Lecture 4

This lecture was a bit of a side-step from the regular material -- we primarily discussed power consumption in the context of computers.

Some hardware history

- vacuum tubes
    - automatic switch for completing/breaking electron flow
    - big enough to change with your hands if the tube burns out

    [diagram]

- battery
    - Modern computing started when we found a way to close a circuit NOT manually (able to automate it using electric currents)

    [diagram]

- transistor
    - does not deal well with heat (stops isolating electricy if it gets hot enough)
    - current on/off
    - micro

    [diagram]

Power Consumption/Power Wall

- The power wall is a major factor in why we can't make our CPUs faster and faster
    - Before, making CPU faster was a matter of increasing frequency (fastest we got to was 5 GHz)
    - Problem: each cycle has an electrical cost. Electricity heats up your wire with the energy lost during transfer
    - More GHz --> hotter
    - Remember: the transistor can only get so hot before it starts malfunctioning and leaking electricity
    - Solution 1: Heat sink, a piece of copper/metal that easily transfers heat, placed on top of the CPU to disseminate as much heat as possible
    - Solution 2: cooler (fans, cooling units, etc)
    - Solution 3: Drop frequency when CPU gets too hot (modern CPUs do this)

    - Problem: Cannot cool modern CPUs sufficiently, so, how do we not heat them in the first place?

- Solution 1: Decrease voltage (less electricity to the CPU --> less heat)
- Problem: at too low voltage, transistors leak through through the closed circuit
- Leakage is always there, but it becomes too significant at low enough voltage (hard to tell between 0 and 1)

Takeaway: Modern engineers are trapped between these two walls: high frequency (over-heating) and low voltage (leakage)

- Other walls: memory wall (RAM is so slow, doesn't matter how fast CPU is)

Miscellaneous note: military computers have very bad specifications sometimes (low frequency, etc.) because they want the computers to function in a large range of conditions/temperatures