Algorithms

Part 2: Measuring Time
Reminders

Reading:
Emma reading (+ videos) - Reading Reflection due Mon 9/25
Has two short embedded videos - watch these too!

Homework 2:
Due Wednesday, 9/27 - practice for the midterm!

Lab 6:
Pre-Lab work before Friday
Importance of Understanding Algorithms

Algorithms have been studied for thousands of years

Intensity of study has exploded in last few decades

Why?
People compute at 1-2 medium-sized multiplications (5 digit) per minute

In 1965, IBM shipped the first IBM System/360 (model 40):
- 133,300 fixed-point additions/sec
- 12,000 fixed-point multiples/sec

Project manager was Fred Brooks - Professor at UNC (was chair of UNC Dept of Computer Science for 20 years)

**Question**: How fast are the fastest computers now?
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In June 2017 the most powerful computer on earth could do 93,015,000,000,000,000 calculations per second (93.015 petaflops).

See http://www.top500.org/

Thinking about computations on this scale is incredibly different from thinking about computations at a few calculations per minute.
How Computing Power Has (and Will) Grow

Example from 2012:
$400 computer, 2.71 Gflops
Approx. $6.8 x 10^9 ops/$1000
... and
... can be more cost effective

Moore's Law: Computing power doubles every 1.5 years (or 2 years, depending on version)

From:
http://www.singularity.com/charts/page70.html
Problems are defined by input/output relation, with no reference to how they are solved (*focus is on what*)

Algorithms are well-defined computational procedures that solve problems (*focus is on how*)

Problem specifier worries about input and outputs
Implementer / algorithm designer worries about the computational process
This is an over-simplification: Sometimes the user wants to know some properties of the block implementation.

**Question:** What kinds of properties?
Algorithm Characteristics

- Does the algorithm work correctly (does it solve the problem)?
- Is the answer provided precise?
- How confident are you in the correctness of the algorithm and implementation (simpler algorithms are easier to verify)?
- How much memory does the algorithm require?
- How fast is the algorithm?
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- How fast is the algorithm?

Assume no problems with correctness or precision for now.

Memory is a problem for some algorithms, but not as common a limiting factor as...

Time is usually the most interesting and limiting characteristic, whether talking about running a big computation for a week, or calculating a new graphics frame in 1/30 of a second.
What is "time" for an Algorithm?

Time is time, right?

But...

- Does time depend on things other than the algorithm?
- If run many times (on the same input), is time always the same?
- If QuickSort runs in 20 seconds on my old IBM PC, and SelectionSort runs in 0.5 seconds on my current computer, is SelectionSort a faster algorithm?
- Can we give clock time without implementing the algorithm?
Correcting for vagueness of timing

Wall-clock times depend on:

- Speed of computer that it's run on
- What else is happening on the computer
- ... and a few other things we'll address later

But... these are not differences in algorithms!

**Solution**: Algorithms are sequences of steps, so count steps!

**Question**: We discussed steps earlier - so what's a step?
Snap! blocks and "steps"

Which of these should not be treated as "one step"?

a) set variable to 15
b) sum + value
c) add 15 to list
d) list contains 412
e) sqrt of 10
Experimenting with timing Snap! scripts

Timer is available to help test things out

- Reset timer to start it at zero
  
- Save current timer value into a variable for "lap timer"

- Watch variable shows limited precision - for more use "say"

- Tip: surround only what you're interested in timing with reset/set blocks (not initializations)
Summary

*Time* is one of the most important algorithm characteristics.

An “algorithm” should be independent of what runs it:

→ So measure time in steps, not seconds.

But - when you want time in seconds for a specific implementation, Snap! gives you tools to measure that.