

Introduction to Formal Models in Computer Science

CSE 322

March 27, 2006

Welcome

- Instructor: Atri Rudra
- TAs
 - Jenny Liu
 - Tobias Roseman



Tobias Roseman

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2

Office Hours

- Look for the “Office Hours” sheet
 - Mark (all) 30 min slots when you can make it
- We’ll (try our best to) schedule the office hours accordingly

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3

Let’s start off with a game

- You need to help the Simpson family

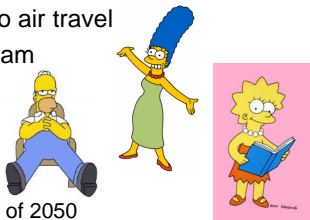


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4

The CSE322 game

- The Simpsons have to solve certain problems
- They all “relate” to air travel
- Who are in the team
 - Homer
 - Marge
 - Lisa
 - IBM Blue Gene
 - Fastest computer of 2050



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5

The “rules”

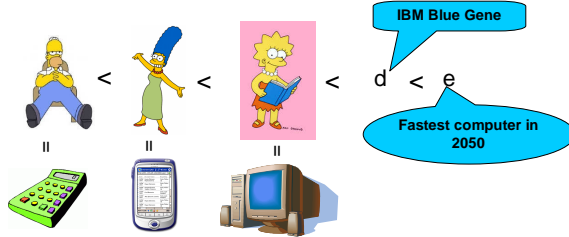
- There will be five problems
- One team member can solve only one problem
- Before we begin
 - Everyone should have an “answer” sheet

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6

Just to make sure...

- Agreement on “powers” of team members



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7

Your task then...

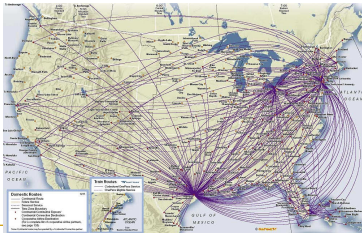
- Is to assign team members to the problems
 - “Easiest” problem goes to Homer
 - “Hardest” problem goes to (e)

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8

The problems

- Given the airline route map
 - Image below is the one just for Continental

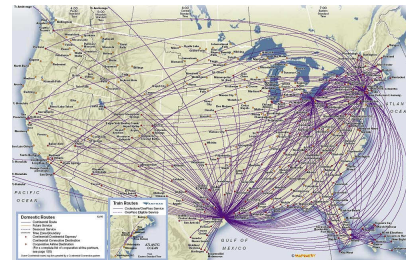


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9

Sample problem

- Is there a flight from SEA to JFK ?



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10

Ready ?

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11

Problem # 1

- Input : An airport name
- Output : Yes, if #e > #a. No otherwise.
- For example
 - Input : **Seattle**
 - Output: Yes
 - Input : **Atlanta**
 - Output: No



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12

Problem # 2

- Given two airports, find the cheapest flight option
 - The direct flight need not be the cheapest
- Given: Access to all pricing schemes and schedules of all airlines
- Input: Two airports
- Output: Sequence of flights with minimum airfare



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13

Problem # 3

- Input: Two airports
- Output: Shortest flight plan in terms of distance
- Given: Distances between any two airports



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14

Problem # 4

- Input : An airport name
- Output : Yes, it has **eat** in it. No otherwise.
- For example
 - Input : **Seattle**
 - Output: Yes
 - Input : **Atlanta**
 - Output: No



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15

Problem # 5

- Input: The whole route map
- Output: Yes, if there is a tour. No otherwise
 - Visit every airport
 - No airport is visited more than once

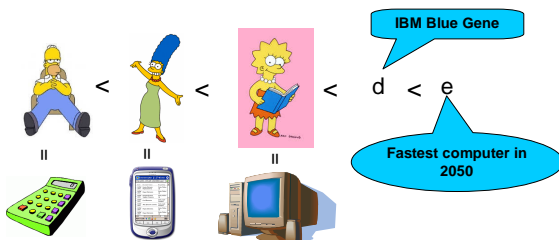


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16

Your task

- For each problem
 - Assign the "dumbest" member to it



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17

Administrative stuff

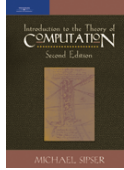
- Sign up for the class mailing list
 - Please subscribe again if you did so before March 26, 2006.
- Mark your favorite 30 min time slots for office hours
- Class website
 - <http://www.cs.washington.edu/322>

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18

Text Book

- *Introduction to the Theory of Computation*
 - 2nd Edition, 2005
 - Michael Sipser (MIT)
- Read Chapter 0



How do I ace this class ?

- Answer
 - Practice,
 - Practice, and
 - Practice
- Why ?
 - It's like skiing
 - You don't learn it by seeing others do it



The numbers

- Weekly Assignments (40-45%)
 - There would be about eight of them
 - See handout/ webpage for course policy
 - Collaboration allowed for some problems
 - No copying of solutions-- write it in your own words
- Midterm exam (20-25%)
 - Friday, May 5, 2006 (in regular class period)
- Final exam (35-40%)
 - Monday, June 5, 2006, 2:30-4:20pm (in class)
- Some extra credit

The answers

- (1) Airport name has #e > #a
 - (b) Marge Simpson (PDA)
- (2) Cheapest flight plan between 2 airports
 - (f) Other: **unsolvable**
- (3) Shortest path between 2 airports
 - (c) Lisa Simpson (Desktop)
- (4) Airport name has eat in it
 - (a) Homer Simpson (Calculator)
- (5) Shortest tour
 - (d)

The big picture

- We want to characterize “hard”/ “easy” problems
- Is computing 200 X 15 hard ?
 - For whom ?
 - Maggie ? Homer ? Lisa ? Atri?

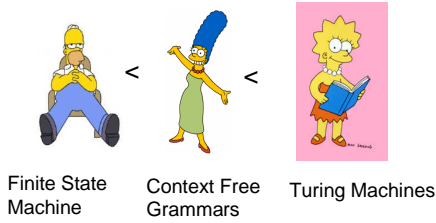


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Notion of computation machines

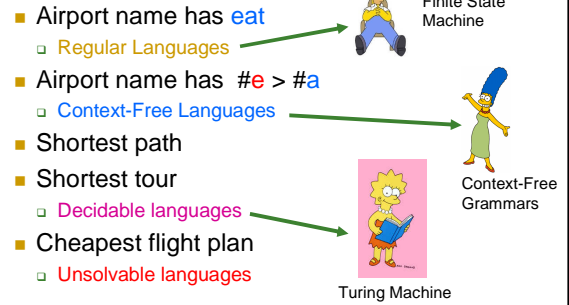
- Problem is hard/easy relative to the computation model
- In this course
 - We will define formal models of computation
 - Talk about their computation powers
 - What they can do and what they cannot

Simpson family model of computation



- We will prove a bunch of stuff about these models

A snapshot of the course



Why should you study in this course

- There is a certain beauty in math
 - What you prove **remains true for eternity**
 - Unless of course you have a wrong proof
- Theory aside, these models are used a lot in practice

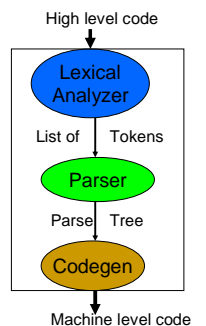
The applications

- Finite State Machine
 - Pattern/String matching
 - "Find a file" feature in Windows
 - "Find/Replace" feature of a text editor (Perl /Awk/ grep)
 - Controller in things that you use
 - The elevator controller
 - Controllers in appliances
 - Hardware
 - Formal verification
 - Bots in video games

Simple yet powerful enough to model many processes

Another application: Compiler

- *javac* for Java
- First step
 - Lexical Analyzer
 - Uses Finite state machines
- Second step
 - Parser
 - Errors messages
 - Context Free grammar
- Last step: Codegen



Application of Turing Machine

- Abstract model of computers
 - The "favorite" model for CS theory people
 - Algorithms
 - Computational complexity
 - P vs NP ?

Finite state machines

- First appearance as a model of the brain
 - W. S. McCulloch and W. Pitts
 - “A logical calculus of the ideas immanent in nervous activity”, *Bulletin of Mathematical Biophysics* 5 (1943), 115-133.

Let's delve into the brain of...

- Homer Simpson!

