ACM SIGCSE 2007

An Introduction to Computer Science for Non-majors using Principles of Computation

Tom Cortina

Carnegie Mellon University

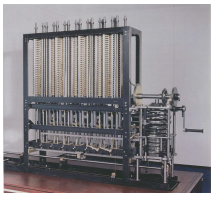
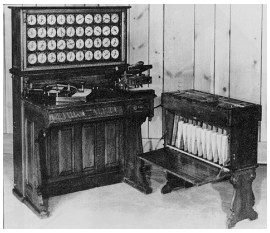
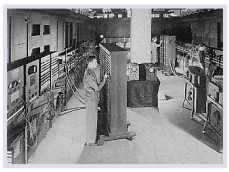
How do we introduce non-majors (and budding majors) to CS?

- CS0 Introduction to Computer Science
  - Typically a crash-course in every computer science topic in one class.
  - Students are bombarded with one week of each major area of CS.
  - How much do they really absorb?
- CS1 Computer Programming with x
  (where x = Java, C, Scheme, C#, etc.)
  - Students spend a great deal of time learning how to "speak" in this new language (syntax).
  - Different paradigms don't help matters.
  - Some CS1 courses use micro-worlds, multimedia, robotics, etc.

Principles of Computation

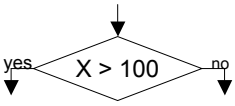
- Survey of the major contributions and issues associated with computer science, focusing on the study of the process of **computation**.
  - CS is not viewed through a specific programming language.
  - CS is not viewed through a specific application area (e.g. multimedia, robotics, etc.)
- This course focuses on what it means to perform computation and what issues arise as mankind automates this process using computers.
- Designed for students who will probably take only **one** CS course in their lives.

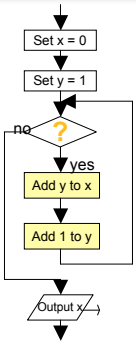
Course Topics


- History of Computation
  - What **societal needs** caused mankind to make great advances in understanding and automating computation?

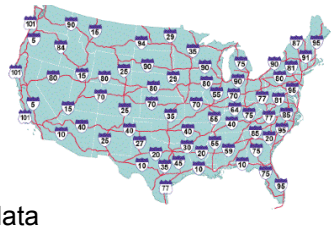
Course Topics





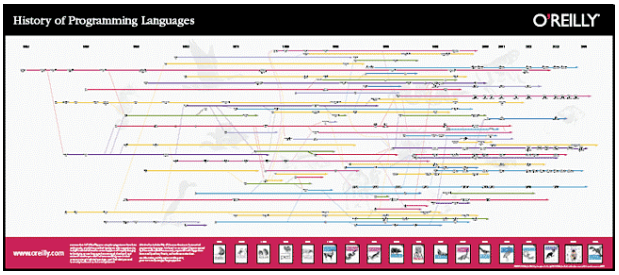
- Expressing Computation using Algorithms
  - Why do computations need to be expressed precisely?
  - How do we trace an **algorithm** to see what it is computing?
  - What common building blocks are used to specify algorithms?

Course Topics



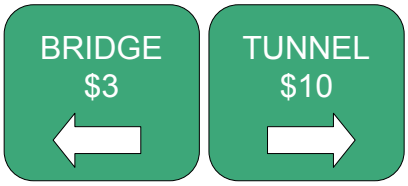
- Organizing Data
  - Are there better ways to **structure** data than just using a linear arrangement (vector)?
  - In what situations would we use these structures?

Course Topics



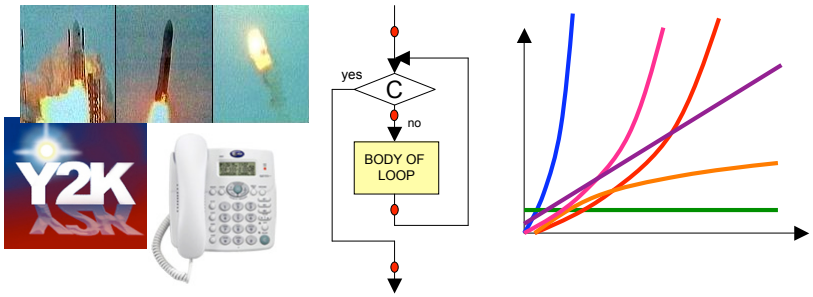
- Expressing Computations to a Computer
  - How do we use programming **languages** to express our algorithms to a computer so it can compute them?
  - Why are there so many programming languages?
  - Does the computer "understand" any of them?

Course Topics



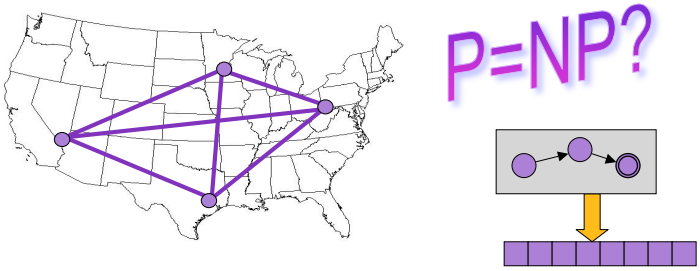
- "Tricks of the Trade" (Algorithmic Techniques)
  - How do we express computations **recursive**ly? Is this more intuitive?
  - How is "**divide and conquer**" used in computation?
  - Does a **greedy** approach to solving a problem always give the optimal answer?

Course Topics



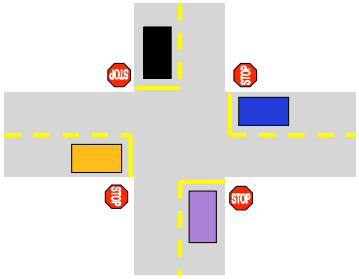
- Perfecting Computation
  - How do we know if a computation is **correct**? Why is this important?
  - How do we measure how **efficient** a computation is? What does that mean anyway?

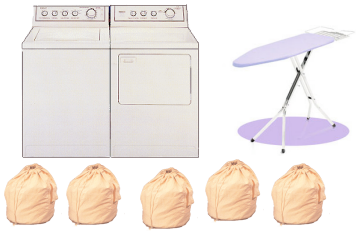
Course Topics



- The Limits of Computation
  - What makes a computation **intractable**?
  - Are all computations theoretically **solvable**?
  - Can we describe a **universal computer**?

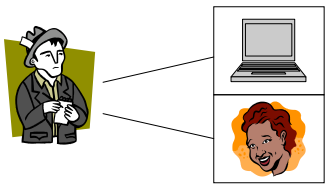
Course Topics

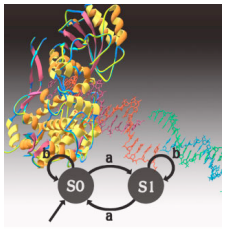




- Parallel and Distributed Computation
  - What problems occur if multiple computational processes need to use the same resources? Can **deadlock** be avoided?
  - If we run a computation in **parallel**, how much faster do we get an answer?

Course Topics



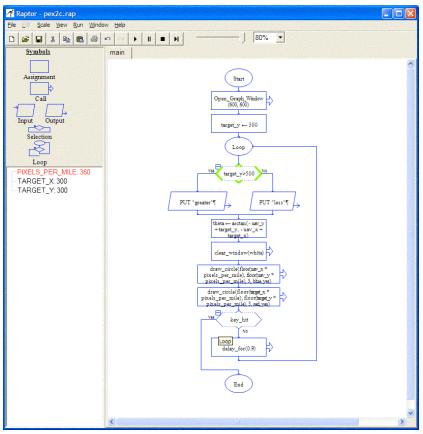


http://www.jyi.org/volumes/volume8/issue2/images/srivastava1.jpg

- Applications
  - What are the computational aspects of public-key **encryption**?
  - How **intelligent** are computers anyway?
- Future of Computing

Exploring Computation Without Syntax

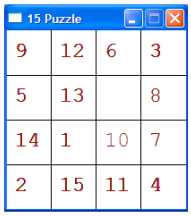
- Our course uses a public-domain program called RAPTOR, a flowchart simulator.
- Students can build simple procedural programs without learning the syntax details of a language.
- Contains conditionals, loops, input and output, arrays, subroutines, graphics.



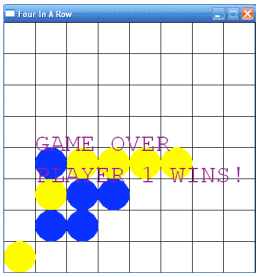
http://raptor.martincarlisle.com/

Programming without Syntax

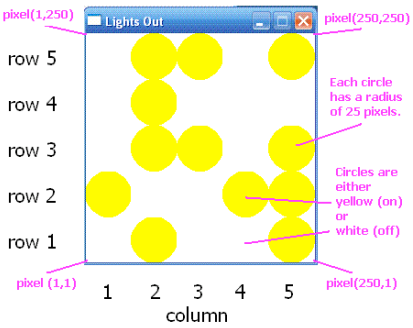
15 Puzzle



Four In A Row



Lights Out

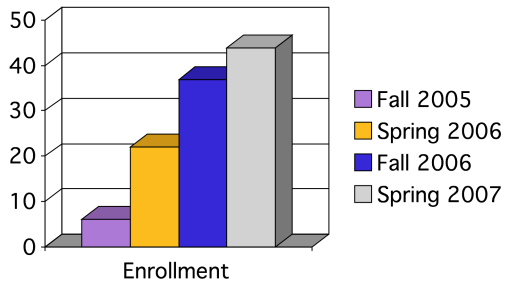


Writing in a CS Course: Examining Social Aspects

- MP3 file sharing systems and copyright infringement
- Privacy and security of electronic data, the rise of identity theft
- Electronic voting systems, verification and security
- The role of online social networks: the good, the bad and the ugly

Enrollment

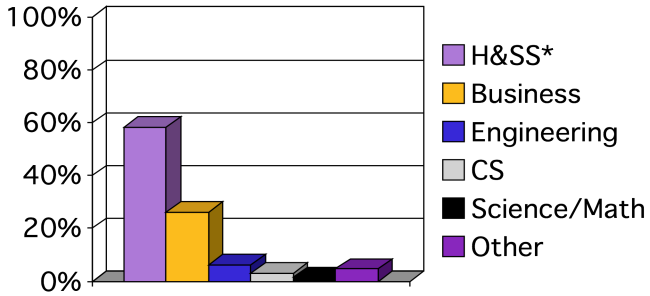
- Enrollment



- Requirements
  - Business: Acts as an alternative to Introduction to Programming.
  - Humanities/Social Science: Satisfies a Gen. Ed. requirement for modeling (mathematics and experiments).

Distribution of Majors by School

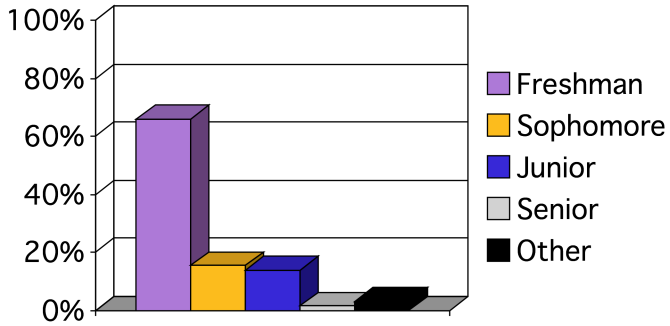
- Through Fall 2006:



(* H&SS = Humanities & Social Science - includes Information Systems)

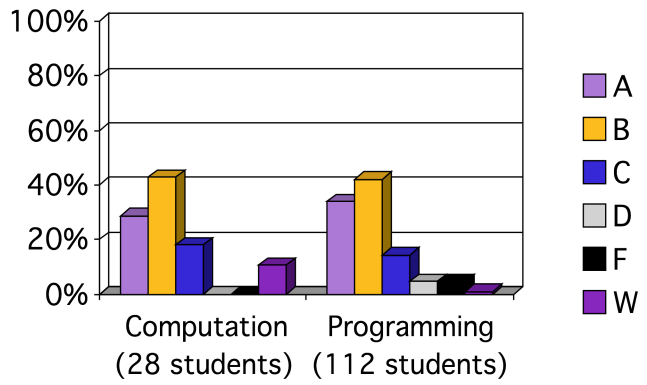
Distribution of Majors by Year

- Through Fall 2006:



Distribution of Grades

- Through Spring 2006:



Student Feedback

- Continue the use of guest speakers?
  - **Yes 80%** No 15% Unsure 5%
- Continue the use of Raptor?
  - Continue 30%
  - **Continue but use more graphics 55%**
  - Use another language/application 20%
  - Stay off the computer! 5%
- Did you take another CS class before or during this class?
  - Yes 20% **No 80%**
- Are you interested in taking another CS class if you could?
  - **Yes 55%** No 35% Unsure 10%
- Would you recommend this course to your friends?
  - **Yes 85%** No 15%

Describe this course in one sentence..

- "An alternative/substitute to [introductory programming]."
- "You learn a lot more than just how to code."
- "It's a lot better than doing real programming."
- "Understanding the world of computing beyond programming, and why and how programs and computers actually work."
- "It's a way to stay away from programming while actually learning something."
- "The fundamentals of programming."

There's still so much work to do...

Future Work

- Offer this course to high school students during the summer for college credit.
  - Aim at those high schools that have no CS courses beyond computer literacy.
- Experiment with non-traditional programming environments (e.g. Alice, Subtext).
- Track students who take additional courses in CS to see if this course had any effect on their interest and performance.

For More Information

- 15-105 Principles of Computation
  - http://www.cs.cmu.edu/~tcortina/15-105fa06
  - http://www.cs.cmu.edu/~tcortina/15-105
- Raptor
  - http://raptor.martincarlisle.com
- More About Computational Thinking
  - http://www.cs.cmu.edu/ct
- Questions after SIGCSE:
  - tcortina@cs.cmu.edu