

Dive into Systems:

A Free, Online Textbook for Introducing Computer Systems

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diveintosystems.org

The opinions expressed in this presentation are solely of the authors and do not necessarily reflect those of the U.S. Military Academy, the DoD or the U.S. Army.

Why a free online textbook introducing Systems?

Selfish: We couldn't find "right fit" textbook for our courses

Systems Topics (& parallel) **at the intro sequence level**

Altruistic: Create Useful Resource to Share Widely

Growing Importance of Systems, P&D into Curriculum

ACM/IEEE 2013, NSF/IEEE-TCPP



Free textbook: available to all

Online: easy to access and update



Source: The Economist

Primary Goals

Introduce Systems Topics assuming only a CS1 background

Introductory level presentation w/some “looking ahead” to more advanced topics

Broad Topic Coverage: “mix and match” for lots of different uses

Primary textbook: Intro to Computer Systems, Computer Org., C programming, ...

Supplemental/Background text: OS, NW, Compilers, Arch, P&D, DB, ...

Use Feedback from Experts in our Community

External Reviewers of Chapters, Early Adopters Program

Main Themes

1. How a Computer Runs a program

HLL to binary encoding

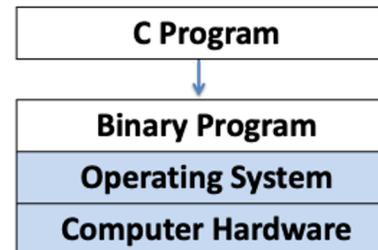
Arch design, OS abstractions & mgmt for running programs

1. How System Costs affect program performance

Focus on Memory Hierarchy & program efficiency

1. How to leverage power of Parallel Computers

Focus on Shared Memory



Content Overview

15 Chapters

1. C Intro
2. C Depth
3. C Debugging
12. Code Optimization

4. Binary Representation
11. Memory Hierarchy
5. Architecture

13. Operating Systems

6. - 10. Assembly
IA32, x86_64, ARM 64

14. Shared Memory Parallel
15. Other Parallel

- **C programming**
 - from CS1 background (in python?)
 - Most of C, gdb, valgrind, optimization
- **Binary Representation of C types & Operations on Binary data**
 - Focus: representation & operations on signed and unsigned
 - Briefly: real number representation
- **Architecture with focus on CPU design for running Programs**
 - Focus: Build CPU from logic gates, instruction execution stages, clock
 - Von Neumann Arch & history of modern computers
 - Looking ahead: today's CPUs (pipelining, multicore, multithreading, ILP)

Content Overview (cont.)

- **Memory Hierarchy & its effects on performance**
 - Storage media/devices, CPU caching
- **Assembly Programming, focus on mapping C to assembly**
 - Arithmetic, conditional, functions, stack, memory mvmt
 - in IA32, x86_64, 64 bit ARM
- **Operating Systems, focus on its role in running programs**
 - Main abstractions: Processes and VM
 - Briefly: IPC & looking ahead to other OS functionality
- **Introduction to Parallelism and Parallel computing**
 - Focus: Shared Memory (multicore, threads, pthread programming, OpenMP)
 - Looking ahead: cloud & MapReduce, clusters & MPI, accelerators & CUDA

1. C Intro
2. C Depth
3. C Debugging
12. Code Optimization

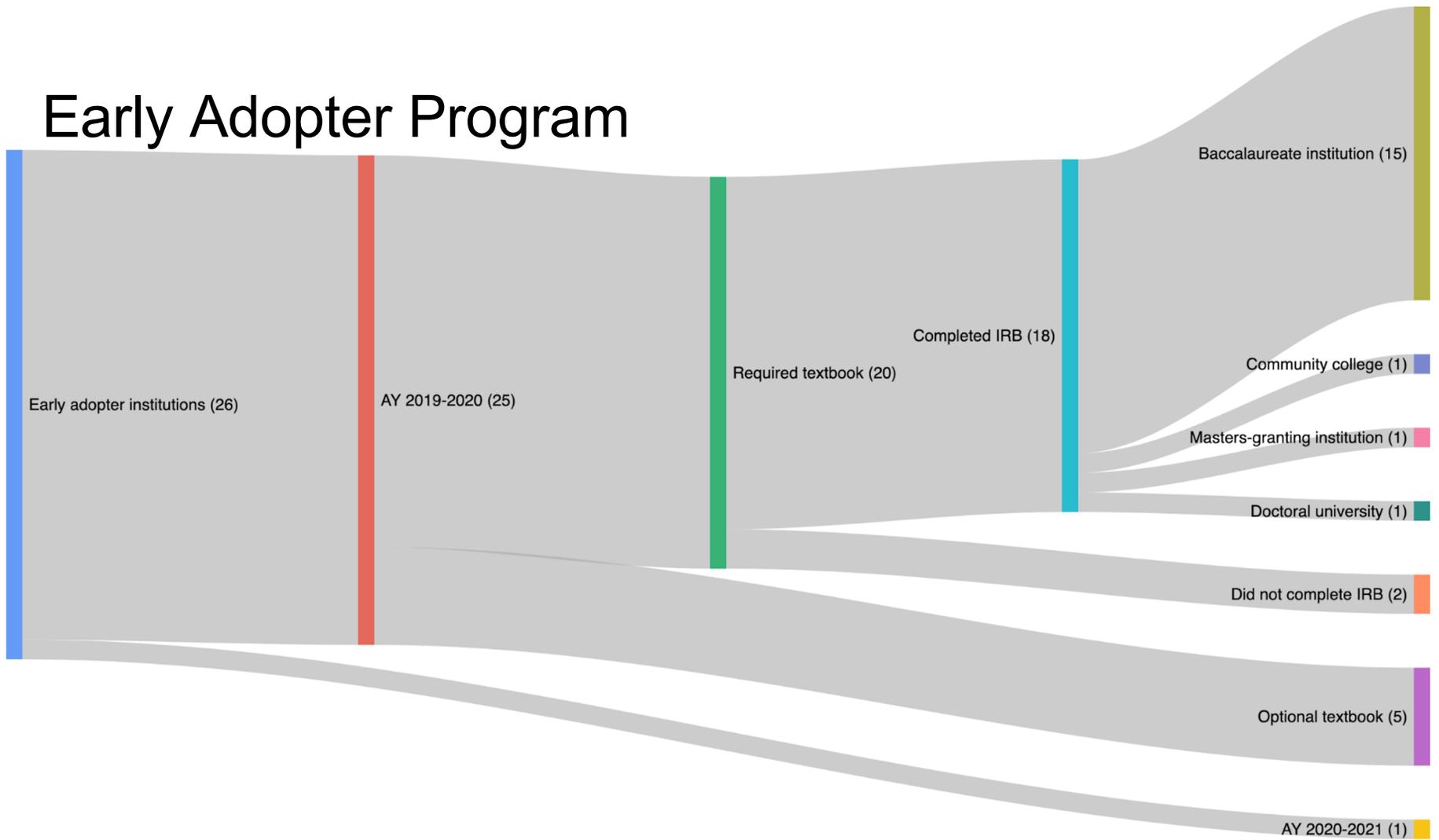
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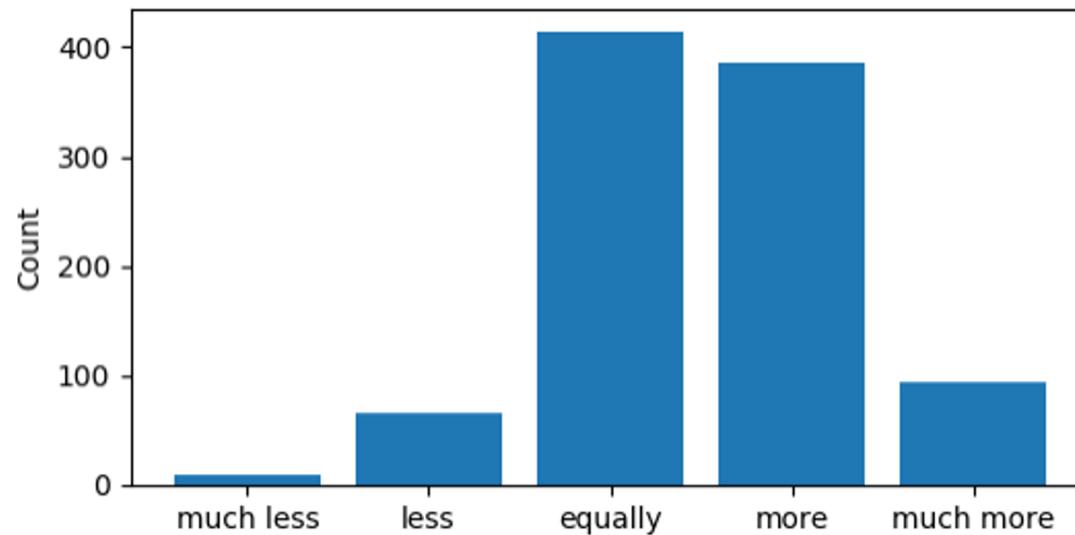
14. Shared Memory Parallel
15. Other Parallel

Early Adopter Program



Student Survey Results

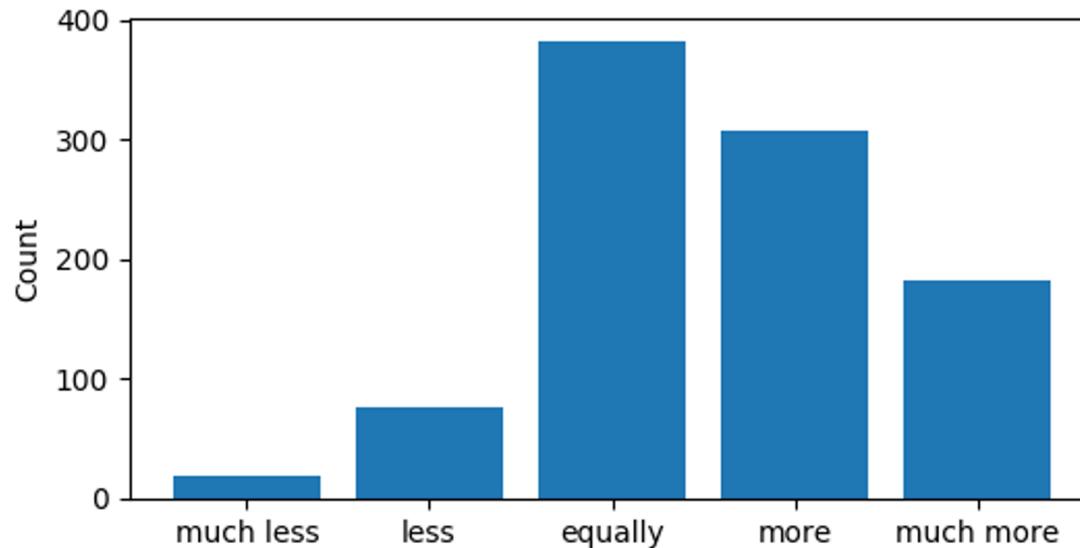
“How helpful did you find *Dive into Systems* compared to other textbooks?”



92.3% found textbook equally or more helpful; 49.6% found it more or much more helpful.

Student Survey Results

“Has the electronic nature of the textbook helped you learn less or more than textbooks in other courses?”



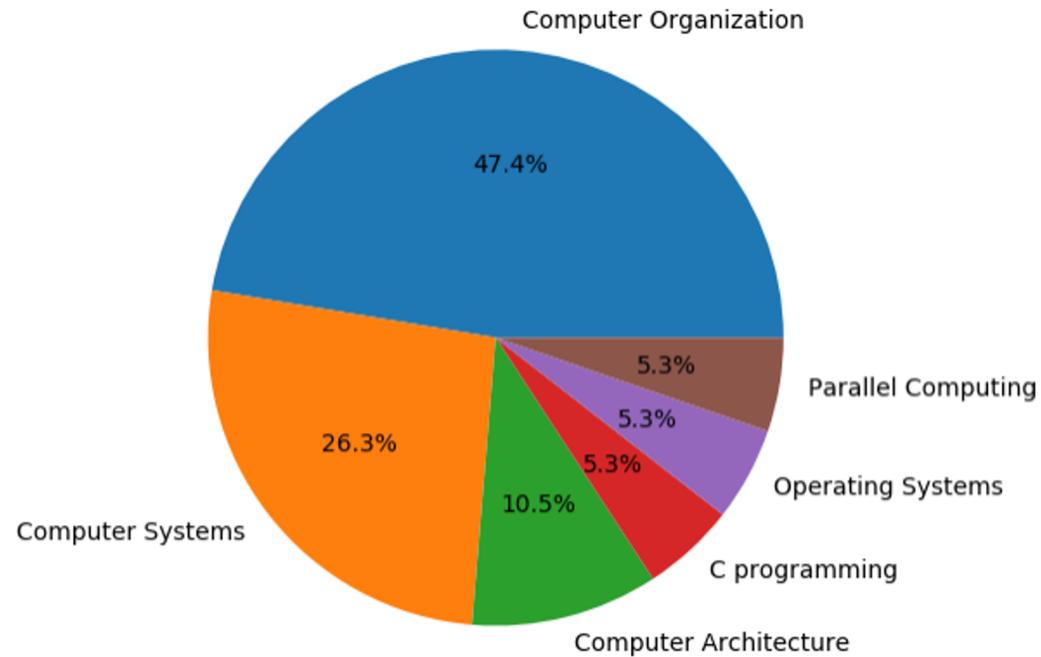
90.1% found the electronic nature of book helped equally or more; 50.6% indicated more or much more

Student Survey Results

- What they liked:
 - Text is *“clear and direct”*, organized in *“concise and digestible sections”*
 - Use of *“engaging examples”* that are *“very helpful in terms of understanding conceptual materials”*
 - Free nature of textbook *“took some financial burden off of college”*
- Areas of Improvement:
 - Students would like to see *“extra problems”*, especially those that allow students to *“somehow check [their] answers”* or *“practice what [they were] reading immediately”*.
 - A vocal minority of self-described *“old fashioned”* students stated a preference for *“a physical book”* that would allow them to avoid looking at a screen.

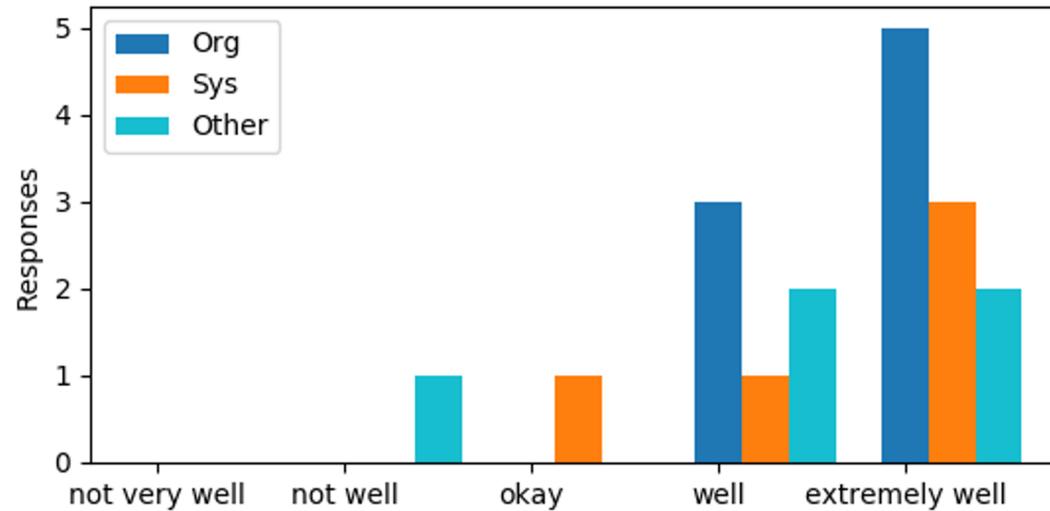
Faculty Survey Results

Types of Courses using *Dive into Systems* as a required text



Faculty Survey Results

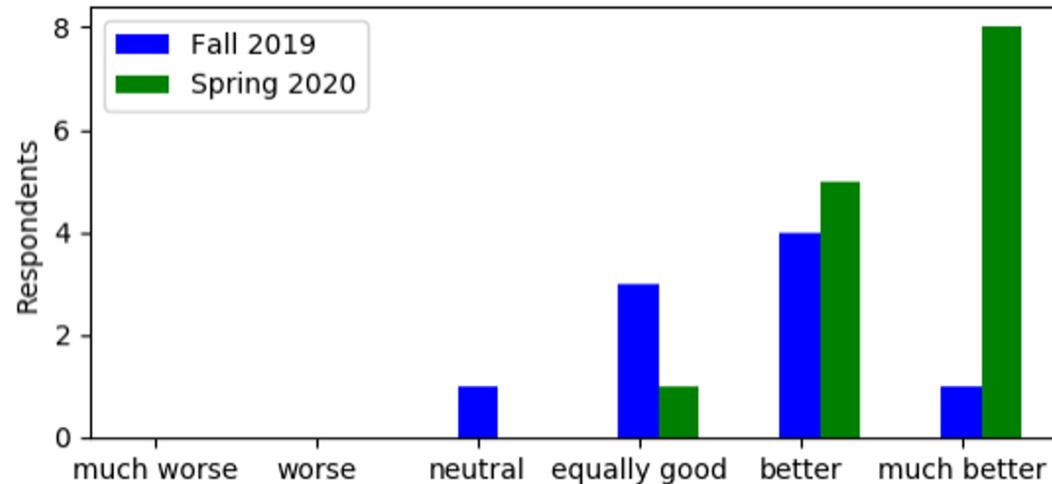
“How well do *Dive into Systems* topics fit your course?”



89.4% of faculty indicated well or extremely well

Faculty Survey Results

“How does *Dive into Systems* compare to other textbooks use for your course?”



95.6% of faculty believed equally good or better; 78.3% believed better or much better

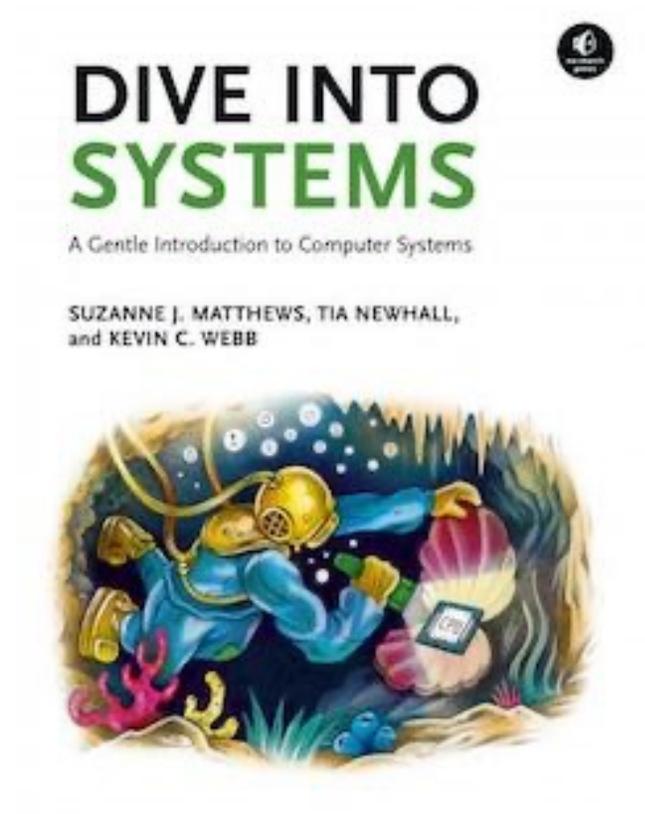
Faculty Survey Results

- What they liked:
 - Book “*explains content well*” and seemed like it was “*almost designed for [their] course*”
 - Free nature of textbook allowed cost-conscious faculty to assign other hardware in the course (e.g. Raspberry Pis)
 - COVID-19 pandemic: online nature of textbook helped ease transition to a virtual environment
- Areas of Improvement:
 - Greater number of example problems/exercises
 - Improved instructor portal

Ongoing Work

1. Working with *No Starch Press* to produce a print version (expected late spring).

The book will remain free online!



Ongoing Work

2. Currently organizing NSF grant to develop free, interactive exercises.
We'll need community help!

Conclusions

Dive into Systems is extensively peer-reviewed and already used by about two-dozen institutions.

Early adopters have provided overwhelmingly positive feedback about the text's clarity and helpful figures.

It covers a broad range of systems topics for use by many courses.

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