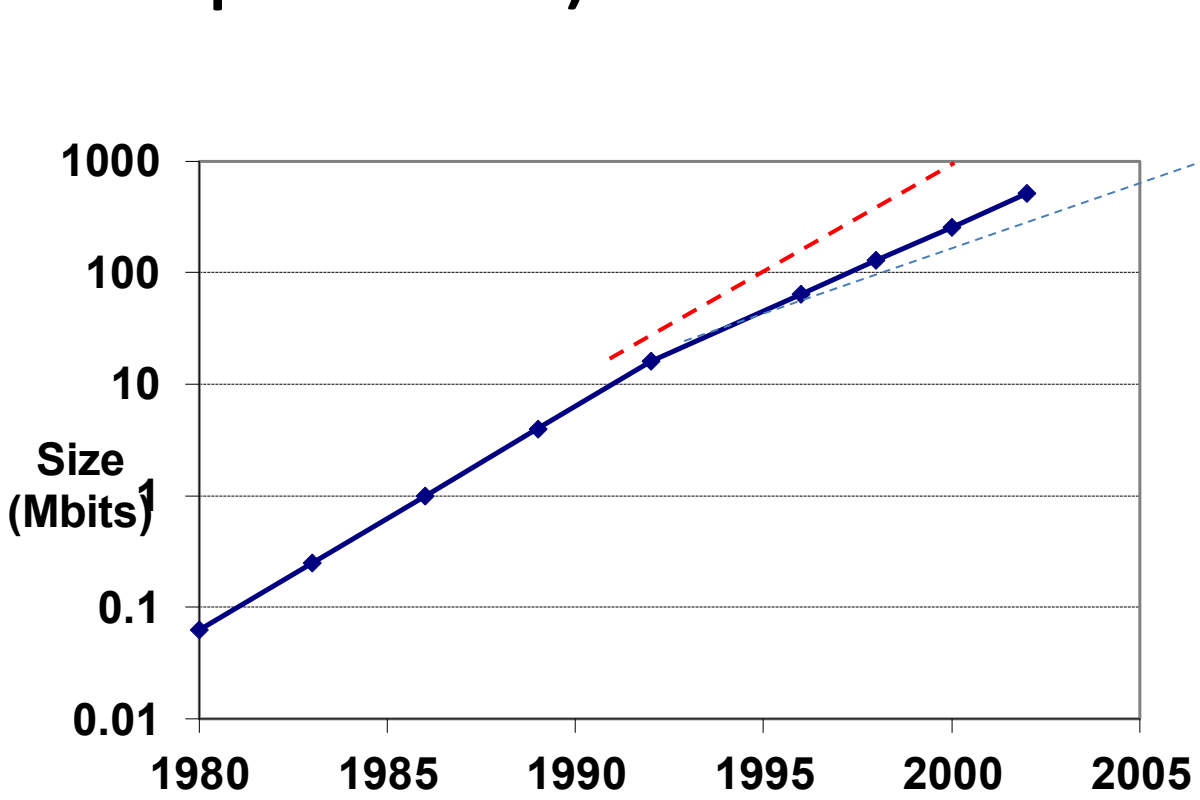
Anatomy: 5 Parts of any Computer




ARDUINO™


HDMI
ETHERNET

Technology Trends: Memory Capacity (Single-Chip DRAM)

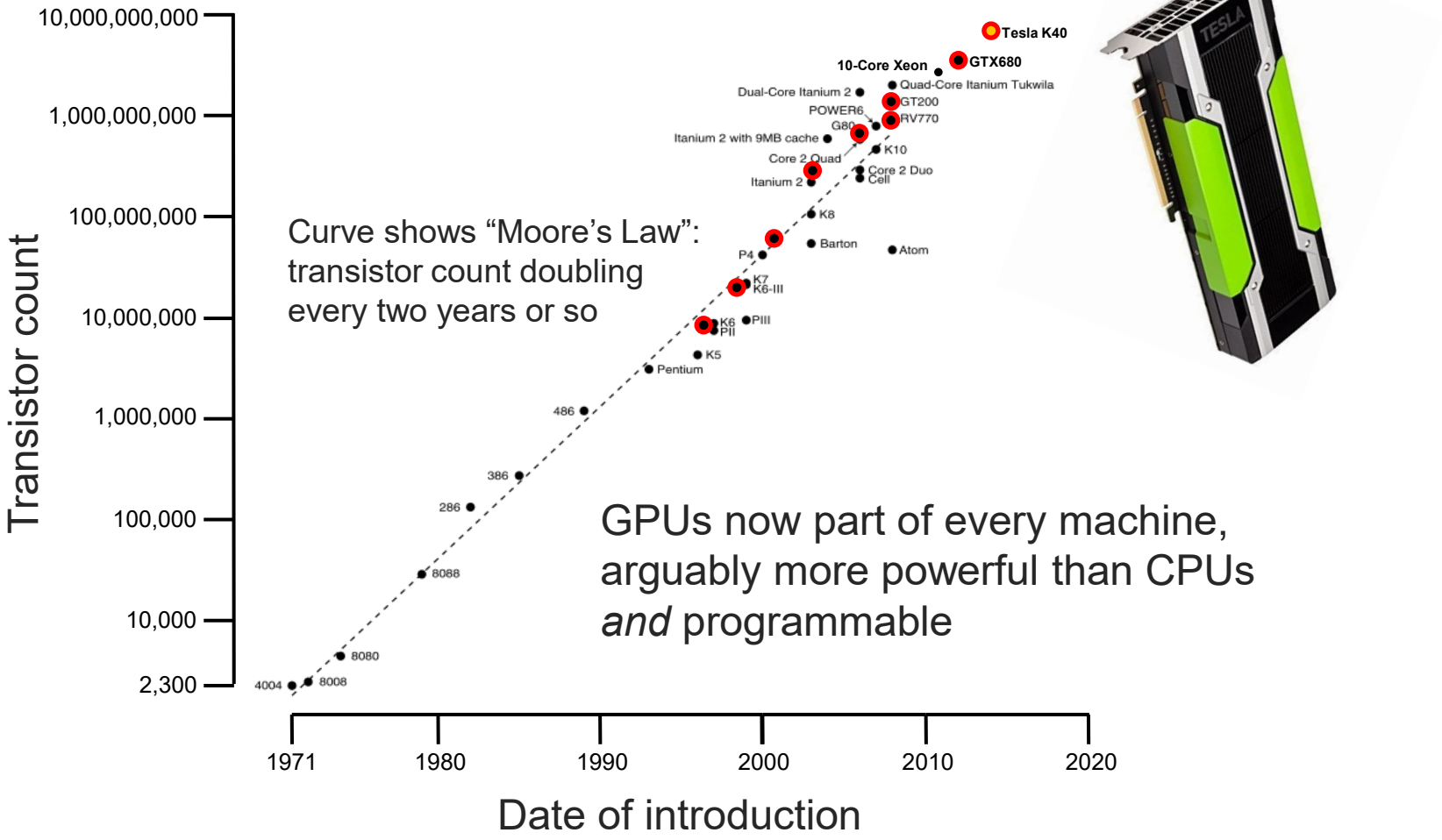


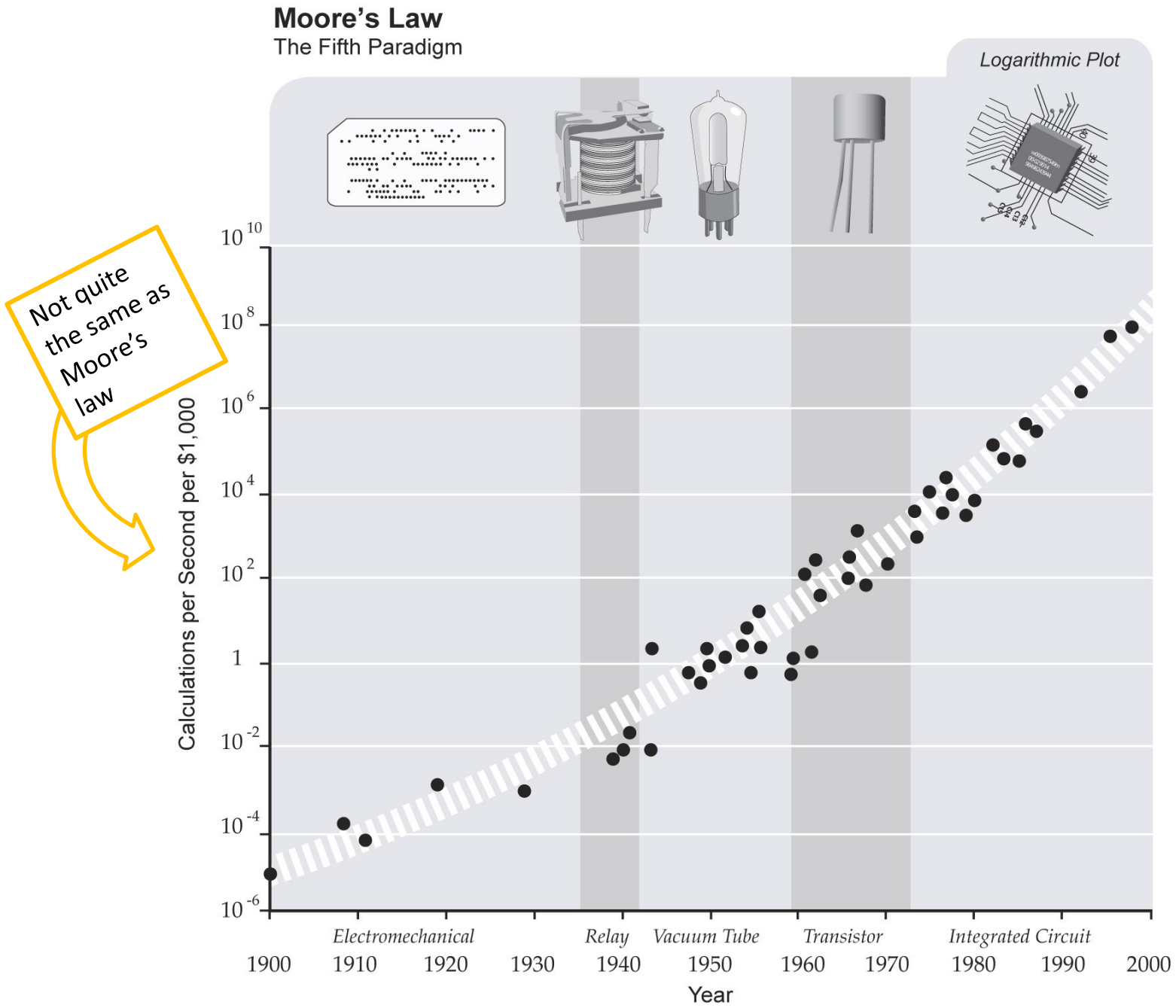
year	size (Mbit)
1980	1/16
1983	1/4
1986	1
1989	4
1992	16
1996	64
1998	128
2000	256
2002	512
2009	4096
2014	8192
2018	8192

- **Was 1.4X/yr, or 2X every 2 years.**
- **4000X from 1980 to 2002**

Technology Trends: Microprocessor Complexity

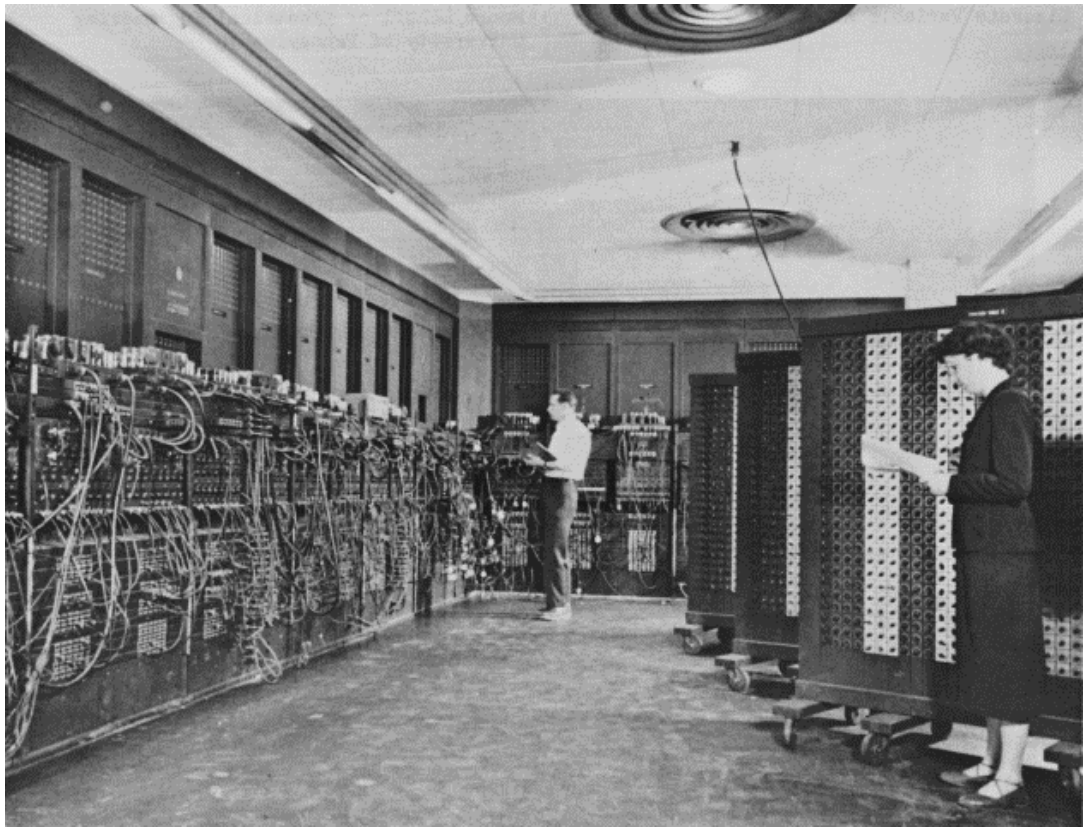
CPU Transistor Counts from 1971 and **Moore's Law**




Moore's Law
The Fifth Paradigm
Logarithmic Plot
Not quite the same as Moore's law
Calculations per Second per $1,000
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
Electromechanical
Relay
Vacuum Tube
Transistor
Integrated Circuit
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year

ENIAC

- First general-purpose electronic computer



If transportation had kept pace…

- How do the hardware predictions hold up?

The story back in 2000

- Processor
  - 2X in speed every 1.5 years (since ‘85);
    100X performance in previous decade.
- Memory
  - DRAM capacity: 2x / 2 years (since ‘96);
    64x size in previous decade.
- Disk
  - Capacity: 2X / 1 year (since ‘97)
  - 250X size in previous decade.

The story back in 2000

- State-of-the-art PC when you graduate:
  - Processor clock speed: 5000 MegaHertz (5.0 GigaHertz)
  - Memory capacity: 2000 MegaBytes (2.0 GigaBytes)
  - Disk capacity: 2000 GigaBytes (2.0 TeraBytes)
  - New units! Mega => Giga, Giga => Tera

2015 and shifting trends

- Energy efficiency now of major importance (mobile computing)
  - Faster clock speeds use too much energy
- Multi core CPUs now the means to increasing performance.
- Very powerful graphics cards now prevalent

3.5 GHz quad core
32 GB
3 TB
$3000

2688 cores, 0.8 GHz, 6 GB
$1000

Other Big Changes

- Smart phones and tablets
- Cloud computing and software as a service

COMP 273 – Course Information

- Learn big ideas in computer science and engineering:
  - 5 Classic components of a Computer
  - Data can be anything (integers, floating point, characters): a program determines what it is
  - Stored program concept: instructions just data
  - Principle of Locality, exploited via a memory hierarchy (cache)
  - Greater performance by exploiting parallelism
  - Principle of abstraction, used to build systems as layers

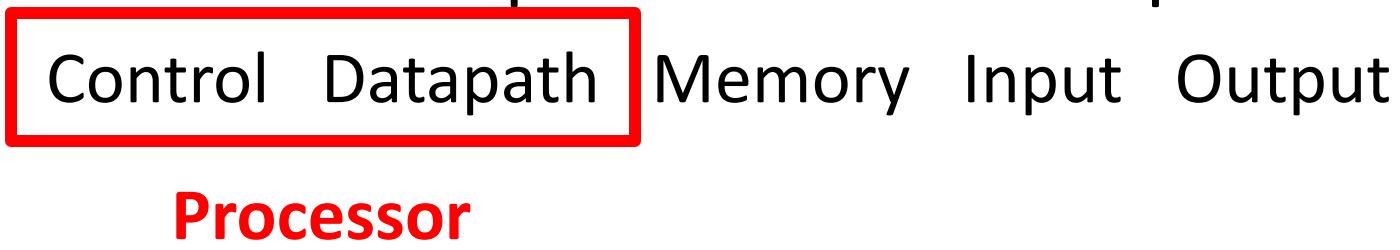
Objectives

- Demystify abstraction layers
  - What is really “under the hood”, how does it work?
- Take advantage of new found capabilities
  - Faster programs!
  - Many examples with impact in many domains!!
  - One example to motivate:
    - *“Computing the Singular Value Decomposition of 3x3 matrices with minimal branching and elementary floating point operations”*
      University of Wisconsin - Madison, Computer Science technical report TR1690, May 2011 ***(VIDEO)***

Production Rig

In Conclusion

- Hierarchical layers of abstraction
- Continued rapid improvement in technology
  - Moore's Law
- 5 classic components of all computers



Review and more information

- Textbook Chapter 1 (section numbers from 5th edition)
  - 1.1 Introduction
  - 1.2 Eight great ideas in computer architecture
  - 1.3 Below your program
  - 1.4 Under the covers
  - 1.5/1.6 Technology and Performance
    (we'll come back to later in the term)
  - 1.7 The power wall
  - 1.8 The sea of change: the switch to multiprocessors