Computer Science @ Boston University

Computer Scientists: Architects of a New World

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Azer Bestavros
Professor

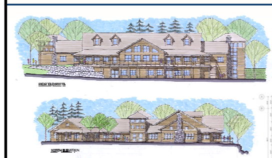
Computer Science

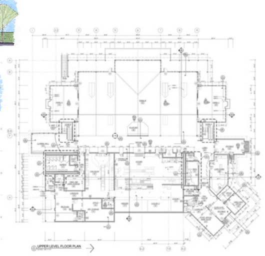
The "computer" is the interface between people and their world; it increasingly affects how we interact with our world, just like the structures we live and work in affect how (well) we interact with our world.

➔ *Advances in CS have the potential to change how we live, work, and interact with others!*

Architectures…

Form and Function



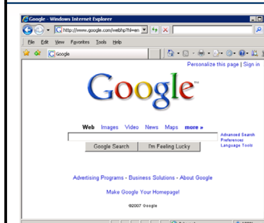


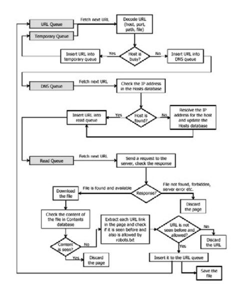
Plenty of tradeoffs!

- Cost
- Aesthetics
- Energy efficiency
- …

Architects of a New World

Form and Function





Plenty of tradeoffs!

Computer Science Research

"CS is faced with scientific challenges that rival any in history, yet are relevant to practical problems of today." *– Jim Morris, Business Week'04*

The results from even the most esoteric CS research projects have widespread practical and economic impact

- *On-line banking is possible thanks to advances in Cryptography*
- *Google is possible thanks to advances in distributed systems, networking, and algorithms*
- *Xbox/animation are possible thanks to advances in Graphics and HPC*
- *iPods are possible thanks to advances in coding, compression, and DB indexing*

My Research

Novel ways to design the Internet (and Web)

- Make it faster, predictable, resilient to failures and attacks, cheaper, and accessible anywhere

Develop approaches for software certification

- You should be able to sue programmers if their software crashes your computer!

Novel ways to embed cyberspace in our world

- Ubiquitous networked sensors and devices that radically change how we live, work, drive, deliver healthcare, …

My Teaching

CS/MA 109: The Arts and Science of Quantitative Reasoning

- A novel approach to teaching mathematics, statistics, and computer science (MCS)
- Team-taught lectures and small discussion groups, emphasizing the relevance of MCS in everyday's life
- Capstone project that allows the student to investigate basic MCS concepts to a problem of choice

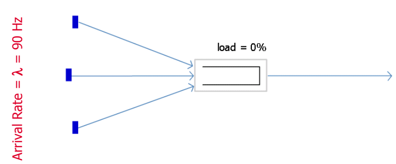
My Teaching

CS350: A Nationally Unique Class on the Fundamentals of Computing System Design

- I teach the design concepts that transcend technology churn
- I teach just enough technology to allow students to apply these concepts in different contexts
- I use analogies to bring the concepts I teach to life, and to relate them to student real-world experiences
- I bring research to the classroom to show students that the fundamentals they learn are timeless

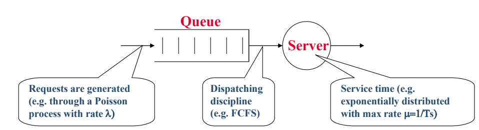
1 Animation = 1K Words

Service Rate = μ = 1/Ts = 100 Hz

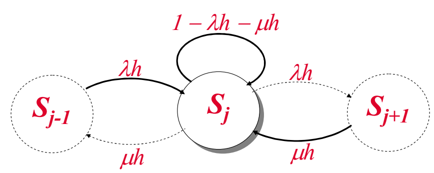


How much space to use for a queue?
How long would it take to go through the line?

Single-Server Queue



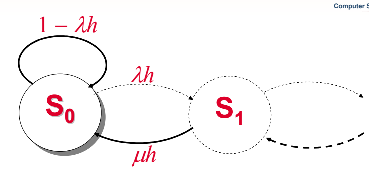
Queuing Analysis



$\Pr(S_j) = \lambda h \Pr(S_{j-1}) + \mu h \Pr(S_{j+1}) + (1-\lambda h-\mu h)\Pr(S_j)$

$\Pr(S_{j+1}) = (1+\rho)\Pr(S_j) - \rho\Pr(S_{j-1})$

Queuing Analysis



S_0 is a special case!

$\lambda h \Pr(S_0) = \mu h \Pr(S_1)$

$\Pr(S_1) = \rho\Pr(S_0)$

Queuing Analysis

Average number of customer in a M/M/1 System; i.e., mean of a Geometric Distribution

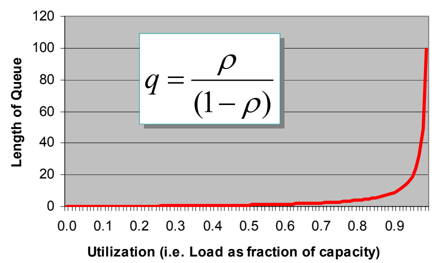
q = E[# of customers]

$q = 0 * \Pr(S_0) + 1 * \Pr(S_1) + 2 * \Pr(S_2) + \ldots$

$q = (\rho + 2\rho^2 + 3\rho^3 + 4\rho^4 + \ldots) * (1-\rho)$

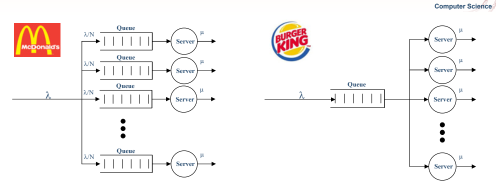
$$q = \frac{\rho}{(1-\rho)}$$

Queues Build Up Fast!



$$q = \frac{\rho}{(1-\rho)}$$

One Queue or N Queues?

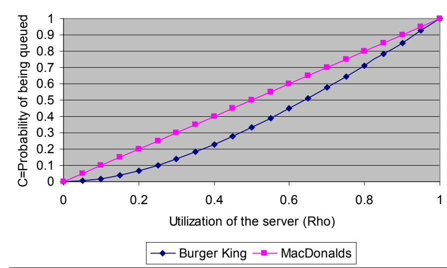


As in Supermarkets, Toll-boths, …

As in Airport check-in, Bank tellers…

How are these two designs different?
What are the tradeoffs?

One Queue or Two Queues?



But Who To Serve Next?

Computer Science

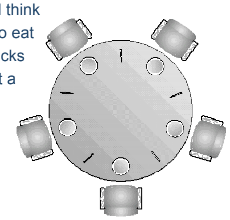
Scheduling could make a big difference
- First-Come-First-Serve
- Shortest-Job-First
- Round-Robin

Approach depends on nature of service
- CPU scheduling
- Disk scheduling
- Real-Time scheduling

And Watch for Dependencies

Computer Science

The Dining Philosophers Problem
- 5 philosophers who only eat and think
- Each need to use 2 chopsticks to eat
- But we only have only 5 chopsticks
- Write a program describing what a philosopher should do to eat…



Philosopher ~ Program
Chopstick ~ Resource

The Dining Philosophers

Computer Science

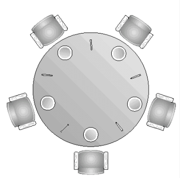
```
Philosopher Pi:
repeat
 THINK;
 wait(right chopstick);
 wait(left chopstick);
 EAT;
 release(right chopstick);
 release(left chopstick);
forever
```

A Demo

And Watch for Dependencies

Computer Science

Classical Synchronization Problem
- Illustrates the difficulty of allocating resources among process without deadlock and starvation



The Dining Philosophers

Computer Science

How do we ensure a deadlock-free solution?
- Allow one philosopher to eat at a time

Could we allow more "concurrency"?
- Up to 4 philosophers could safely co-exist!

Could we devise methodical approaches to solve such problems?

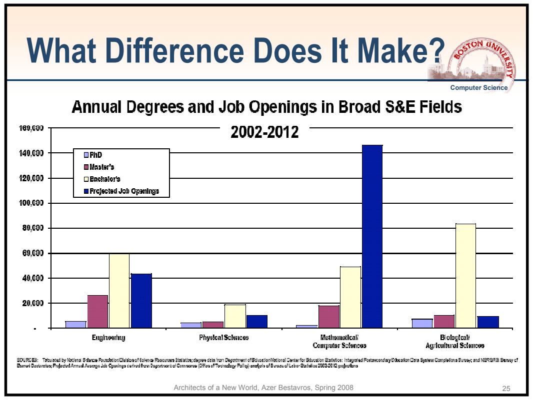
Why Do I Love Teaching?

Computer Science

Nothing rivals the satisfaction from knowing that what I teach makes a real difference in a student's life – way beyond the CS degree…

"I will never think about McDonald's and Burger King the same way I did before taking your class!"

"The basic queuing analysis and simulation techniques I learned in CS-350 were invaluable in my work on the Disney's Fastpass service, which is now being rolled out at Disney parks"


What Difference Does It Make?
Computer Science
Annual Degrees and Job Openings in Broad S&E Fields
2002-2012
PhD
Master's
Bachelor's
Projected Job Openings
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Engineering
Physical Sciences
Mathematical/ Computer Sciences
Biological/ Agricultural Sciences
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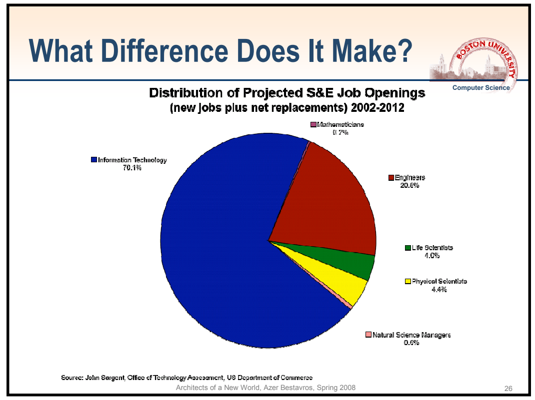
What Difference Does It Make?
Computer Science
Distribution of Projected S&E Job Openings
(new jobs plus net replacements) 2002-2012
Information Technology 70.1%
Engineers 20.6%
Life Scientists 4.0%
Physical Scientists 4.4%
Source: John Sargent, Office of Technology Assessment, US Department of Commerce
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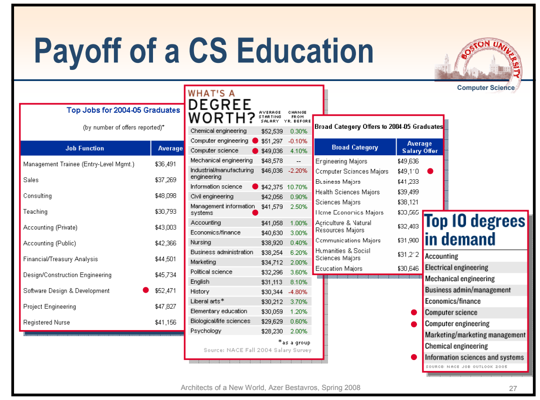
Payoff of a CS Education
Computer Science
Top Jobs for 2004-05 Graduates
WHAT'S A DEGREE WORTH?
Broad Category Offers to 2004-05 Graduates
Top 10 degrees in demand
Accounting
Electrical engineering
Mechanical engineering
Business admin/management
Economics/finance
Computer science
Computer engineering
Marketing/marketing management
Chemical engineering
Information sciences and systems
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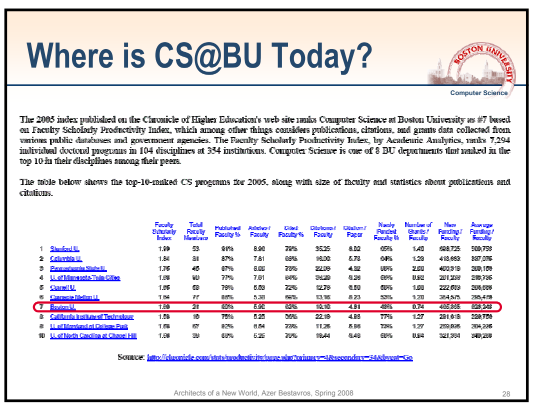
Where is CS@BU Today?
Computer Science
The 2005 index published on the Chronicle of Higher Education's web site ranks Computer Science at Boston University as #7 based on Faculty Scholarly Productivity Index, which among other things considers publications, citations, and grants data collected from various public databases and government agencies. The Faculty Scholarly Productivity Index, by Academic Analytics, ranks 7,294 individual doctoral programs in 104 disciplines at 354 institutions. Computer Science is one of 8 BU departments that ranked in the top 10 in their disciplines among their peers.
The table below shows the top-10-ranked CS programs for 2005, along with size of faculty and statistics about publications and citations.
Faculty Scholarly Index
Total Faculty Members
Published Faculty %
Articles / Faculty
Cited Faculty %
Citations / Faculty
Citation / Paper
Newly Funded Faculty %
Number of Grants / Faculty
New Funding / Faculty
Average Funding / Faculty
1 Stanford U.
2 Columbia U.
3 Pennsylvania State U.
4 U. of Minnesota-Twin Cities
5 Cornell U.
6 Carnegie Mellon U.
7 Boston U.
8 California Institute of Technology
9 U. of Maryland at College Park
10 U. of North Carolina at Chapel Hill
Source:
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