CMPSC210
Lesson 2: Under the Hood

Prof. John Wenskovitch
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Last Time

• Lots of types of computers
• Von Neumann architecture
• Development of the transistor
• Decadal technology revolutions
Under the Hood

• Or, “what happens when I click compile?”

• What we’ll cover today:
  – An overview about computer hardware (boring knowledge review stuff)
  – A quick introduction to C programming
  – A quick introduction to C compilation
What’s Inside My Computer?

Motherboard
– printed circuit board with expansion capability, connects all major components together

CPU (Central Processing Unit)
– carries out the instructions of a computer program (both logical and arithmetic)

RAM (Random Access Memory)
– volatile data storage, relies on integrated circuits, major types include DRAM, SRAM

HDD (Hard Disk Drive)
– nonvolatile data storage, defined by capacity and performance, being phased out by flash memory

Optical drive, floppy drive, flash drive
– nonvolatile data storage, “secondary storage,” not directly accessible by the CPU

Video cards and other peripheral cards
– provide access between CPU and components outside the tower
What Else Gets Hooked Up?

Monitor – electronic visual display, used to view output of computations

Keyboard & mouse – facilitate user input to computations, either text or location interactions supported

Printer – peripheral which makes a persistent, human-readable representation of graphics or text on paper or similar media

Other peripherals – webcams, microphones, speakers, barcode reader, scanner, etc.
Back to Von Neumann
Volatile vs. Non-volatile

**Volatile**
- Information is gone following a power loss
- Electric storage
- Examples:
  - RAM, CPU cache

**Non-volatile**
- Can retrieve stored information after losing power
- Mechanical storage
- Examples:
  - HDD/SSD
  - CD/DVD/floppy/flash
Why have both RAM and HDD? (Price)
Why have both RAM and HDD? (Speed)
### RAM vs. HDD (summary)

<table>
<thead>
<tr>
<th>Device</th>
<th>PROs</th>
<th>CONs</th>
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</thead>
<tbody>
<tr>
<td>Hard Disk Drive (HDD)</td>
<td>• High Capacity</td>
<td>• Slow relative access time</td>
</tr>
<tr>
<td></td>
<td>• Low Cost/MB</td>
<td>• Slow relative data rate</td>
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<tr>
<td></td>
<td>• Nonvolatile</td>
<td></td>
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<tr>
<td>Solid State Drive (SDD)</td>
<td>• 5x faster read rate vs. HDD</td>
<td>• Expensive</td>
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<tr>
<td></td>
<td>• 50x faster than HDD for small files</td>
<td>• 20x lower capacity than a HDD</td>
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<tr>
<td></td>
<td>• Nonvolatile</td>
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<tr>
<td>RAM Disk</td>
<td>• Up to 50x faster than HDD for large files</td>
<td>• Uses a portion of System RAM</td>
</tr>
<tr>
<td></td>
<td>• Up to 200x faster than HDD for small files</td>
<td>• Low capacity; 2-8GB typical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Volatile</td>
</tr>
<tr>
<td>RAM Cache</td>
<td>• Faster than a RAM Disk</td>
<td>• Uses a portion of System RAM</td>
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Operating Systems

- **Operating System** – “software that manages computer hardware and software resources, and provides common services for computer programs”

- **Examples:**
  - Windows
  - UNIX/Linux
  - Mac OS X
  - FreeBSD
  - Solaris
Systems Software

• **Systems Software** – “Software that provides services that are commonly useful, including operating systems, compilers, loaders, and assemblers.”

• **Compiler** – “A program that translates high-level language statements into assembly language statements.”

• **High-level language** – C, C++, Java, VB

• **Assembly language** – “A symbolic representation of machine instructions.”
• **Machine Instructions** – Individual computations performed by the CPU, expressed in a binary representation called machine language.
Compilation (Java)

- Write the .JAVA file
- Run the .CLASS file

- In C, it’s similar:
  - Write the .C file
  - Run the executable
Compilation (C)

```c
#include <stdio.h>
#define STRING "Hello world"

int main(void) {
    printf(STRING);
    return 0;
}
```
gcc

• “GNU Compiler Collection”

• To compile:
  – gcc myprogram.c

• More options:
  – gcc myprogram.c –Wall –o run.out

• To run:
  – ./run.out
Four Stages of Compilation

- Preprocessing
- Compiling
- Assembly
- Linking
1. Preprocessing

- Macro substitution
- Comments stripped away
- Expansion of included files

```
gcc -Wall -save-temps helloworld.c -o helloworld.out
```

- `helloworld.i` contains preprocessed output
2. Compiling

- **Lexical Analysis** – transforms the code into a sequence of tokens
- **Parsing** – Checks to be sure that the code isn’t breaking any syntax rules
- **Semantic Analysis** – Takes the sequence of tokens from Lexical Analysis and builds a syntax tree
- **Output Generation** – Output in target representation

• helloworld.s contains the output from this stage
3. Assembly

- Produces an object file (.o)
- Contains machine-level instructions
- ELF – Executable and Linkable Format
4. Linking

- Plugs in addresses of external functions (previously just placeholders)
- Adds code for setting up and closing down the running environment
- Lots of other stuff that we won’t worry about right now
Any Questions?
Material Credits

- HP sections 1.2, 1.3
- “Computer Hardware Pictures” (http://computer.howstuffworks.com/computer-hardware-pictures.htm)
- “Motherboard” (https://en.wikipedia.org/wiki/Motherboard)
- “Central Processing Unit” (https://en.wikipedia.org/wiki/Cpu)
- “Mouse (computing)” (https://en.wikipedia.org/wiki/Mouse_%28computing%29)
- “Printer (computing)” (https://en.wikipedia.org/wiki/Printer_%28computing%29)
- RAM vs HDD: (http://www.storagereview.com/introduction_ram_disks)
- “GCC, the GNU Compiler Collection” (https://gcc.gnu.org/)
- “Journey of a C Program to an Executable” (http://www.thegeekstuff.com/2011/10/c-program-to-an-executable/)
Image Credits

- Slide 4: What’s Inside My Computer?
  (http://upload.wikimedia.org/wikipedia/commons/a/ac/Computer_from_inside_018.jpg),
  (http://computer.howstuffworks.com/computer-hardware-pictures.htm),
  (http://computersales-serviceschennai.com/wp-content/uploads/2014/01/optical-drives.png),

- Slide 5: What Else Gets Hooked Up?
  (http://atechbuzz.com/wp-content/uploads/2014/03/Pc.jpg),
  (http://www.all-about-computer-parts.com/image-files/lcd_monitor1.jpg),
  (http://www.logitech.com/assets/45638/us-glamour-lg.png),
  (http://www.wpclipart.com/computer/mouse/computer_Mouse.png),
  (http://www.computeworldaz.com/images/22001.jpg)

- Slide 8: RAM vs HDD Price:

- Slide 9: RAM vs HDD Speed:
  (http://www.storagereview.com/images/ramdiskarticle1.jpg)

- Slide 10: RAM vs HDD Summary:
  (http://www.storagereview.com/introduction_ram_disks)

- Slide 11: Operating System
  (https://upload.wikimedia.org/wikipedia/commons/thumb/e/e1/Operating_system_placement.svg/500px-Operating_system_placement.svg.png)