Class 1: Introduction

cs4414 Spring 2014

rust-class.org

University of Virginia

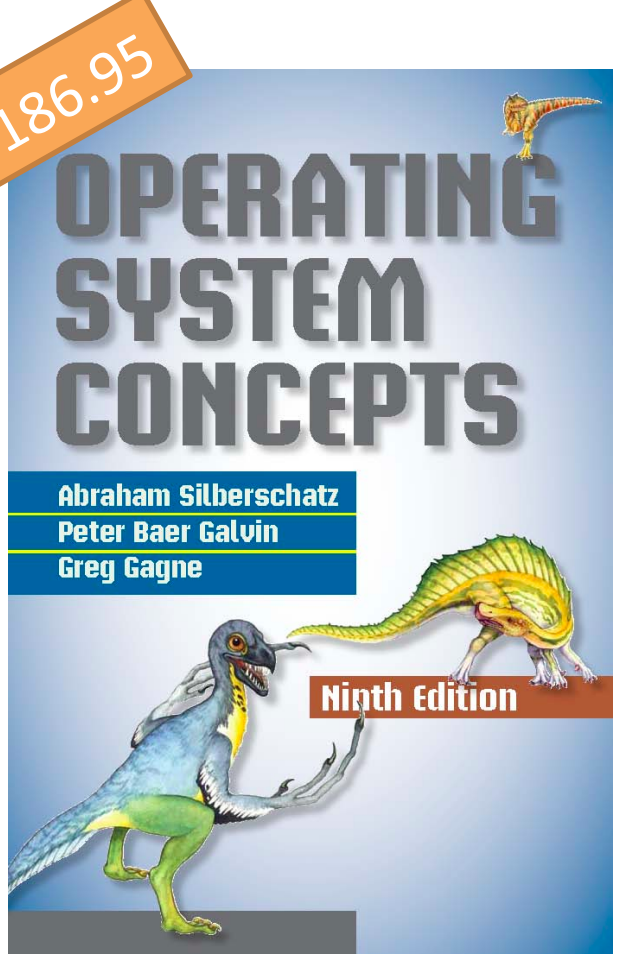
David Evans

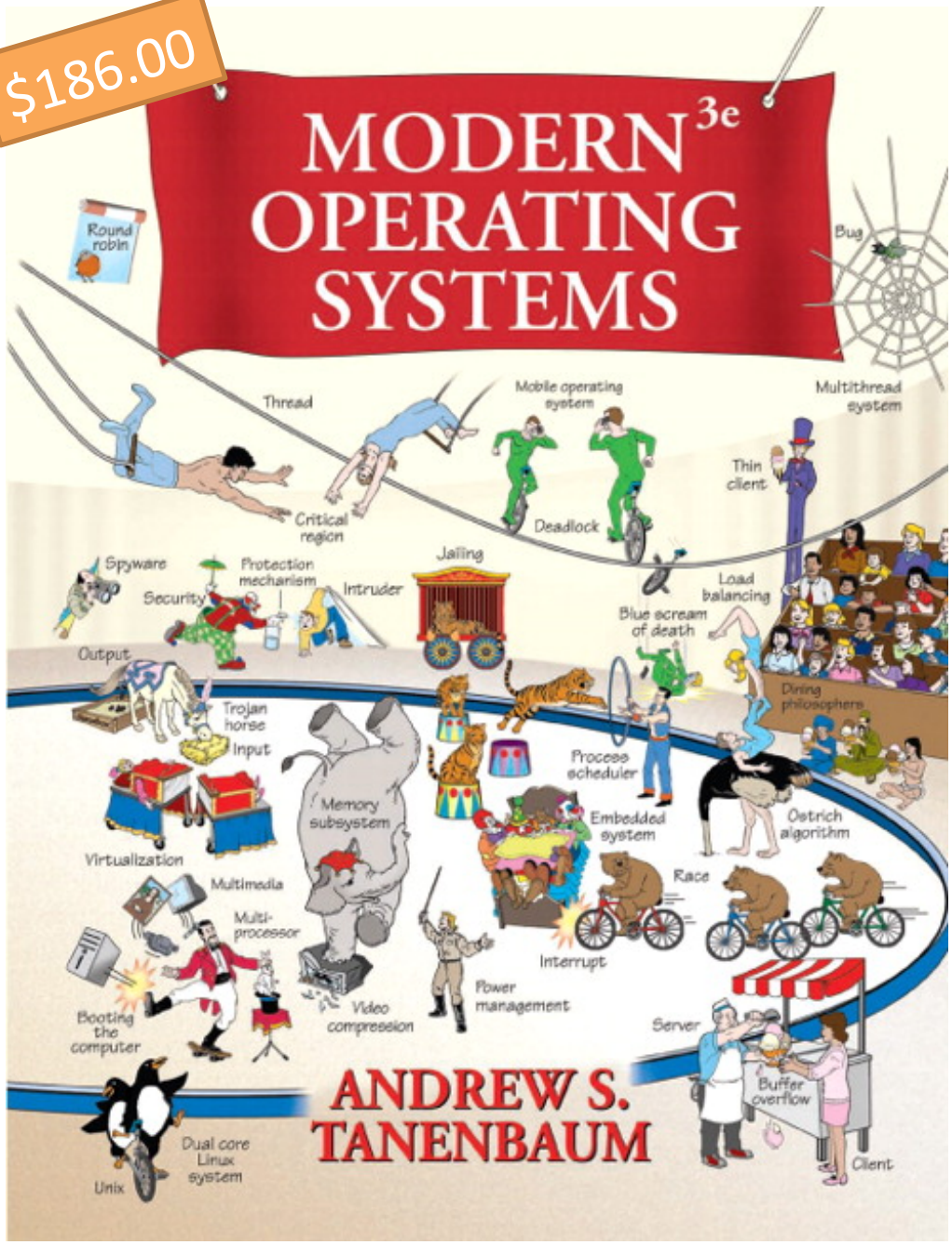
Plan for Today

- What is an Operating System?
- Course Overview
- Introducing Rust

What is an Operating System?

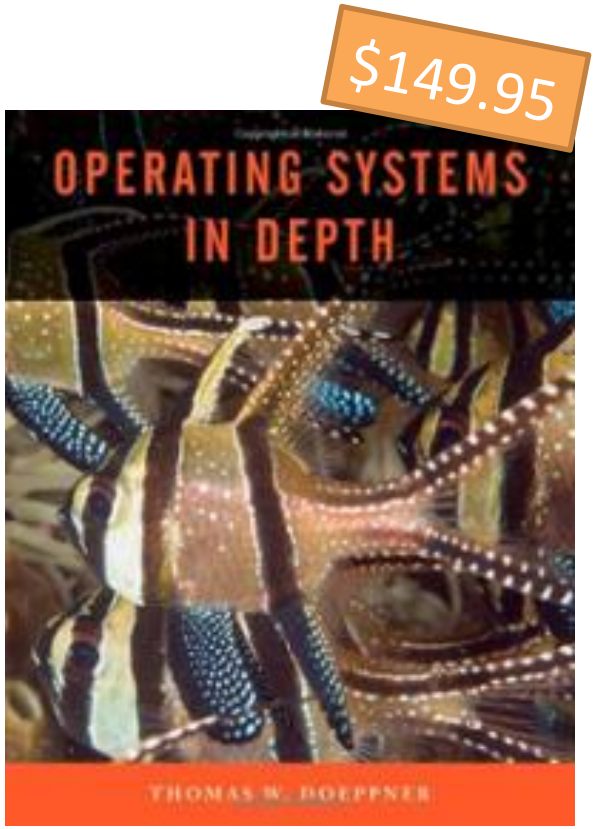
An **operating system** is a program that manages a computer's hardware. It also provides a basis for application programs and acts as an intermediary between the computer user and the computer hardware. An amazing aspect of operating systems is how they vary in accomplishing these tasks. Mainframe operating systems are designed primarily to optimize utilization of hardware. Personal computer (PC) operating systems support complex games, business applications, and everything in between. Operating systems for mobile computers provide an environment in which a user can easily interface with the computer to execute programs. Thus, some operating systems are designed to be **convenient**, others to be **efficient**, and others to be some combination of the two.





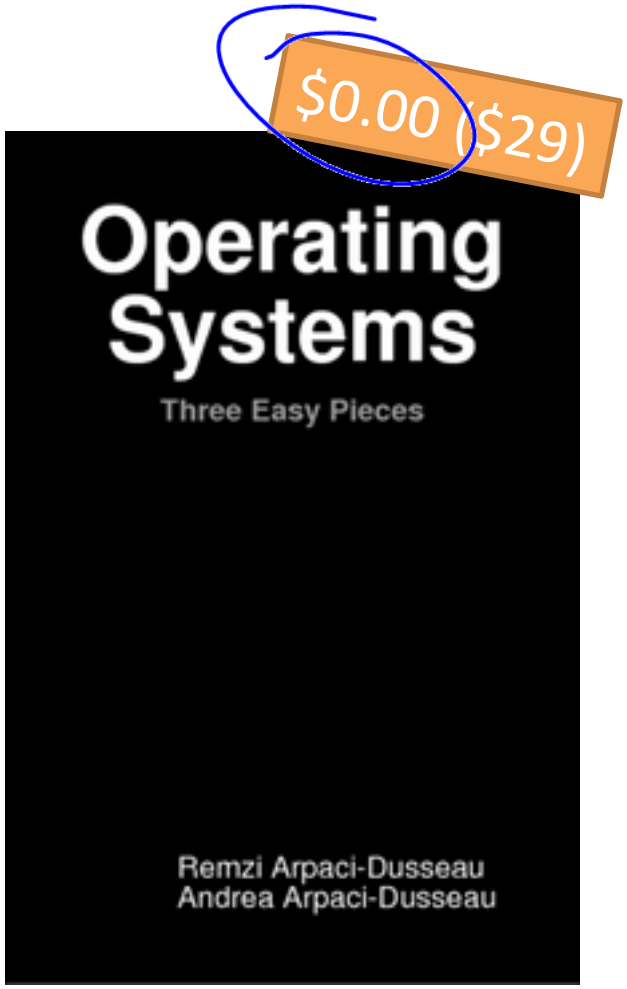
It is hard to pin down what an operating system is other than saying it is the **software that runs in kernel mode** – and even that is not always true. Part of the problem is that operating systems perform two basically unrelated functions: providing application programmers (and application programs, naturally) a clean abstract set of resources instead of the messy hardware ones and managing these hardware resources.

What's an operating system? You might say it's what's between you and the hardware, but that would cover pretty much all software. So let's say it's the software that sites between your software and the hardware. But does that mean that the library you picked up from some web site is part of the operating system? We probably want our operating-system definition to be a bit less inclusive. So, let's say that **it's that software that almost everything else depends upon.** This is still vague, but then the term is used in a rather nebulous manner throughout the industry.



Perhaps we can do better by describing what an operating system is actually supposed to do. From a programmer's point of view, **operating systems provide useful abstractions of the underlying hardware facilities.** Since many programs can use these facilities at once, **the operating system is also responsible for managing how these facilities are shared.**

There is a body of software, in fact, that is responsible for making it easy to run programs (even allowing you to seemingly run many at the same time), allowing programs to share memory, enabling programs to interact with devices, and other fun stuff like that. That body of software is called the **operating system**, as it is in charge of making sure the system operates correctly and efficiently in an easy-to-use manner.



Do we like any of these definitions?

def·i·ni·tion *noun* \ˌde-fə-ˈni-shən\

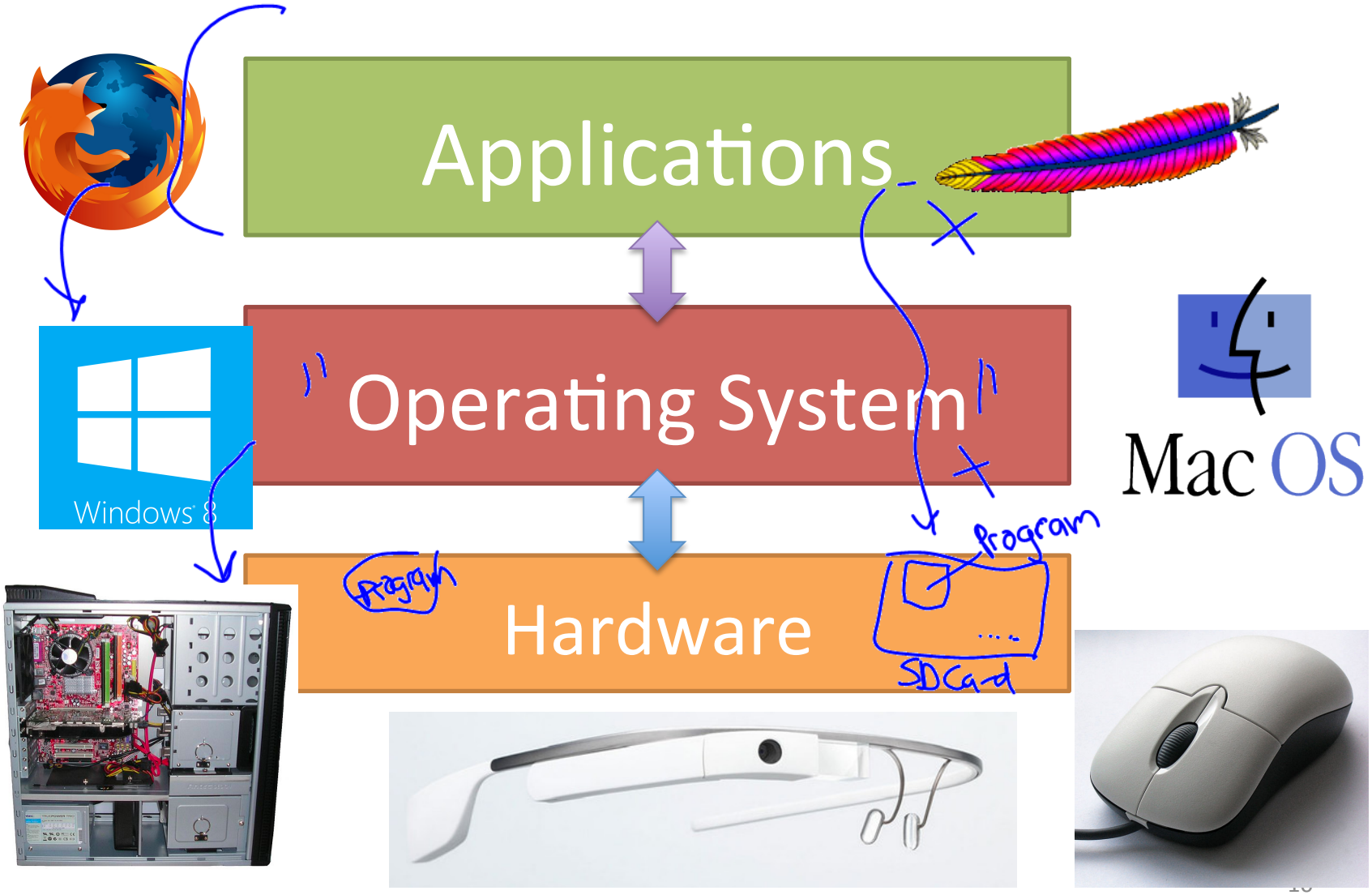
: an explanation of the meaning of a word, phrase, etc. : a statement that defines a word, phrase, etc.

: a statement that describes what something is

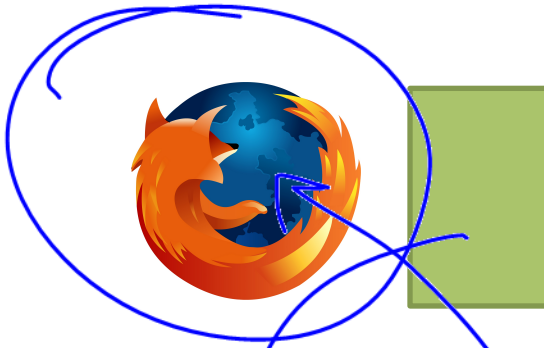
: a clear or perfect example of a person or thing

http://www.merriam-webster.com/dictionary/definition

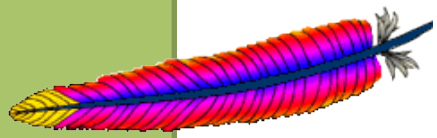
Simplistic View of Computing Systems



More Realistic View



Applications



Operating System

Hardware

cs4414 OS Definition

An **operating system** is a program that **manages resources** and **provides abstractions.**

Main Ideas in cs4414

Managing Resources

How do you share processors, memory, and hardware devices among programs?

Providing Abstractions

How do you provide programs with clean and easy to use interfaces to resources, without sacrificing (too much) efficiency and flexibility?

Does it have an Operating System?

Apple II
1977


diskware™
diskware™
DOS 3.3
SYSTEM MASTER
© APPLE 1980
disk II™

✖ Manage Resources
✔ Provide Abstractions

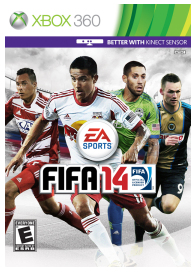
Not just one operating system, but dozens of them!

Does it have an Operating System?

① Provide abstractions (to programs)

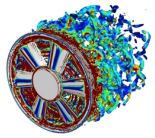
② Manage resources

Course Overview



Google

DuckDuckGo



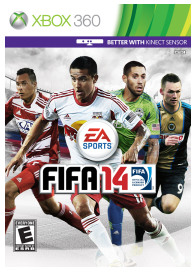
HealthCare.gov
Take health care into your own hands

Cool Computing Stuff

Its all magic!

Physics

Minimizing Magic



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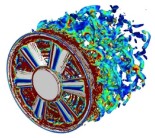

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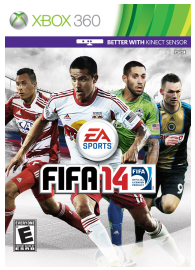
Four Years Studying Computing at an Elite Public University

Physics

Minimizing Magic



Google

DuckDuckGo

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Cool Computing Stuff

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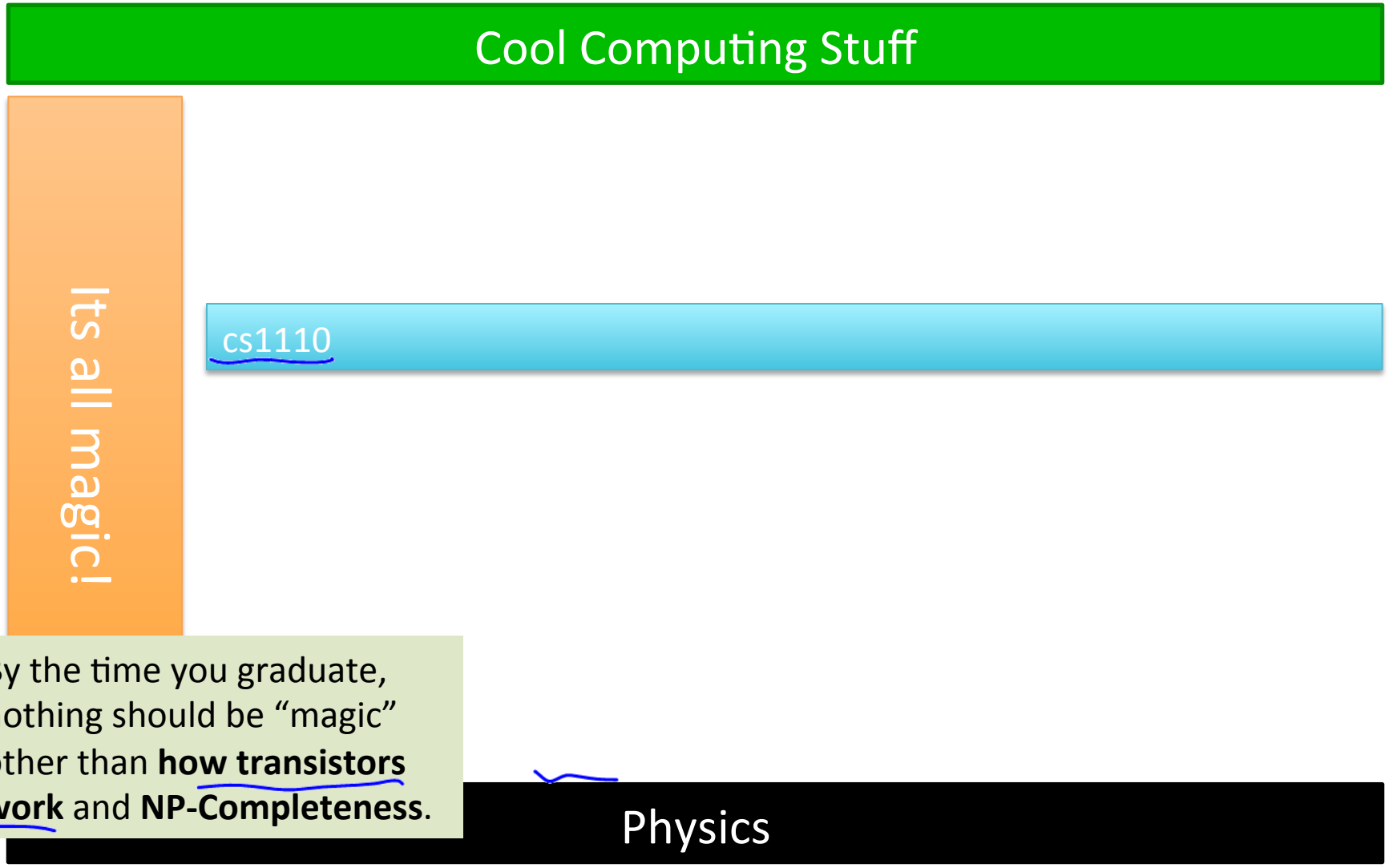
Four Years Studying Computing at an Elite Public University

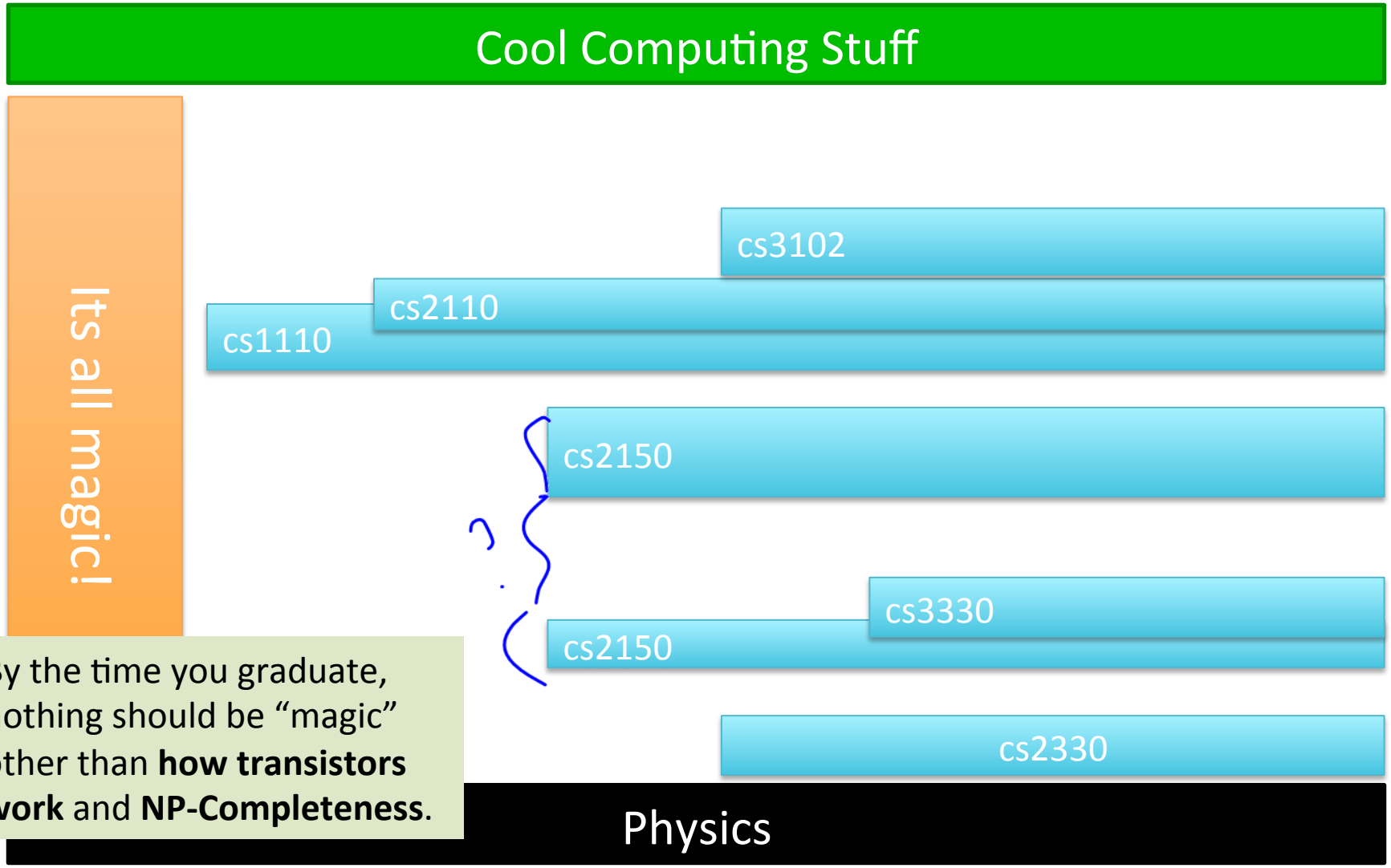
Its all understandable!
(and I can do magical things!)

Physics

Minimizing Magic

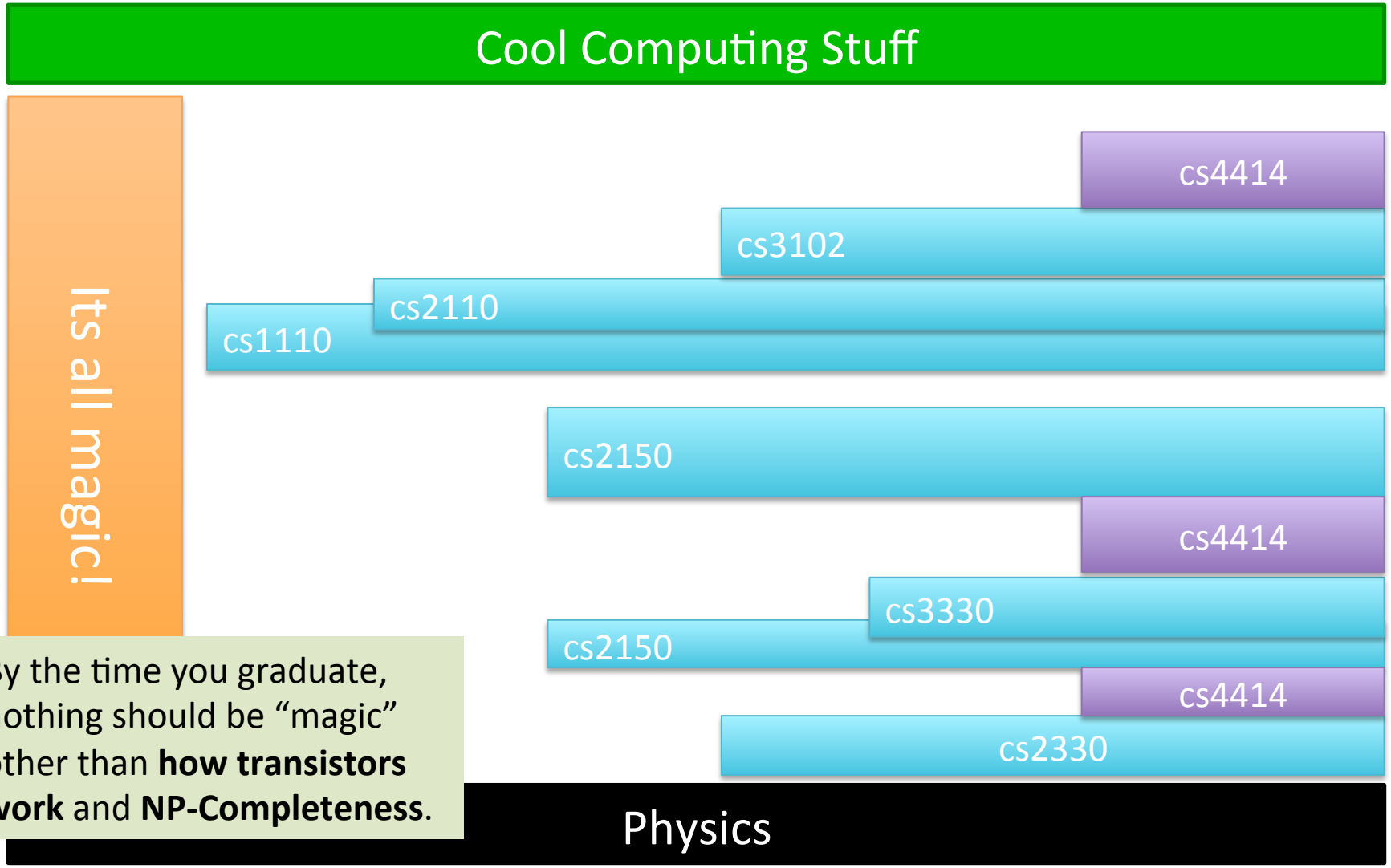


Minimizing Magic



By the time you graduate, nothing should be "magic" other than **how transistors work** and **NP-Completeness**.

Minimizing Magic



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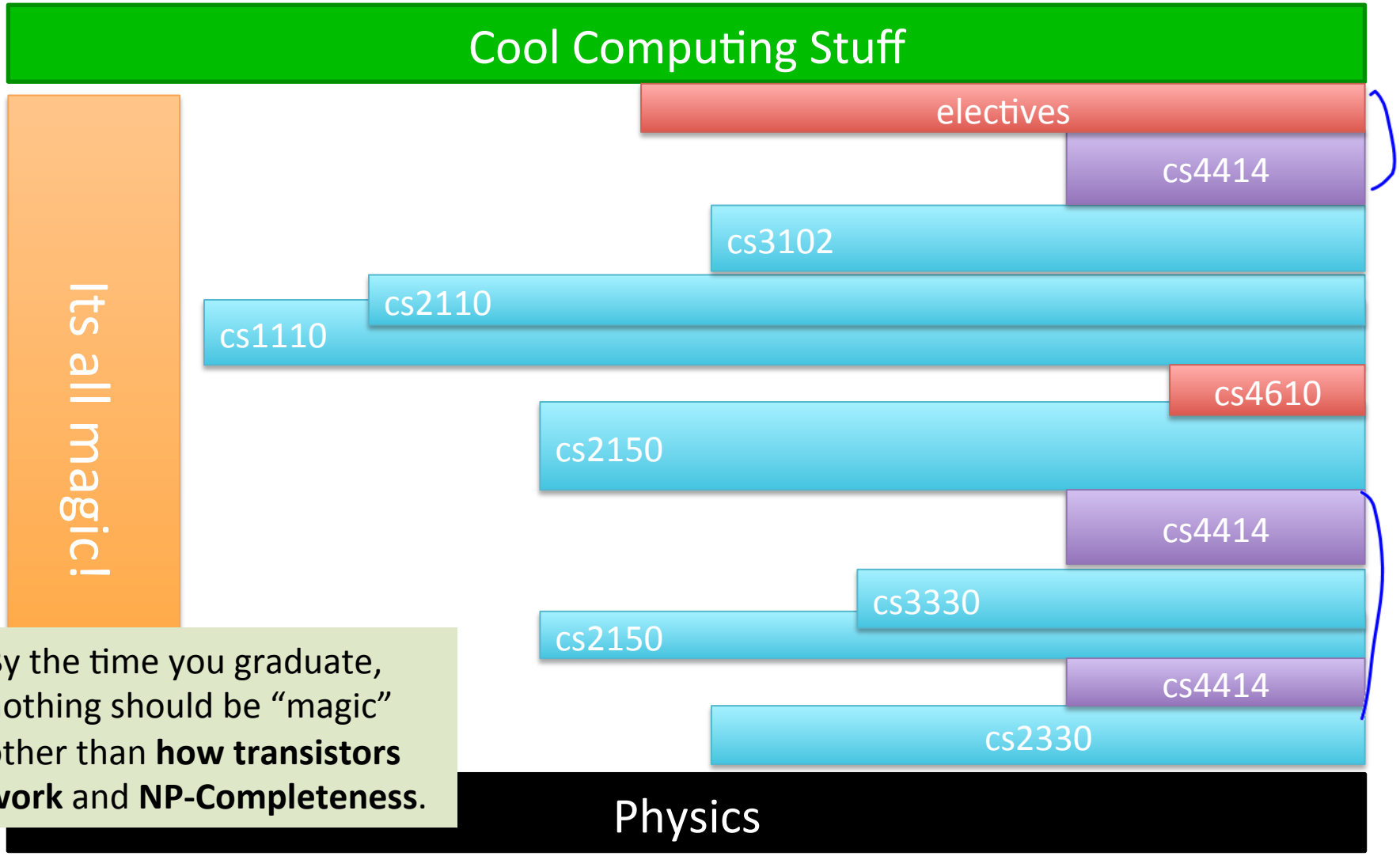
Minimizing Magic



Minimizing Magic

(Academic) Goal of the Class

Improve our understanding of how computers work.

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Not: Learn how to build an Operating System

Learn about Rust

Why bother?

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1. Better understanding of how computers work make you a **better programmer** which will help you build something cool, succeed in grad school, or get a more interesting job.

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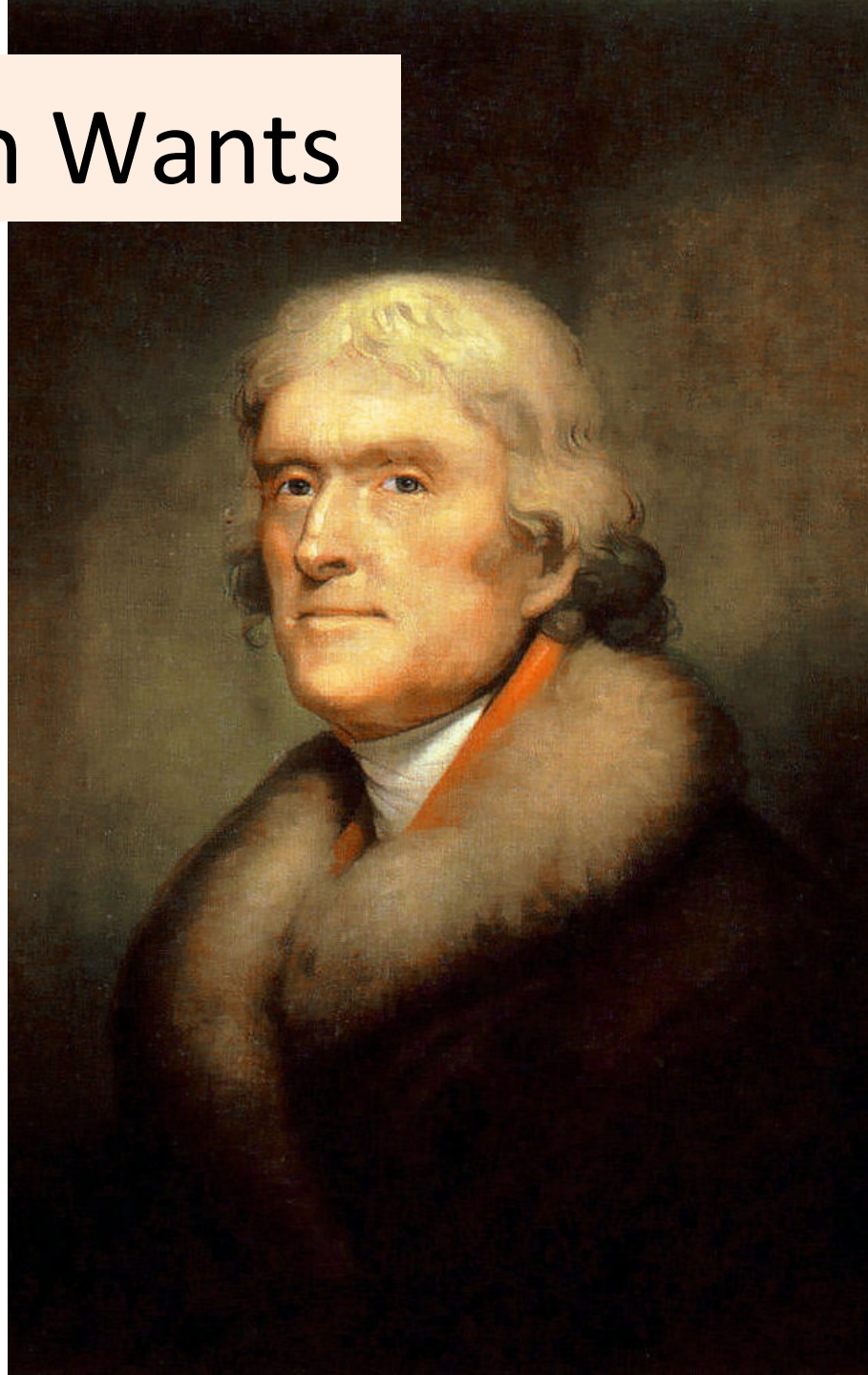
2. Better understanding of how computers work (and why) is **intellectually**, **culturally**, and **scientifically interesting.**

If these reasons don't apply for you and you are only in this class because there is a **bureaucratic requirement** that you take it so some Dean will hand you a nice bit of paper in front of your parents, you should meet with me to figure out an alternative.

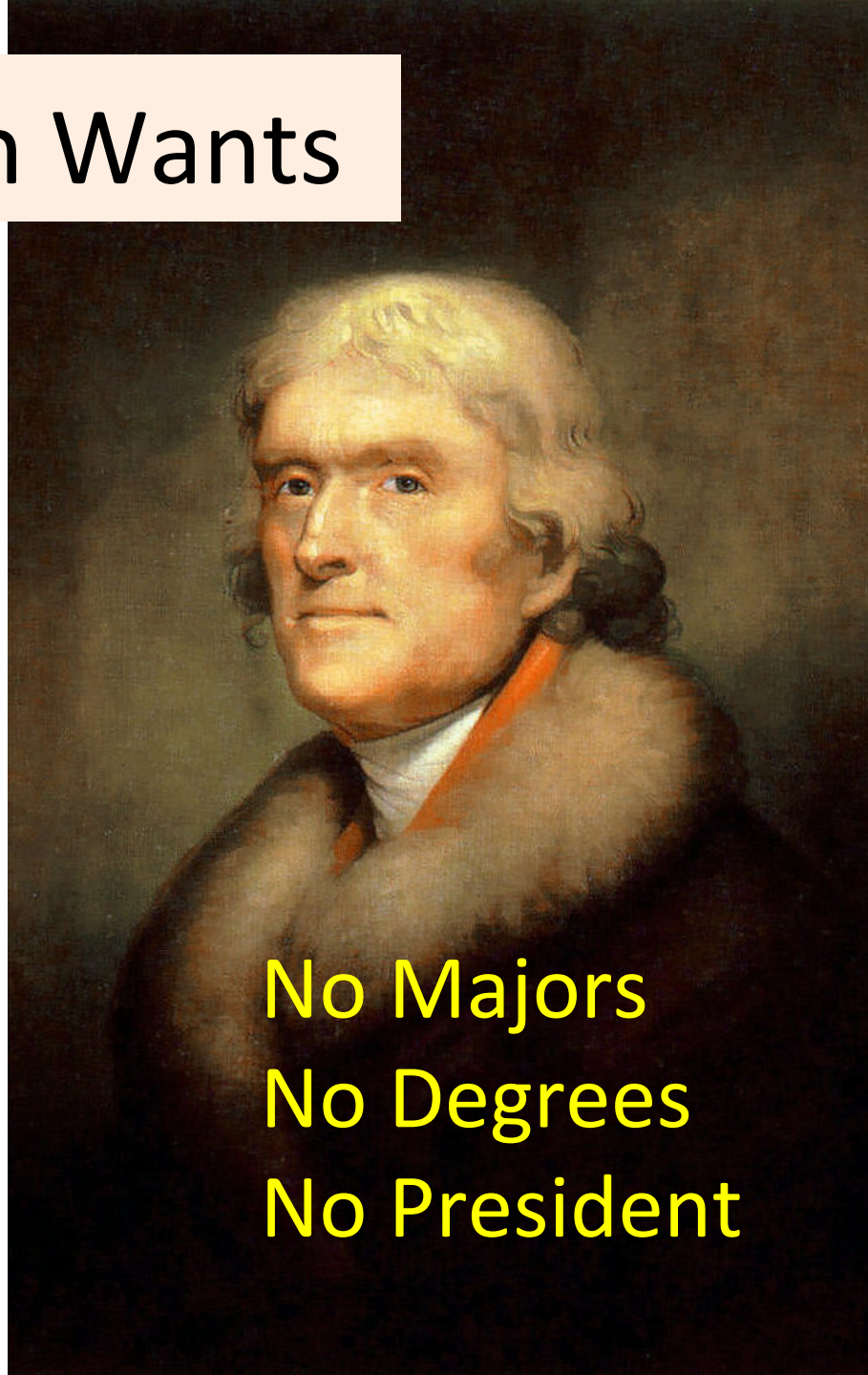
What Mr. Jefferson Wants



What Mr. Jefferson Wants

"We wish to establish in the upper country of Virginia, and more centrally for the State, **a University** on a plan **so broad and liberal and modern**, as to be **worth patronizing with the public support**, and be **a temptation to the youth of other States to come and drink**…"

TJ's letter to Joseph Priestly, 1800



Note: this does not mean he wants you to be lazy:

Thomas Jefferson enrolled in the College of William and Mary on March 25, 1760, at the age of 16… By the time he came to Williamsburg, the young scholar was proficient in the classics and able to read Greek and Latin authors in the original… He was instructed in natural philosophy (**physics**, **metaphysics**, and **mathematics**) and moral philosophy (**rhetoric**, **logic**, and **ethics**). A keen and diligent student, he displayed an avid curiosity in all fields and, according to family tradition, **he frequently studied fifteen hours a day**.

http://www.wm.edu/about/history/tjcollege/tjcollegelife/

What is my goal for lectures?

Convey some ~~complex technical~~ ideas

Teach you what you need to know to do the projects

Avoid being fired

Keep most of you awake for 75 minutes

Get you to laugh at dumb jokes

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Monty Python is **funnier** (unless you are Kevin Redmon)

My **Real Goal** for Lectures

Provide **context** and **meaning** for the things you have or will later **learn on your own**.

(I also have an insidious goal for lectures, that I won't tell you about until later…)

Course Assignments

The Problem Sets are **Suggestions**

If you have a **better idea**, convince me, and you should **do that instead**.

Plan for Projects

PS0 (Friday): Rust tutorial and course survey

PS1 (23 Jan): **zhttpto** web server

PS2 (9 Feb): gash (learn about processes)

PS3 (3 March): zhtta web server (learn about synchronization, memory management)

PS4 (2 April): hacking a (relatively simple) kernel

This generation of students got into "UVa" by doing exactly and precisely what teacher wants. If teacher is vague about what he wants, they work a lot harder to figure out what they want and whether or not it is good. **The vaguer the directions, the more likely the opportunity for serendipity to happen. It drives them nuts!**

Harvard Professor John Stilgoe
(on "60 Minutes", 4 January 2004)

Final Project

Final Project (29 April):
(almost*) anything you want!

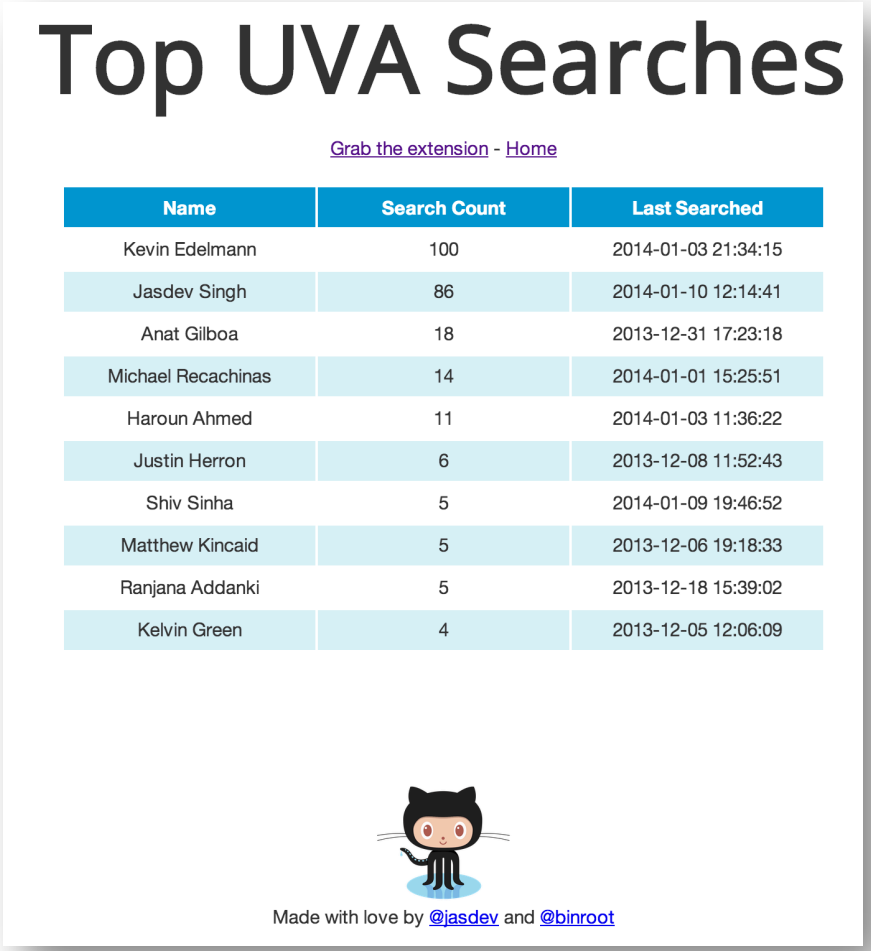
* must be at least two of:
  fun, technically interesting,
  useful, relevant

Start thinking of ideas now – if you come up with something sufficiently worthwhile, can substitute for PS4/PS3/PS2/etc.

Some Examples

http://uvasear.ch/

Nishant Shukla
Jasdev Singh



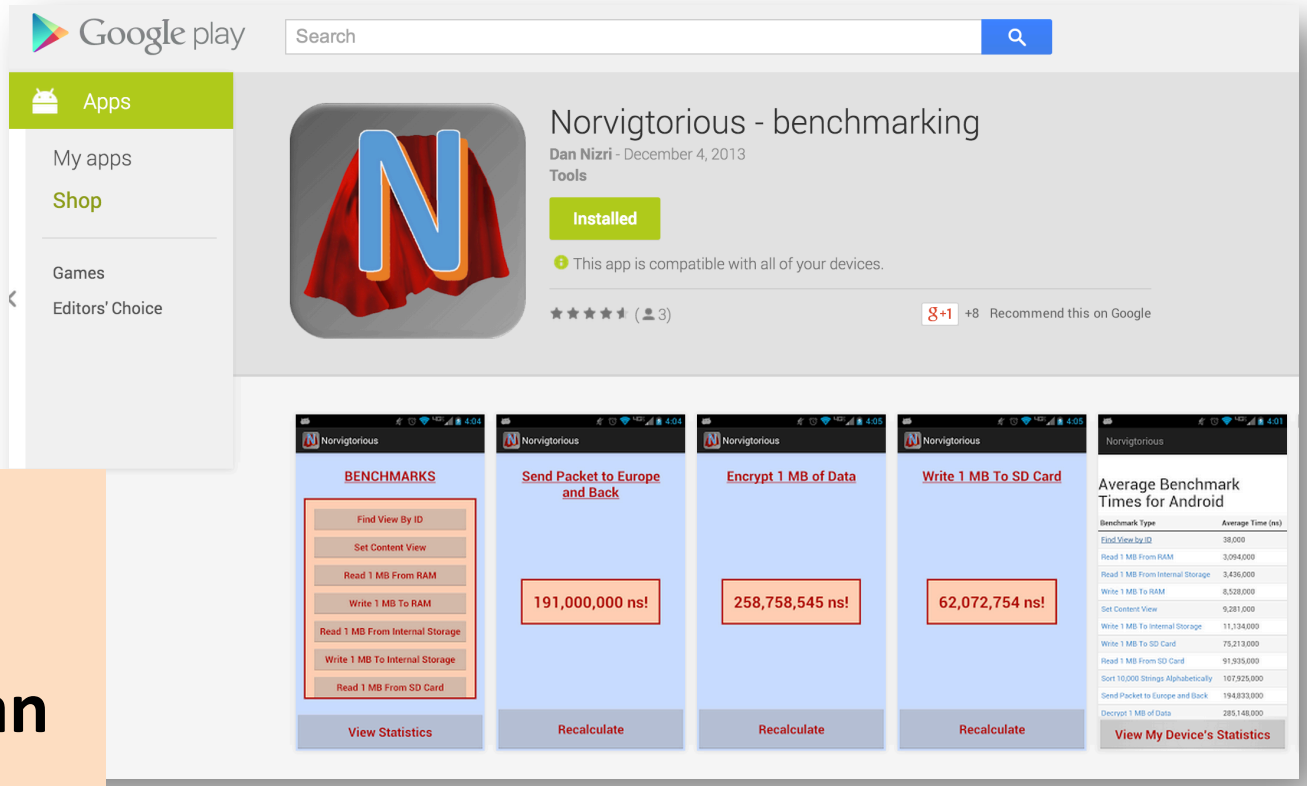
Top UVA Searches

Grab the extension - Home

Name	Search Count	Last Searched
Kevin Edelmann	100	2014-01-03 21:34:15
Jasdev Singh	86	2014-01-10 12:14:41
Anat Gilboa	18	2013-12-31 17:23:18
Michael Recachinas	14	2014-01-01 15:25:51
Haroun Ahmed	11	2014-01-03 11:36:22
Justin Herron	6	2013-12-08 11:52:43
Shiv Sinha	5	2014-01-09 19:46:52
Matthew Kincaid	5	2013-12-06 19:18:33
Ranjana Addanki	5	2013-12-18 15:39:02
Kelvin Green	4	2013-12-05 12:06:09

Made with love by @jasdev and @binroot

Norvigtorious

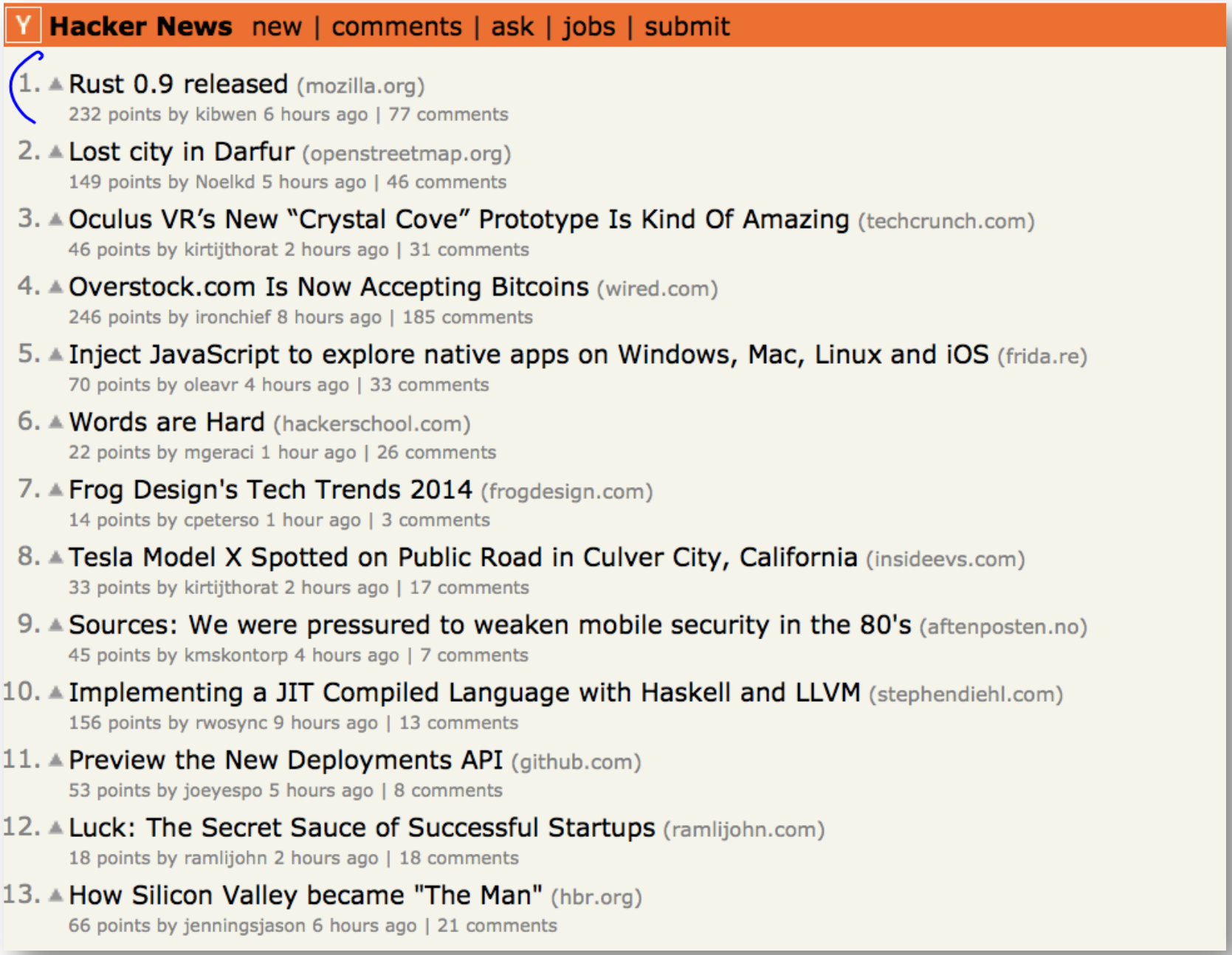


Alex Fabian
Daniel Nizri
Renee Seaman
Casey Silver

IronKernel

Kevin Broderick
Alex Lamana
Zeming Lin
John Stevans
Wil Thomason

We will use this for PS4!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1. Rust 0.9 released (mozilla.org)
232 points by kibwen 6 hours ago | 77 comments
2. Lost city in Darfur (openstreetmap.org)
149 points by Noelkd 5 hours ago | 46 comments
3. Oculus VR's New "Crystal Cove" Prototype Is Kind Of Amazing (techcrunch.com)
46 points by kirtijthorat 2 hours ago | 31 comments
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246 points by ironchief 8 hours ago | 185 comments
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7. Frog Design's Tech Trends 2014 (frogdesign.com)
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8. Tesla Model X Spotted on Public Road in Culver City, California (insideevs.com)
33 points by kirtijthorat 2 hours ago | 17 comments
9. Sources: We were pressured to weaken mobile security in the 80's (aftenposten.no)
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13. How Silicon Valley became "The Man" (hbr.org)
66 points by jenningsjason 6 hours ago | 21 comments

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▲ Rust 0.9 released (mozilla.org)

232 points by kibwen 6 hours ago | 77 comments

add comment

▲ kibwen 5 hours ago | link

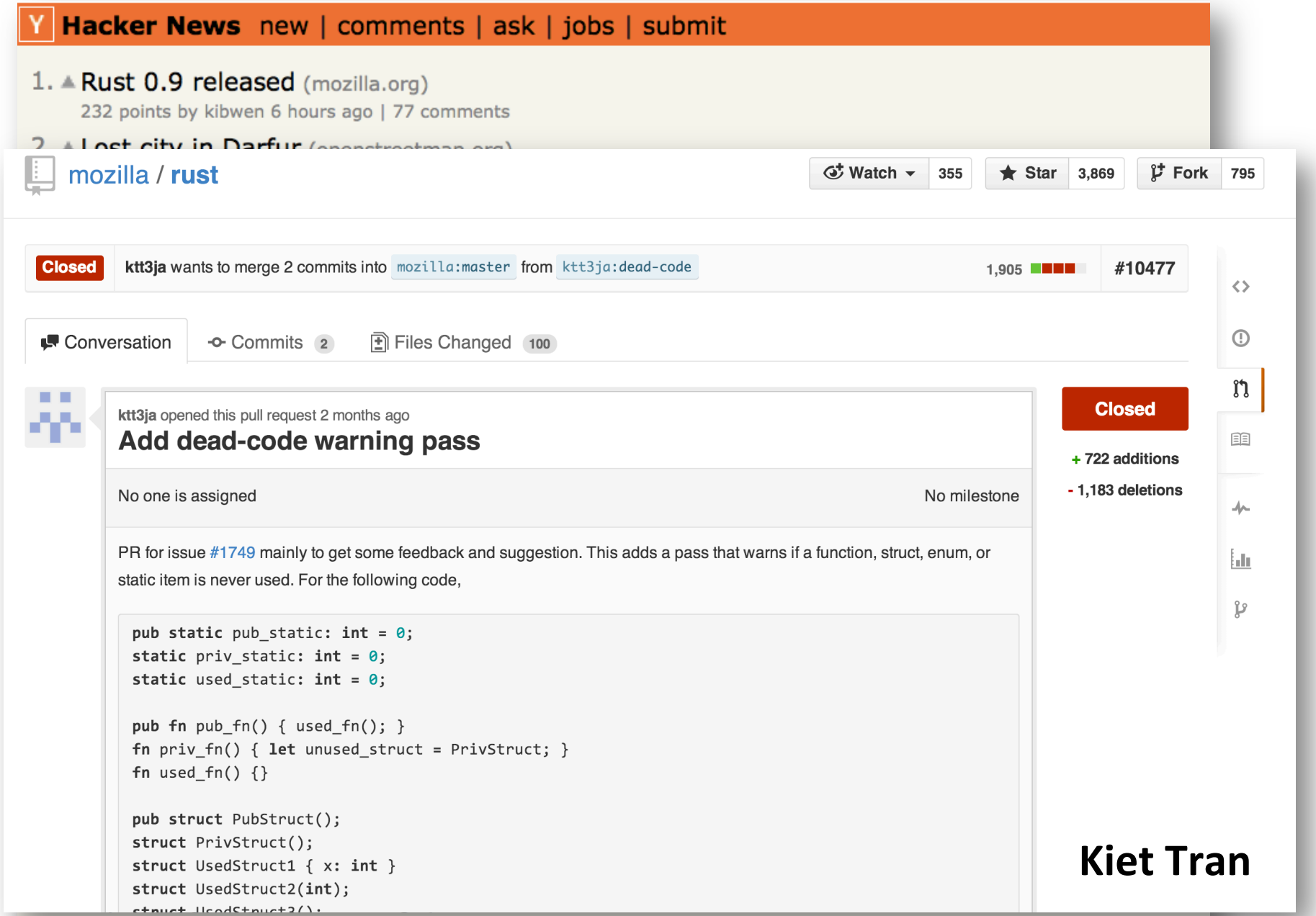
A selection of some of my favorite aspects of this release:

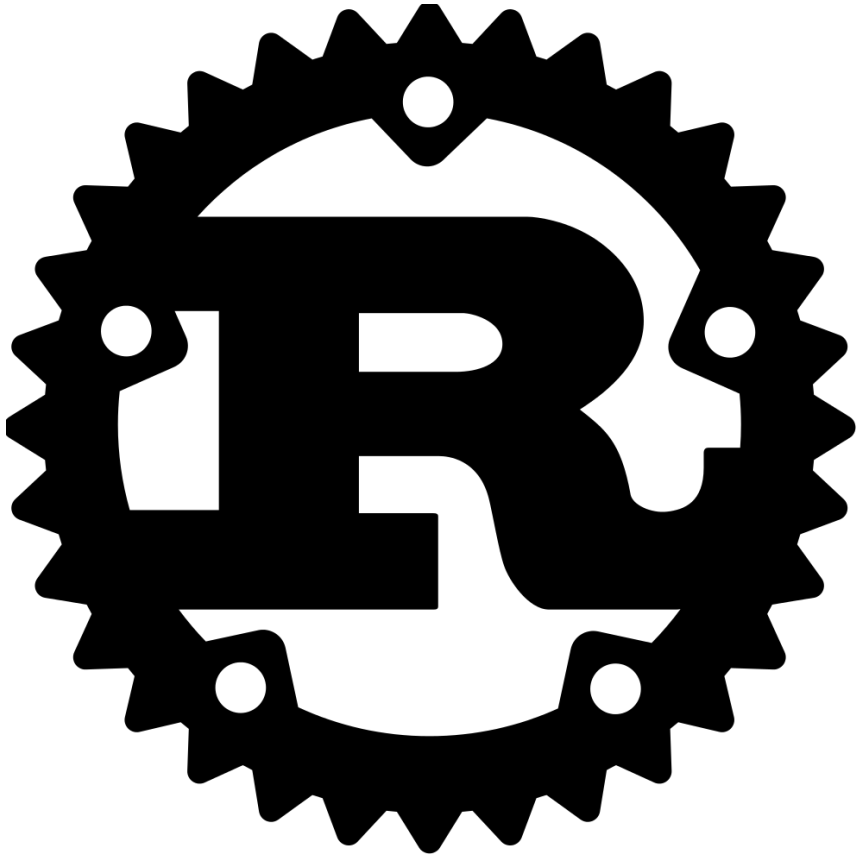
1. The (yet-ongoing) removal of managed pointers, leaving us with one fewer pointer type. Final tally of built-in pointer types: unique pointers, mutable references, and immutable references.

2. The dead code detection pass (https://github.com/mozilla/rust/pull/10477), contributed by a student of the University of Virginia's Rust-based systems programming class (http://rust-class.org/pages/using-rust-for-an-undergraduate-...).

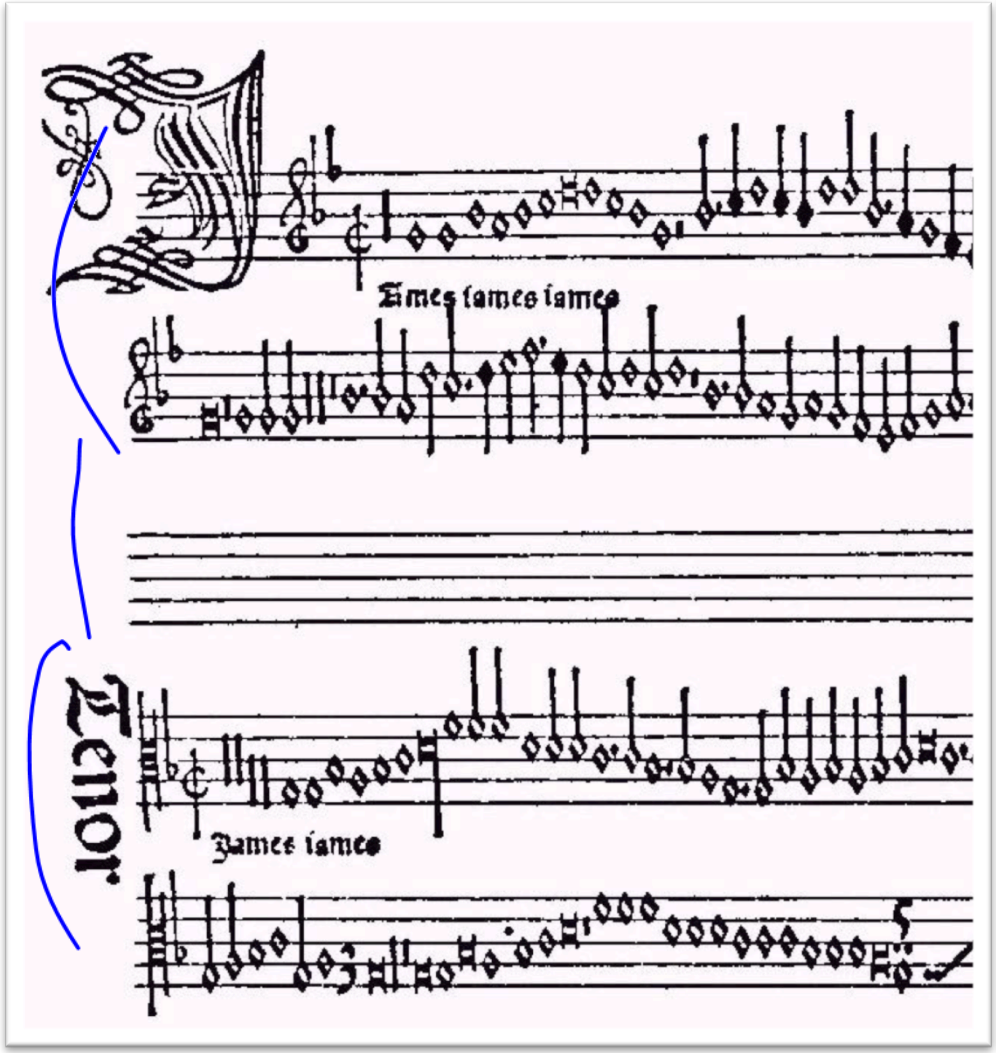
3. The `Any` trait, giving us on-demand dynamic typing (https://github.com/mozilla/rust/pull/9967).

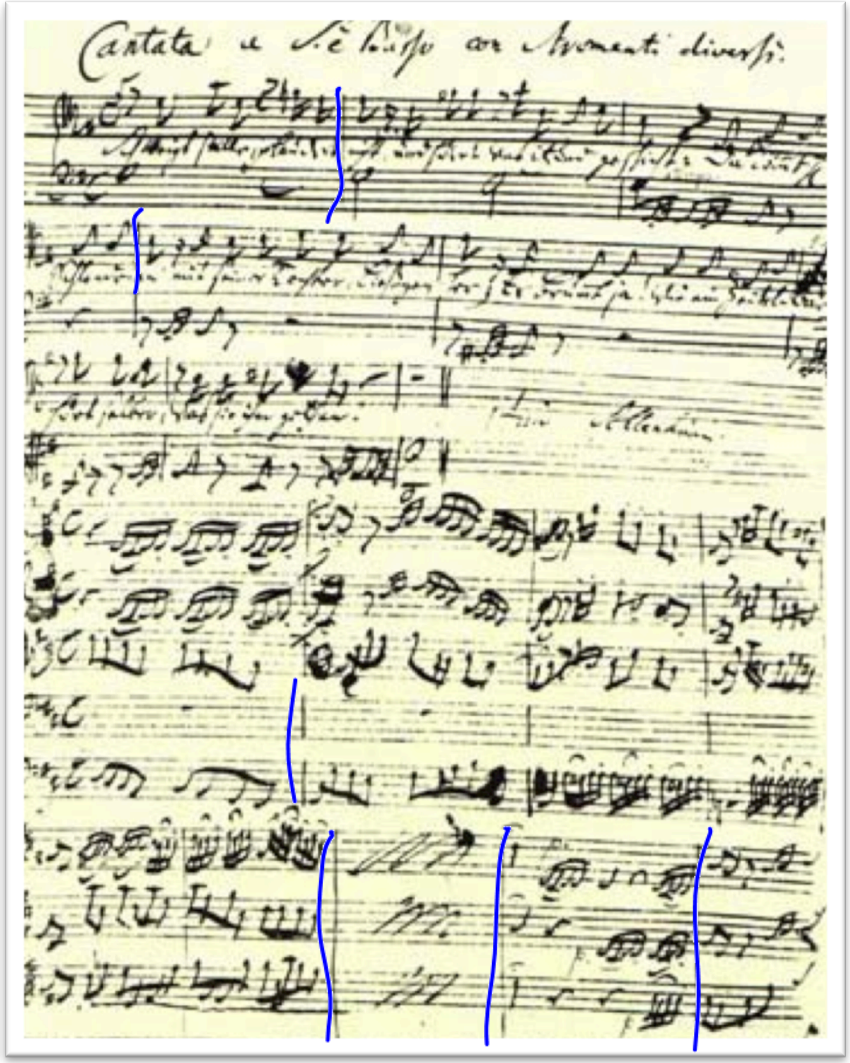
4. The clean abstraction of green threads and native threads out into their own libraries (https://mail.mozilla.org/pipermail/rust-dev/2013-December/00...) such that any library that makes use of the stdlib will work regardless of which strategy the user selects.


Hacker News new | comments | ask | jobs | submit
1. Rust 0.9 released (mozilla.org)
232 points by kibwen 6 hours ago | 77 comments
mozilla / rust
Watch 355
Star 3,869
Fork 795
Closed
ktt3ja wants to merge 2 commits into mozilla:master from ktt3ja:dead-code
1,905
#10477
Conversation
Commits 2
Files Changed 100
ktt3ja opened this pull request 2 months ago
Add dead-code warning pass
No one is assigned
No milestone
PR for issue #1749 mainly to get some feedback and suggestion. This adds a pass that warns if a function, struct, enum, or static item is never used. For the following code,
pub static pub_static: int = 0;
static priv_static: int = 0;
static used_static: int = 0;
pub fn pub_fn() { used_fn(); }
fn priv_fn() { let unused_struct = PrivStruct; }
fn used_fn() {}
pub struct PubStruct();
struct PrivStruct();
struct UsedStruct1 { x: int }
struct UsedStruct2(int);
Closed
+ 722 additions
- 1,183 deletions
Kiet Tran



Why learn a new programming language?



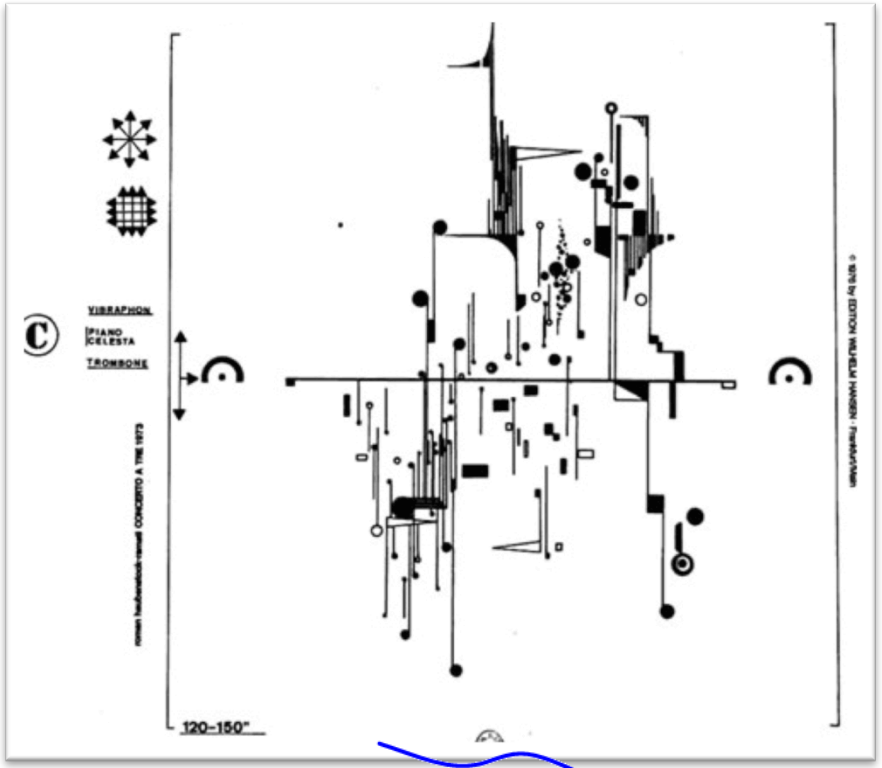


"Jamais Jamais Jamais" from *Harmonice Musices Odhecaton A*. (1501)

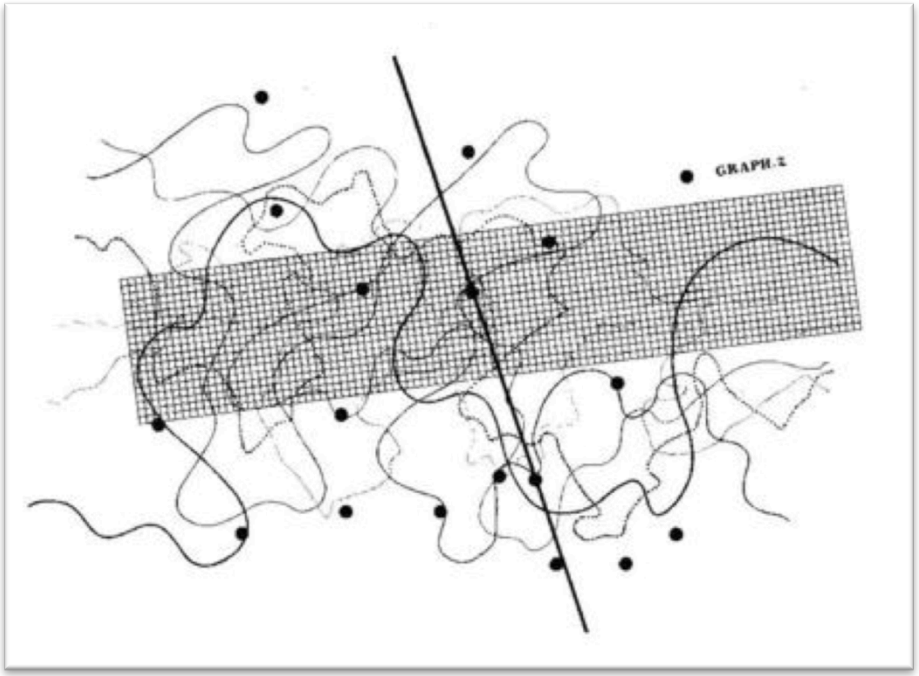
J S Bach, "Coffee Cantata", BWV 211 (1732)

www.npj.com/homepage/teritowe/jsbhand.html

Modern Music Notation

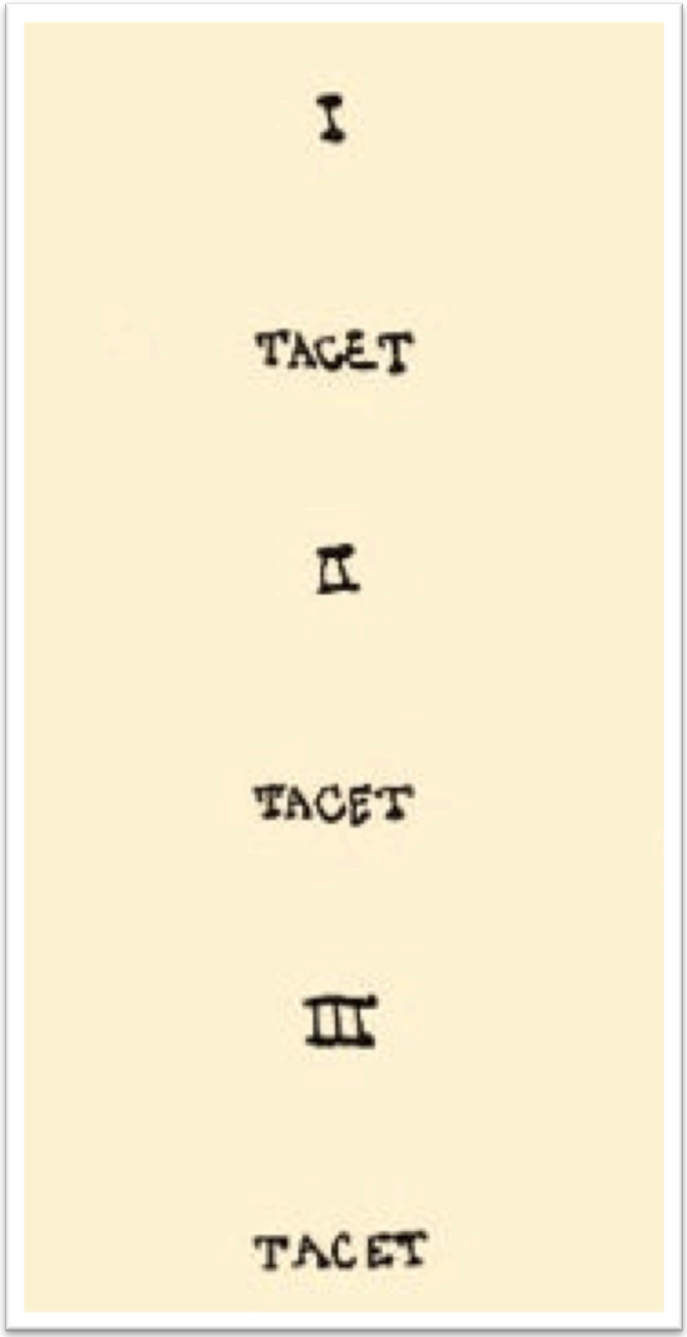


Roman Haubenstock-Ramati, *Concerto a Tre*



John Cage, *Fontana Mix*

http://www.medienkunstnetz.de/works/fontana-mix/audio/1/


I
TACET
II
TACET
III
TACET

I

TACET

II

TACET

III

TACET

4' 33"

FOR ANY INSTRUMENT OR COMBINATION OF INSTRUMENTS

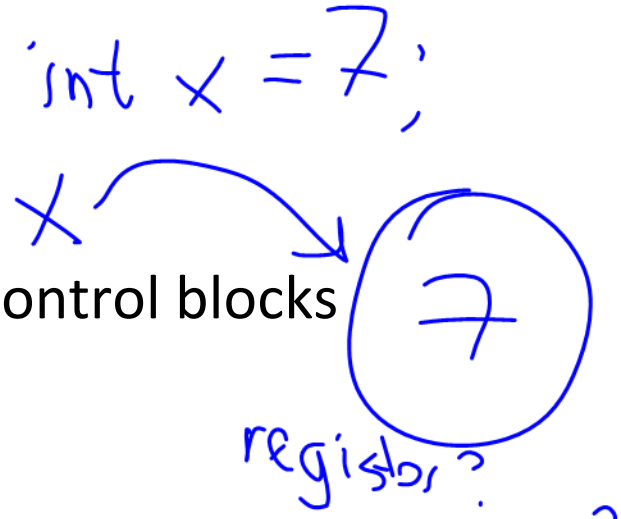
John Cage

NOTE: THE TITLE OF THIS WORK IS THE TOTAL LENGTH IN MINUTES AND SECONDS OF ITS PERFORMANCE. AT WOODSTOCK, N.Y., AUGUST 29, 1952, THE TITLE WAS 4'33" AND THE THREE PARTS WERE 33", 2'40", AND 1'20". IT WAS PERFORMED BY DAVID TUDOR, PIANIST, WHO INDICATED THE BEGINNINGS OF PARTS BY CLOSING, THE ENDINGS BY OPENING, THE KEYBOARD LID. AFTER THE WOODSTOCK PERFORMANCE, A COPY IN PROPORTIONAL NOTATION WAS MADE FOR IRWIN KREMEN. IN IT THE TIMELENGTHS OF THE MOVEMENTS WERE 30", 2'23", AND 1'40". HOWEVER, THE WORK MAY BE PERFORMED BY ANY DISTRUMENTALIST(S) AND THE MOVEMENTS MAY LAST ANY LENGTHS OF TIME.

Thought and Action

Languages change the way we **think**

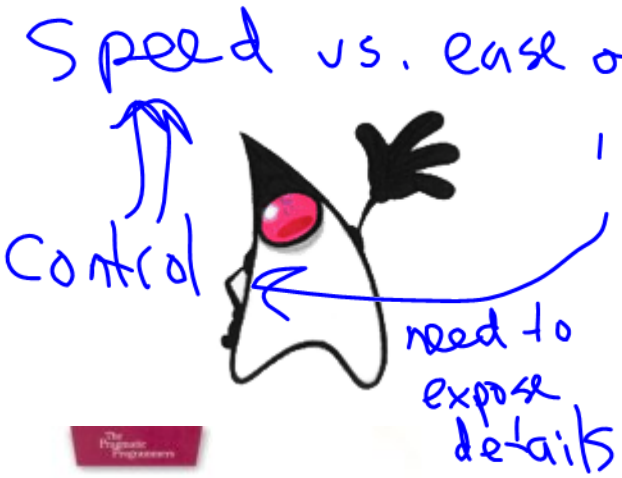
- **BASIC**: think about GOTO
- **Algol**, **Python**: think about assignments, control blocks
- **Scheme, Haskell**: think about procedures
- **Java, C++**: think about types, objects

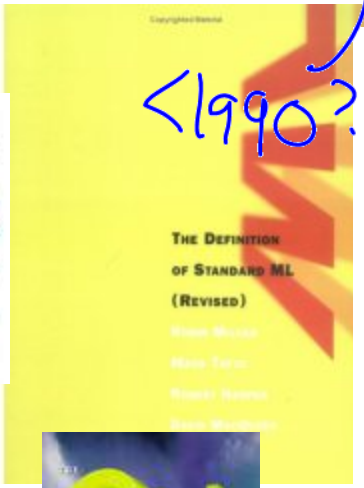


Languages provide **abstractions** of machine resources

- Hide dangerous/confusing details: memory locations, instruction opcodes, number representations, calling conventions, etc.
- Hiding more increases **simplicity**, but limits **control**

Why so many programming languages?

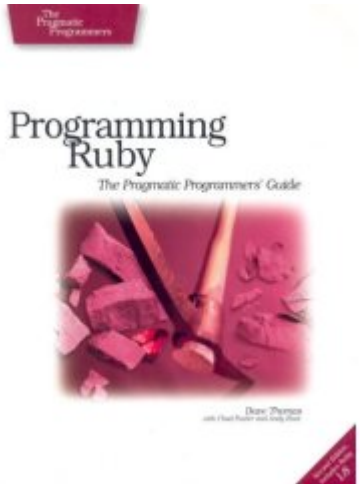


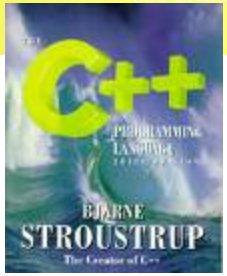


Cost/size of compiler/runtime?

<1990?

<$0.10





Fundamental Differences

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All equivalently powerful!

- *Universal languages*: all capable of simulating each other

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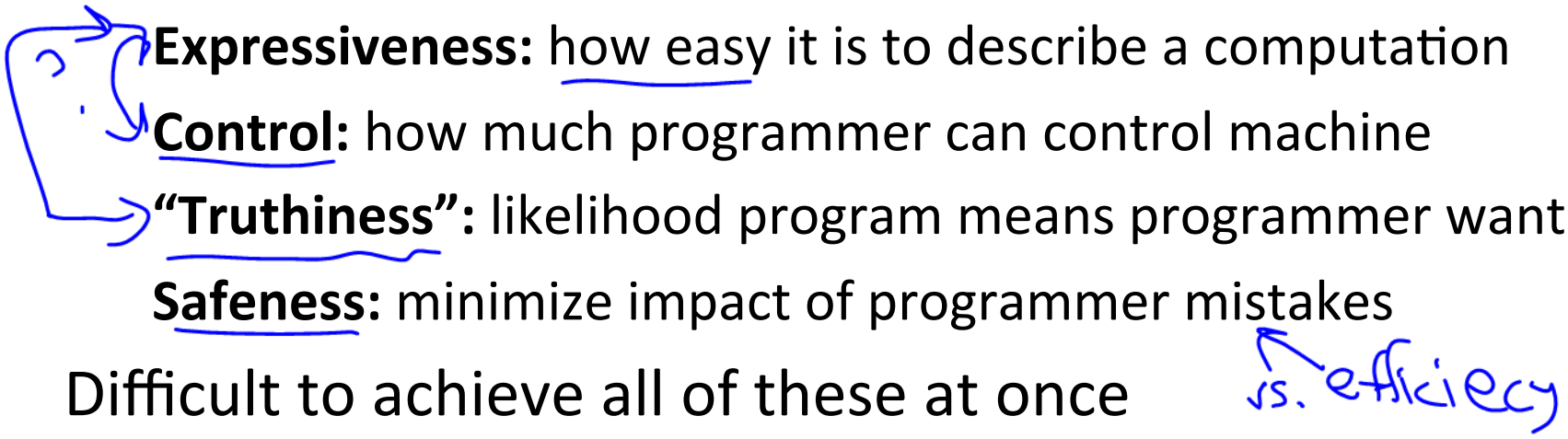
Fundamental differences

- **Expressiveness:** how easy it is to describe a computation
- **Control:** how much programmer can control machine
- **"Truthiness":** likelihood program means programmer wants
- **Safeness:** minimize impact of programmer mistakes

Difficult to achieve all of these at once



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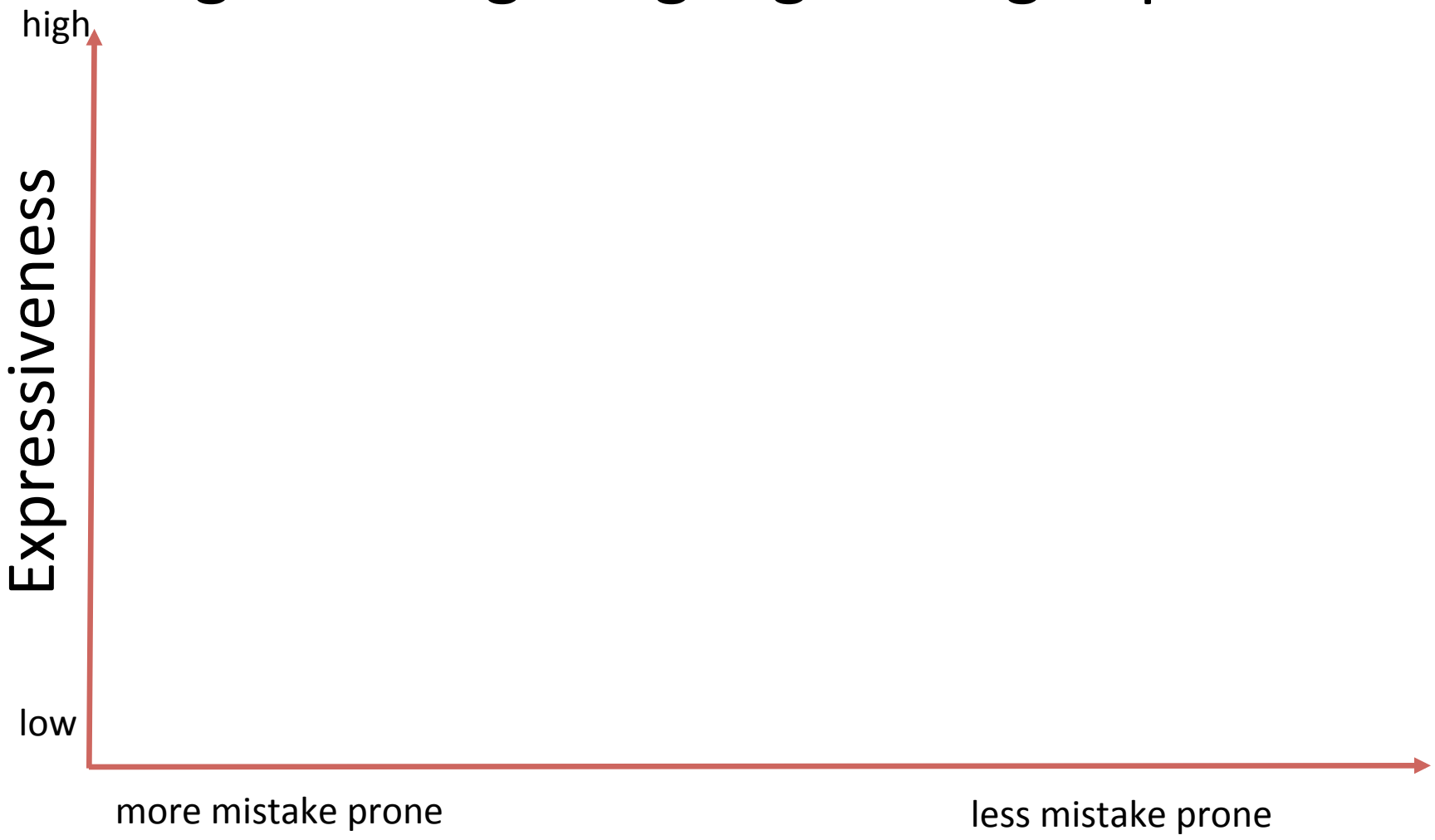
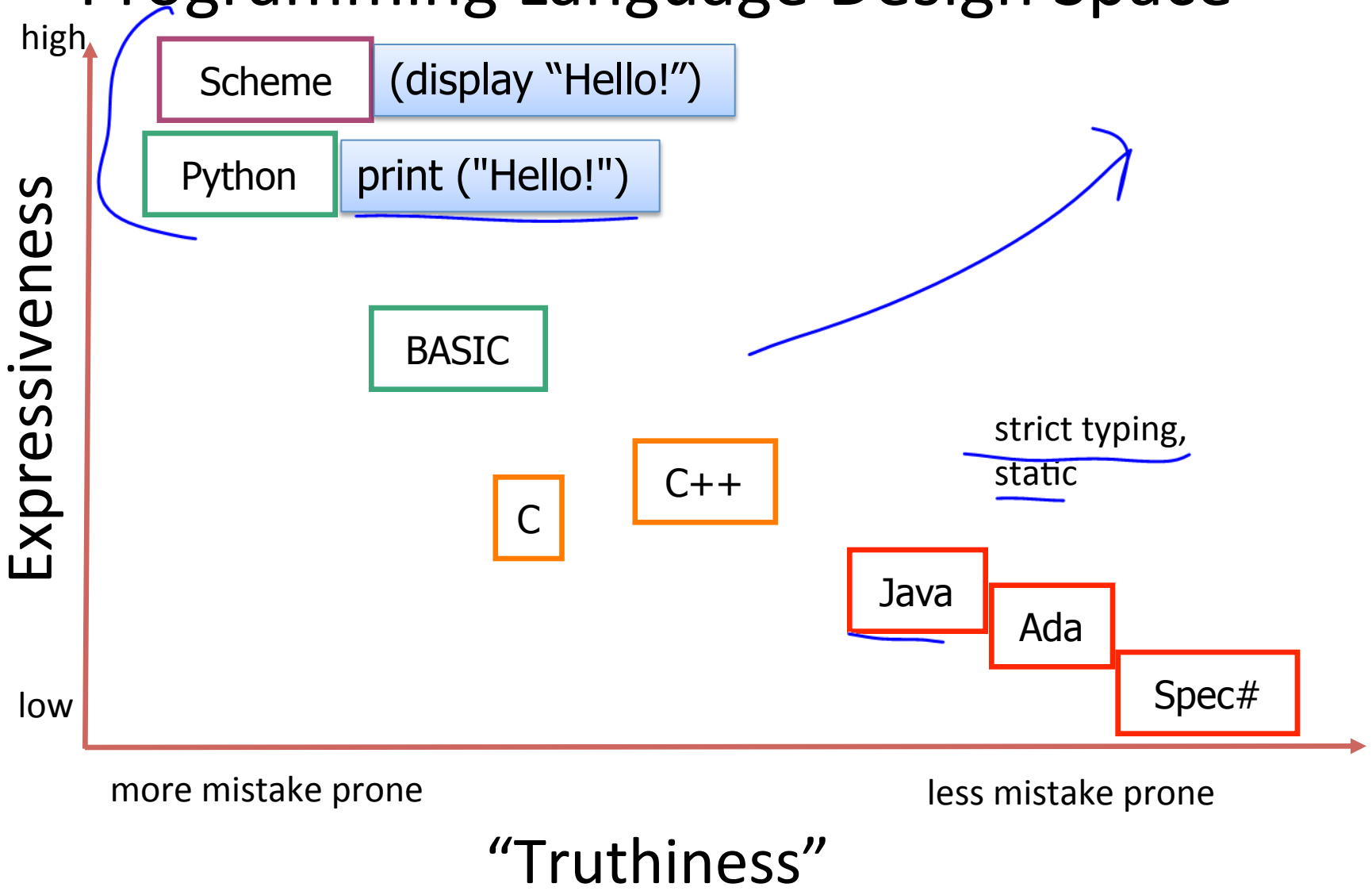
What do we want for systems programming?

Programming Language Design Space



Programming Language Design Space



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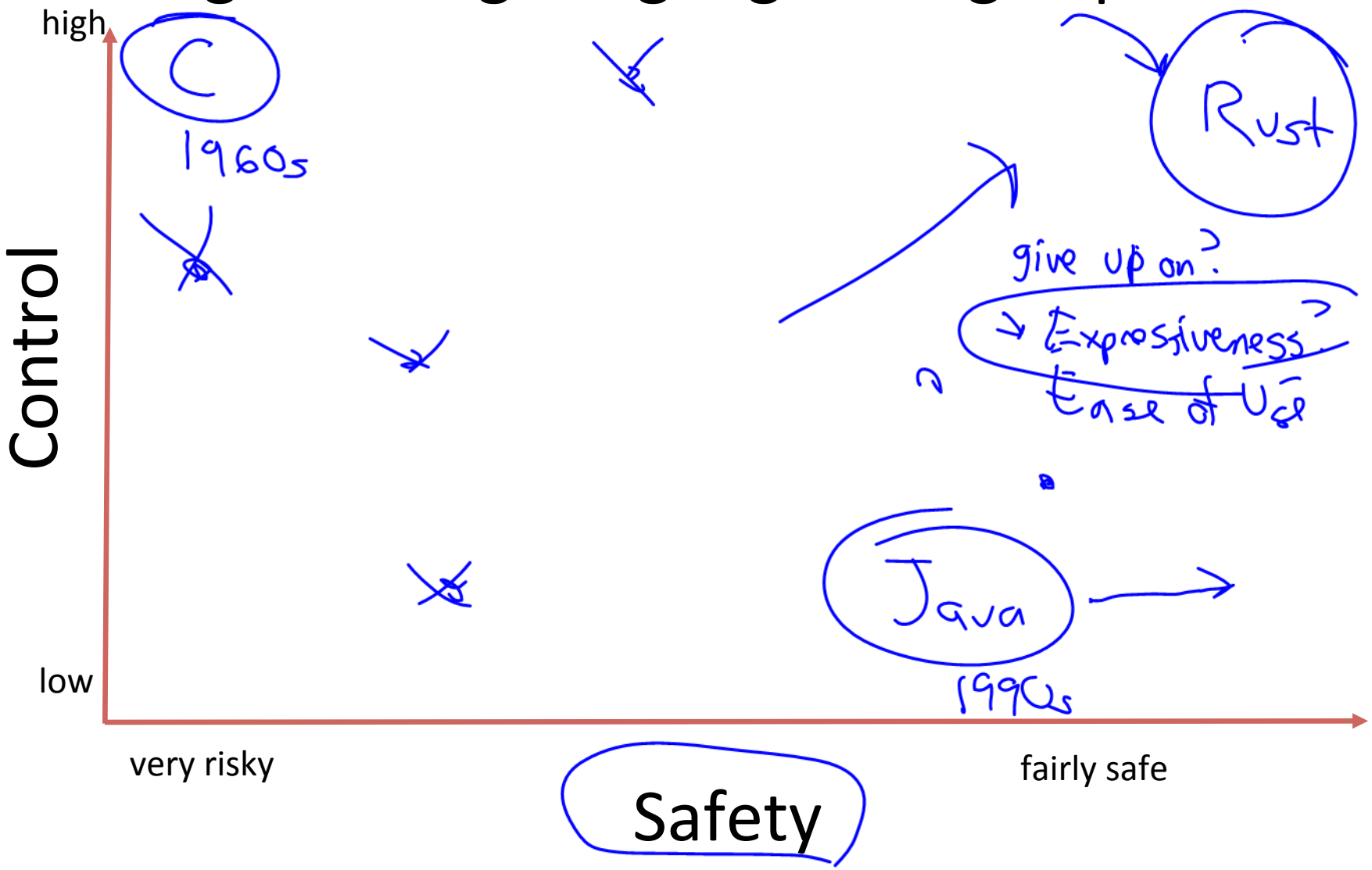

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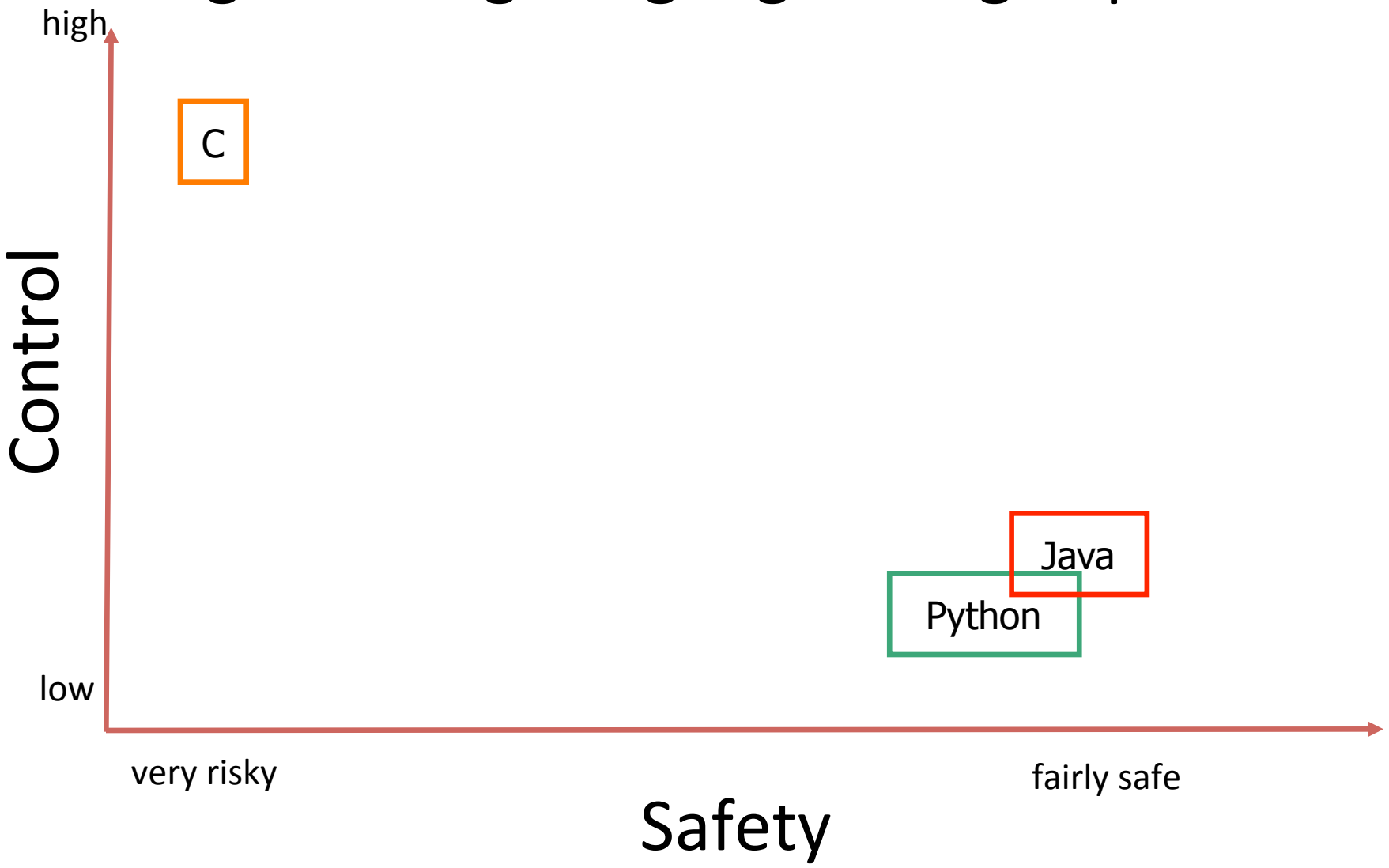

“a safe, concurrent, practical language”

Its design is oriented toward concerns of “programming in the large”, that is, of creating and maintaining boundaries – both abstract and operational – that preserve large-system integrity, availability and concurrency.

from http://www.rust-lang.org/

Rust

Advances in programming language design and compiler implementation make it possible to get both control and safety, and mostly get expressiveness and “truthiness” all at the same time!

Charge

Bring a laptop to use in Thursday's class!

- Do (or at least attempt) everything on the Class 1 notes **Action Items** before class Thursday
  - Download and setup your computing environment for cs4414
  - Setup your github account
- Next class:
  - Help getting everything working on your machine
  - Help getting started with Rust (Rust tutorial)