

What is Computing? Informatics?

- **What is computer science, what is its potential?**
 - What can we do with computers in our lives?
 - What can we do with computing for society?
 - Will networks transform thinking/knowing/doing?
 - Society affecting and affected by computing?
 - Changes in science: biology, physics, chemistry, ...
- **Privileges and opportunities available if you know code**
 - Writing and reading code, understanding algorithms
 - Majestic, magical, mathematical, mysterious, ...

Computer Science: Duke Connection



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The Department of **Computer Science** at Duke University excel learning in **computer science**, and engages with the broader cor
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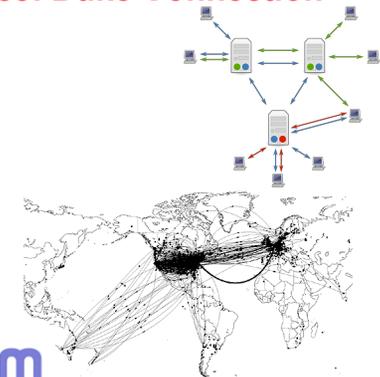
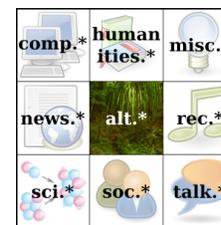
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usenet.com

Luis, Noam, Tom



Comp

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Fundamental Compsci Concepts

- “Mathematics is the Queen of the Sciences”
Carl Friedrich Gauss
- What is Computer Science?
 - > Why study it, what is it, why is it interesting (or not)?
- Historically
 - > What can we program: at all, efficiently, optimally
- Present
 - > Lots of data, lots of connectivity, lots of inferences
- Future
 - > Where do we go from here?

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What can be programmed?

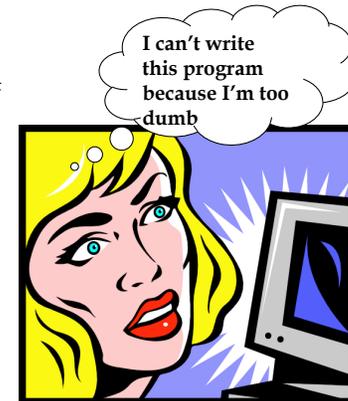
- What class of problems can be *solved*?
 - > G5, 1000Mhz Pentium III, Cray, pencil?
 - > Alan Turing contributions
 - Halting problem, Church-Turing thesis
- What class of problems can be *solved efficiently*?
 - > Problems with no practical solution
 - What does practical mean?
 - > We can't find a practical solution
 - Solving one solves them all
 - Would you rather be rich or famous?

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Schedule students, minimize conflicts

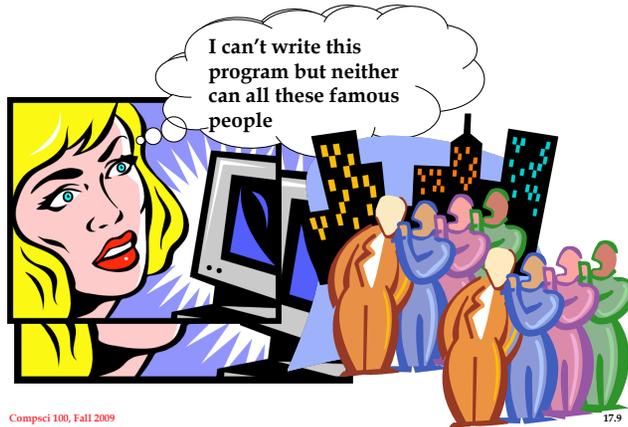
- Given student requests, available teachers
 - > write a program that schedules classes
 - > Minimize conflicts
- Add a GUI too
 - > Web interface
 - > ...
 - > ...



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Still another scenario, is this better?



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Entscheidungsproblem

- What can we program?
 - What kind of computer?
- What can't we program?
 - Can't we try harder?
- Can we write a program that will determine if any program P will halt when run on input S ?
 - Input to halt: P and S
 - Output: yes/no halts



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Good sites: <http://del.icio.us/>

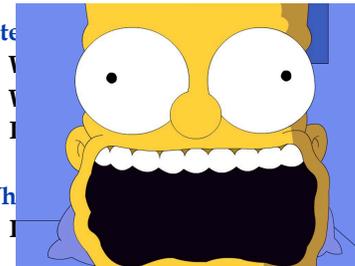
- What is social bookmarking?
 - Why is del.icio.us interesting?
 - Who posts, who visits?
- What about a website of interesting websites?
 - What would you expect to find there?
 - Would the site list itself?
- What about sites that list/link to themselves?
 - What about a site with all sites that list themselves?

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Bad sites: <http://haz.ardo.us>

- Site (them?)
 - V
 - V (tionally?)
 - I
- Wh (selves?)
 - I
- Website of all the sites that don't list themselves?
 - Is `notlisted.com` listed on `notlisted.com`?



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The halting problem: writing `doesHalt`

```
public class ProgramUtils
/**
 * Returns true if progname halts on input,
 * otherwise returns false (progname loops)
 */
public static boolean doesHalt(String progname,
                               String input){
}
}
```

- A compiler is a program that reads other programs as input
 - > Can a word counting program count its own words?
- The `doesHalt` method might simulate, analyze, ...
 - > One program/function that works for *any* program/input

How to tell if Foo stops on 123 456

```
public static void main(String[] args) {
    String prog = "Foo.java";
    String input = "123 456"
    if (ProgramUtils.doesHalt(prog,input)) {
        System.out.println(prog+" stops");
    }
    else {
        System.out.println(prog+" 4ever");
    }
}
```

- Can user enter name of program? Input?
 - > What's the problem with this program?

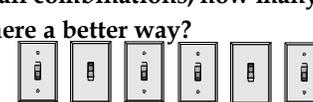
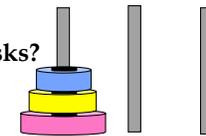
Consider the class `Confuse.java`

```
public static void main(String[] args){
    String prog = "Foo.java";
    if (ProgramUtils.doesHalt(prog,prog)) {
        while (true) {
            // do nothing forever
        }
    }
}
```

- We want to show writing `doesHalt` is impossible
 - > Proof by contradiction:
 - > Assume possible, show impossible situation results
- Can a program read a program? Itself?

Not impossible, but impractical

- Towers of Hanoi
 - > How long to move n disks?
- What combination of switches turns the light on?
 - > Try all combinations, how many are there?
 - > Is there a better way?



Travelling Salesperson

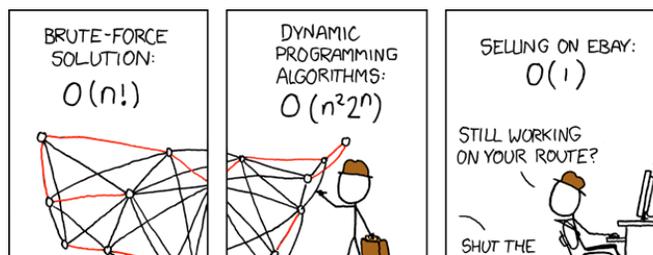
- Visit every city exactly once
- Minimize cost of travel or distance
- Is there a tour for under \$2,000 ? less than 6,000 miles?
- Is close good enough?
 - > Within 10% of optimal
 - > Within 50% of optimal
 - > ...



Try all paths, from every starting point -- how long does this take?

a, b, c, d, e, f, g
b, a, c, d, e, f, g ...

Travelling Salesman: XKCD 399



What's the complexity class of the best linear programming cutting-plane techniques? I couldn't find it anywhere. Man, the Garfield guy doesn't have these problems ...

Are hard problems easy? Clay Prize



Theory and Practice

- Number theory: pure mathematics
 - > How many prime numbers are there?
 - > How do we factor?
 - > How do we determine primeness?
- Computer Science
 - > Primality is "easy"
 - > Factoring is "hard"
 - > Encryption is possible



public-key cryptography

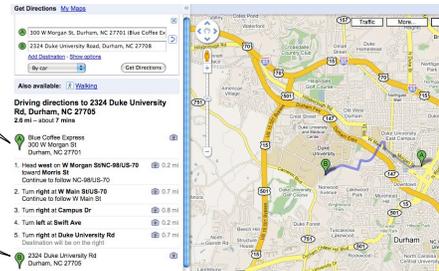
randomized primality testing

Useful Computer Science

- [http://maps.google.com/maps?f=d&source=s_d&saddr=300+W+Morgan+St,+Durham,+NC+27701+\(Blue+Coffee+Express\)&daddr=2324+Duke+University+Road,+Durham,+NC+27708&hl=en&qecode=FcNJJQIdYw5_M-vGT6vAZOfvdOg%3B&mra=1s&sl1=36.088126,-79.01786&sspn=1.333,898.2,11212](http://maps.google.com/maps?f=d&source=s_d&saddr=300+W+Morgan+St,+Durham,+NC+27701+(Blue+Coffee+Express)&daddr=2324+Duke+University+Road,+Durham,+NC+27708&hl=en&qecode=FcNJJQIdYw5_M-vGT6vAZOfvdOg%3B&mra=1s&sl1=36.088126,-79.01786&sspn=1.333,898.2,11212)

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How does this work?

- <http://tinyurl.com/d5o8mr>

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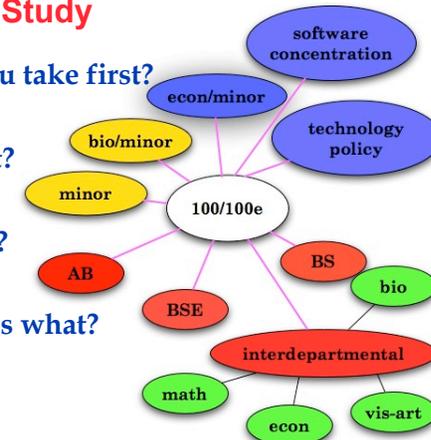


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Courses of Study

- What do you take first?
- What's next?
- In between?
- Who teaches what?



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