The Hardware/Software Interface
CSE 351 Winter 2024

Instructor:
Justin Hsia

Teaching Assistants:
Adithi Raghavan
Aman Mohammed
Connie Chen
Eyoel Gebre
Jaawei Huang
Malak Zaki
Naama Amiel
Nathan Khuat
Nikolas McNamee
Pedro Amarante
Will Robertson

An x64 processor is screaming along at billions of cycles per second to run the XNU kernel, which is frantically working through all the POSIX-specified abstraction to create the Darwin system underlying OS X, which in turn is straining itself to run Firefox and its Gecko renderer, which creates a Flash object which renders dozens of video frames every second because I wanted to see a cat jump into a box and fall over.

I am a god.

http://xkcd.com/676/
Quarter Specifics
Course Staff

❖ Instructor: just call me Justin
  ▪ CSE Associate Teaching Professor
  ▪ Raising a toddler takes up energy and dictates my schedule

❖ TAs:

❖ More than anything, we want you to feel...
  ✓ Comfortable and welcome in this space
  ✓ Able to learn and succeed in this course
  ✓ Comfortable reaching out if you need help or want change
Bookmarks

❖ Website: [https://courses.cs.washington.edu/courses/cse351/24wi/](https://courses.cs.washington.edu/courses/cse351/24wi/)
   ▪ Schedule, policies, materials, tutorials, assignment specs, etc.

❖ Ed Course: [https://edstem.org/us/courses/50549/](https://edstem.org/us/courses/50549/)
   ▪ Discussion: announcements, ask and answer questions
   ▪ Lessons: lessons, practice problems, homework

❖ Linked from website and Ed
   ▪ Canvas: surveys, grade book, Zoom links
   ▪ Gradescope: lab submissions, take-home exams
   ▪ Panopto: lecture recordings
Grading

- **Lesson Problems:** 6%  
  - Can reveal solution after one attempt (completion)
- **Homework:** 20% total  
  - Unlimited submission attempts (autograded correctness)
- **Labs:** 40% total  
  - Last submission graded (correctness)
- **Exams:** Midterm (16%) and Final (16%)  
  - Take-home; individual, but some discussion permitted
- **EPA:** Effort, Participation, and Altruism (2%)
Support Hours

- Check Weekly Calendar on website for scheduled support hours:
  - In-person or virtual, but NOT hybrid
  - Zoom meeting links found in Zoom tab within Canvas

- All support hours will use a Google Sheets queue:
  - Fill out first 3 columns to enter queue:

- We encourage you to chat with other students if the TAs are busy!
In-Person Support Hours

- Allen 3\textsuperscript{rd} & 4\textsuperscript{th} floor breakouts
  - Up the stairs in the CSE Atrium (Allen Center, not Gates)
  - The open areas with the whiteboard walls are the breakouts!
Lecture Polls and Discussions

- Increase learning, test your understanding, increase student interactions, makes the class more engaging and fun
  - Lot of research supports its effectiveness:
- Polls on technical material will be multiple-choice and short answer
  - You haven’t mastered the material yet; mistakes are part of the process!
- Discussion questions will be more open-ended
  - Be respectful of others’ opinions and experiences
- Respond on Lecture Ed lesson for credit (extra late day tokens) and we will use random call to solicit live responses from audience
  - Don’t need to be correct, just want the feedback of what was discussed
To-Do List

❖ Admin
  ▪ Explore/read the course website *thoroughly*, especially the syllabus
  ▪ Check that you can access Ed Discussion & Lessons
  ❌ Get your machine set up to access the CSE Linux environment *(attu or cancun)* *as soon as possible*
  ▪ Optionally, sign up for CSE 391: System and Software Tools

❖ Assignments
  ▪ Pre-Course Survey and hw0 due Friday (1/5)
  ▪ HW1 and Lab 0 due Monday (1/8)
  ▪ Lessons quiz questions due 11:59 pm *after* the associated lecture
Binary and Numerical Representation
Lesson Summary

❖ Humans think about numbers in decimal; computers think about numbers in binary
  ▪ Base conversion: digit $d$ in position $i$ in base $b$ has a decimal value of $d \times b^i$
    • Changing bases does not change the value; just a different representation
  ▪ Hexadecimal (base 16, prefix 0x) is more human-readable than binary (base 2, prefix 0b)
  ▪ Unit of data in a computer is 1 byte = 8 bits = 2 hex digits

❖ Binary encoding can represent anything!
  ▪ Computer/program needs to know how to interpret the bits

<table>
<thead>
<tr>
<th>Base 10</th>
<th>Base 2</th>
<th>Base 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0b0000</td>
<td>0x0</td>
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<tr>
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<td>0b0001</td>
<td>0x1</td>
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<td>0b1010</td>
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<td>13</td>
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<td>0b1110</td>
<td>0xE</td>
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<tr>
<td>15</td>
<td>0b1111</td>
<td>0xF</td>
</tr>
</tbody>
</table>
Lesson Q&A

❖ Learning Objectives:

- Convert between binary, decimal, and hexadecimal number representations.
- Given an encoding scheme, decode and encode binary to/from its intended representation.
- Identify limitations of given encoding schemes.

❖ What lingering questions do you have from the lesson?

- Introduce yourself to your neighbors and chat about the lesson for a few minutes to come up with questions
Binary and Numerical Representation – Practice
Polling Questions

❖ What is the decimal value of the numeral 107₈?

- A. 71
- B. 87
- C. 107
- D. 568

❖ Represent 0b100110110101101 in hex.

❖ What is the decimal number 108 in hex?

- A. 0x6C
- B. 0xA8
- C. 0x108
- D. 0x612

❖ Represent 0x3C9 in binary.

- 0b001111001001
  - can add leading zeros
  - can drop leading zeros
Homework Setup

- Binary alphabet using five 4-bit numbers stacked on top of each other:
  
  0 1 1 0  
  1 0 0 1  

  0x69F99 → 1 1 1 1 →  
  1 0 0 1  
  1 0 0 1  

- What string of 5 hex digits represents a “C”?
  
  Other possibilities: 0xF888F
  0x78887
  0xE989E
Binary and Numerical Representation – Context
Why Base 2?

❖ Electronic implementation
  ▪ Easy to store with bi-stable elements
  ▪ Reliably transmitted on noisy and inaccurate wires

❖ Other bases possible, but not yet viable:
  ▪ DNA data storage (base 4: A, C, G, T) is hot @ UW
  ▪ Quantum computing
Binary Encoding – Colors

❖ RGB – Red, Green, Blue
  ▪ Additive color model (light): byte (8 bits) for each color
  ▪ Commonly seen in hex (in HTML, photo editing, etc.)
  ▪ Examples: Blue → 0x0000FF, Gold → 0xFFD700, White → 0xFFFFFFF, Deep Pink → 0xFF1493
# Binary Encoding – Characters/Text

- **ASCII Encoding** ([www.asciitable.com](http://www.asciitable.com))
  - American Standard Code for Information Interchange

<table>
<thead>
<tr>
<th>Dec</th>
<th>Hex</th>
<th>Oct</th>
<th>Char</th>
<th>Dec</th>
<th>Hex</th>
<th>Oct</th>
<th>Char</th>
<th>Dec</th>
<th>Hex</th>
<th>Oct</th>
<th>Char</th>
<th>Dec</th>
<th>Hex</th>
<th>Oct</th>
<th>Char</th>
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<td>Space</td>
<td>64</td>
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<td>#64:</td>
<td>96</td>
<td>60</td>
<td>143</td>
<td>#96:</td>
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<td>1</td>
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<td>21</td>
<td>033</td>
<td>'</td>
<td>65</td>
<td>41</td>
<td>041</td>
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<td>141</td>
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<td>'</td>
<td>66</td>
<td>42</td>
<td>042</td>
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<tr>
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<td>003</td>
<td>3</td>
<td>ETX (end of text)</td>
<td>35</td>
<td>23</td>
<td>035</td>
<td>'</td>
<td>67</td>
<td>43</td>
<td>043</td>
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<td>24</td>
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<td>'</td>
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<td>047</td>
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<td>047</td>
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<td>(unit separator)</td>
<td>0F</td>
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<td></td>
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<td>69</td>
<td>149</td>
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</tr>
</tbody>
</table>
Binary Encoding – Characters/Text

❖ ASCII Encoding (www.asciitable.com)
  ▪ American Standard Code for Information Interchange

❖ Created in 1963
  ▪ Memory was expensive, 32KB in brand new machines
  ▪ Economic incentive to use fewer bits for encoding

❖ Design Goals:
  ▪ Represent everything on an American typewriter as efficiently as possible
  ▪ Organize similar characters together
    • Numbers, uppercase, lowercase, then other stuff
Binary Encoding – Unicode & Emoji

❖ Unicode Standard is managed by the Unicode Consortium
  ▪ “Universal language” that uses 1-4 bytes to represent a much larger range of characters/languages, including emoji
  ▪ Adds new emojis every year, though adoption often lags: 🪖 (ninja)
    • https://emojipedia.org/new/

❖ Emojipedia demo: http://www.emojipedia.org
  ▪ Taco: 🌮 (added 2015)
  ▪ Code points: U+1F32E
  ▪ Display (as of 2023):
Discussion Question

❖ Discuss the following question(s) in groups of 3-4 students
  ▪ I will call on a few groups afterwards so please be prepared to share out
  ▪ Be respectful of others’ opinions and experiences

❖ The Unicode Consortium publicly solicits proposals from the public for new emoji to add to future standards
  ▪ What do you think some of the decision factors are (or should be) in how many and which ones to add?
  ▪ Voting is done by a combination of paid members consisting of companies, institutions, and individuals – how do you feel about who has control and how they gained that control?
    • https://home.unicode.org/membership/members/
Group Work Time

❖ During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the homework problems
  3) Work on the lab (if applicable)

❖ Resources:
  ▪ You can revisit the lesson material
  ▪ Work together in groups and help each other out
  ▪ Course staff will circle around to provide support