Discrete Structures for Computer Science

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Lecture #1: Course Introduction

University of Pittsburgh

Based on materials developed by Dr. Adam Lee

Administrivia

CS 441: Discrete Structures for Computer Science

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Course meeting times

- Lecture
  - IS 405, T/H 12:30–2:15

- Recitation
  - Tuesday 2:30–3:20, IS 411
  - Thursday 11:30–12:20, IS 411

- It is important to attend ***both*** lecture and your assigned recitation section!
  - (No recitations this week)

Grading

- Overall breakdown:
  - 30% Midterm exam
  - 30% Cumulative final exam
  - 30% Homework
  - 10% Recitation exercises

  - 100%

Homework

Weekly homework assignments

- Assigned in class, due one week later at the **start** of lecture
- Late homework is not accepted—don't be late to class!
- Two lowest homework grades will be dropped

Homework may be discussed with others, but must be written up **individually**

- Limit discussion to understanding problems and developing solution tactics
- Identify collaborators on your homework cover sheet
- Failure to comply with this policy is a violation of academic integrity

Policies

- Check the web page 2–3 times per week. Announcements, homework, and lecture slides will be posted there.
  - Lecture slides are intentionally incomplete—take notes!!

- We will drop your two lowest homework scores before computing your homework average—no excuses necessary!

- If necessary, we will allow regrade requests. However, we reserve the right to regrade the *entire* assignment, not just the portion in question.

- Other policies are on the web page
  - Accommodating students with disabilities
  - Religious observances
  - Etc.

Questions?

Course overview

- What *is* discrete mathematics?
- Why is a math course part of the computer science curriculum?
- Will I really ever use this stuff again?
- How to succeed in this course

What is discrete mathematics?

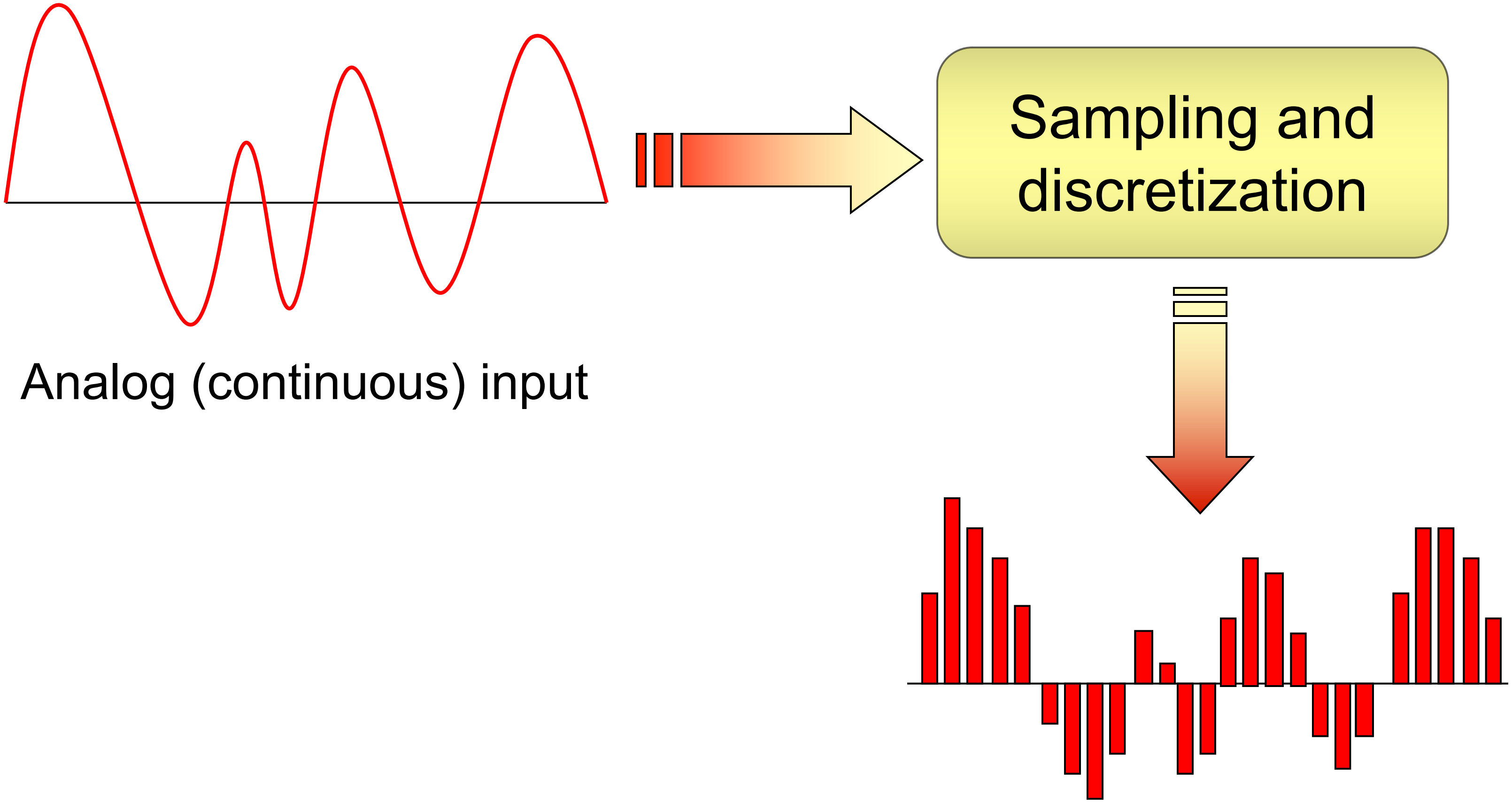
- Discrete mathematics is the study of *distinct* objects or structures and their relationships to one another

- For example:
  - How many ways can a valid password be chosen?
  - Can traffic flow between two computers in a network?
  - How can we transform messages to hide their contents?
  - How do we parse a given sequence of commands?

- By contrast, continuous mathematics (e.g., calculus) studies objects and relationships that vary continuously
  - e.g., position, velocity, and acceleration of a projectile

Why study discrete math?

Reason 1: Computers do not process continuous data



Sampling and discretization

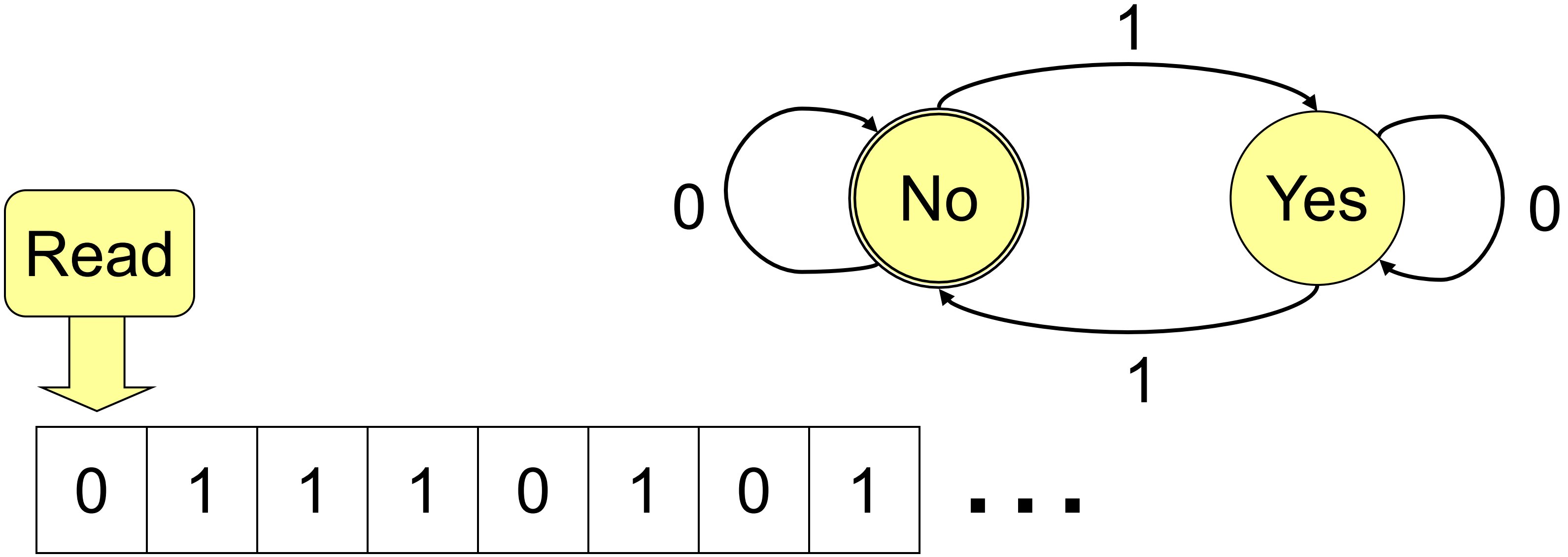
Analog (continuous) input

Digital (discrete) output

Why study discrete math?

Reason 2: Computers aren’t actually all that smart, they are just deterministic functions that map discrete inputs to discrete outputs

Example: Does a given string contain an odd number of 1s?



Why study discrete math?

In general: Discrete mathematics allows us to better understand computers and algorithms

```
function fib(int n)
  if(n == 0 || n == 1)
    return 1;
  else
    return fib(n-1) + fib(n-2);
```

```
function fib(int n)
  int first = 0;
  int second = 1;
  int tmp;
  for(i = 1 to n)
    tmp = first + second;
    first = second;
    second = tmp;
  end for
  return first;
```

Tentative Syllabus

- Logic and proofs
- Sets
- Functions
- Integers and modular arithmetic
- Counting
- Probability and expectation
- Relations

Are these topics really useful?

Logic and proofs

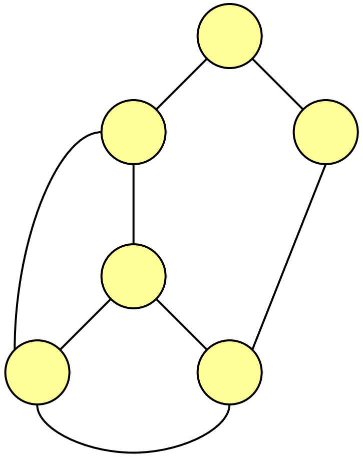
```
grant(X, projector) :- role(X, presenter), located(X, 104)
located(adam, 104)
role(adam, presenter)

=> ?grant(adam, projector)
=> true
```

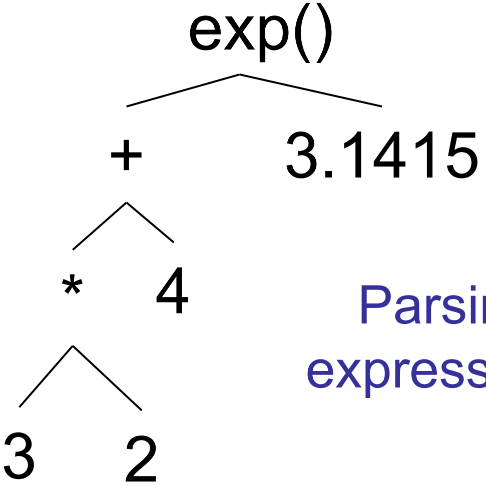
Automated reasoning, AI, security

```
function fib(int n)
  int first = 0;
  int second = 1;
  int tmp;
  for(i = 1 to n)
    tmp = first + second;
    first = second;
    second = tmp;
  end for
  return first;
```

Algorithm and protocol analysis

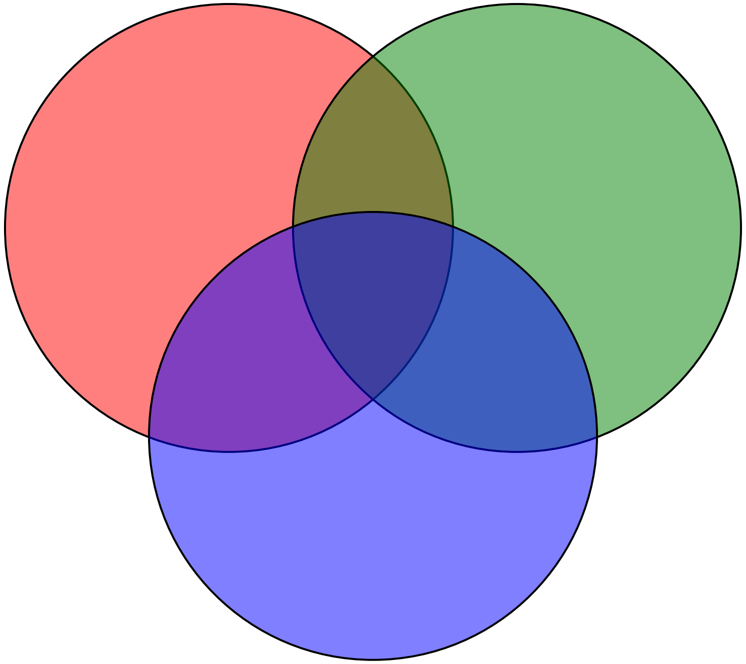


Verifying data structures and hardware



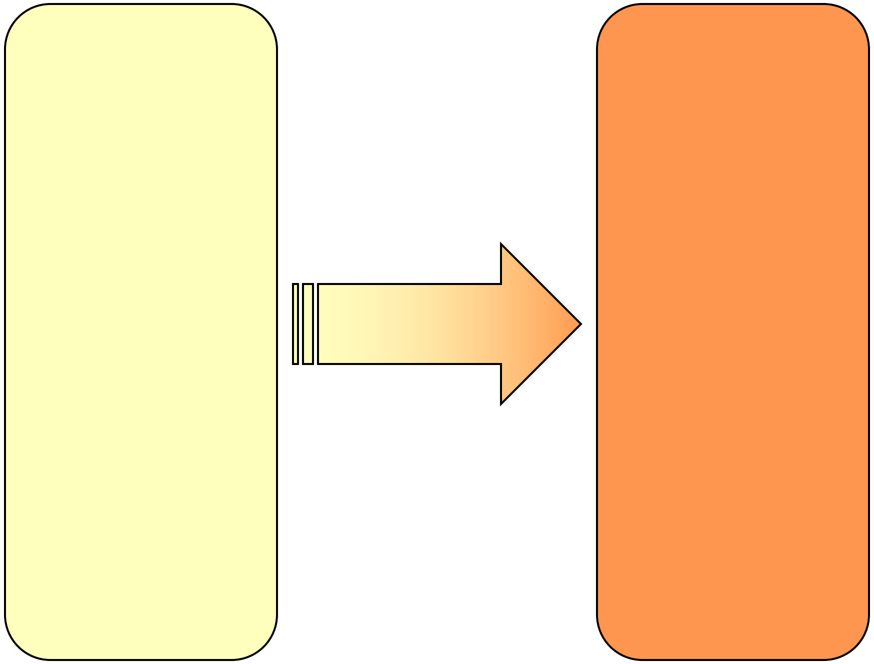
Parsing expressions

Sets

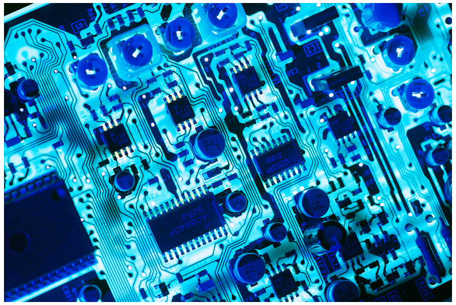


Sets define collections of objects…

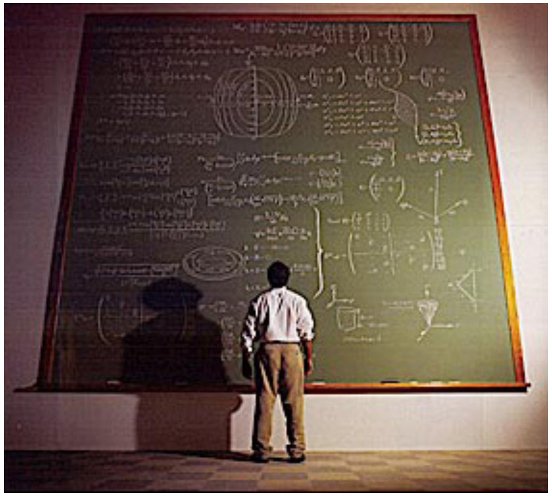
… and give us a means of reasoning about the relationships between objects



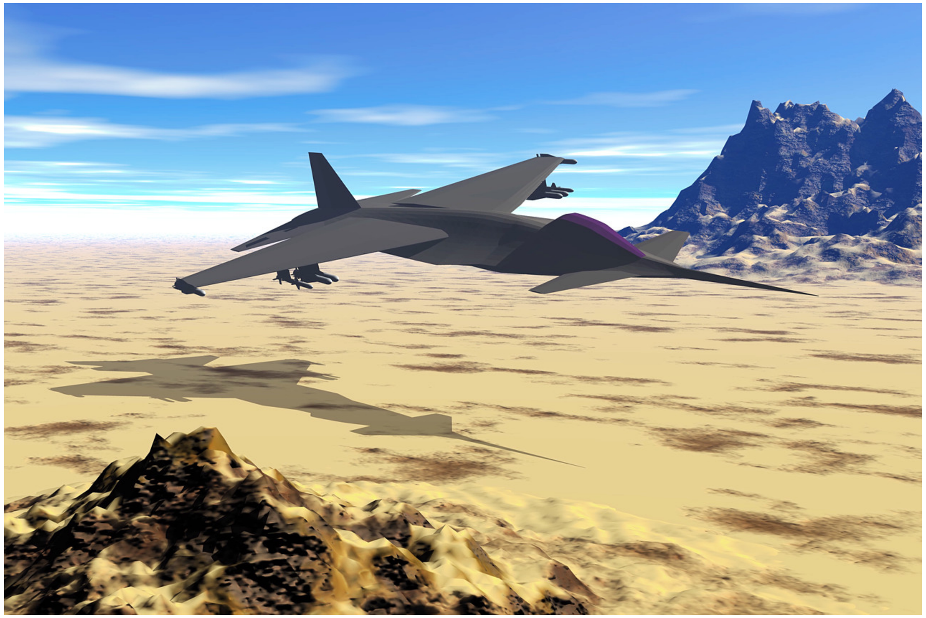
Functions



Hardware design



Theory of computation

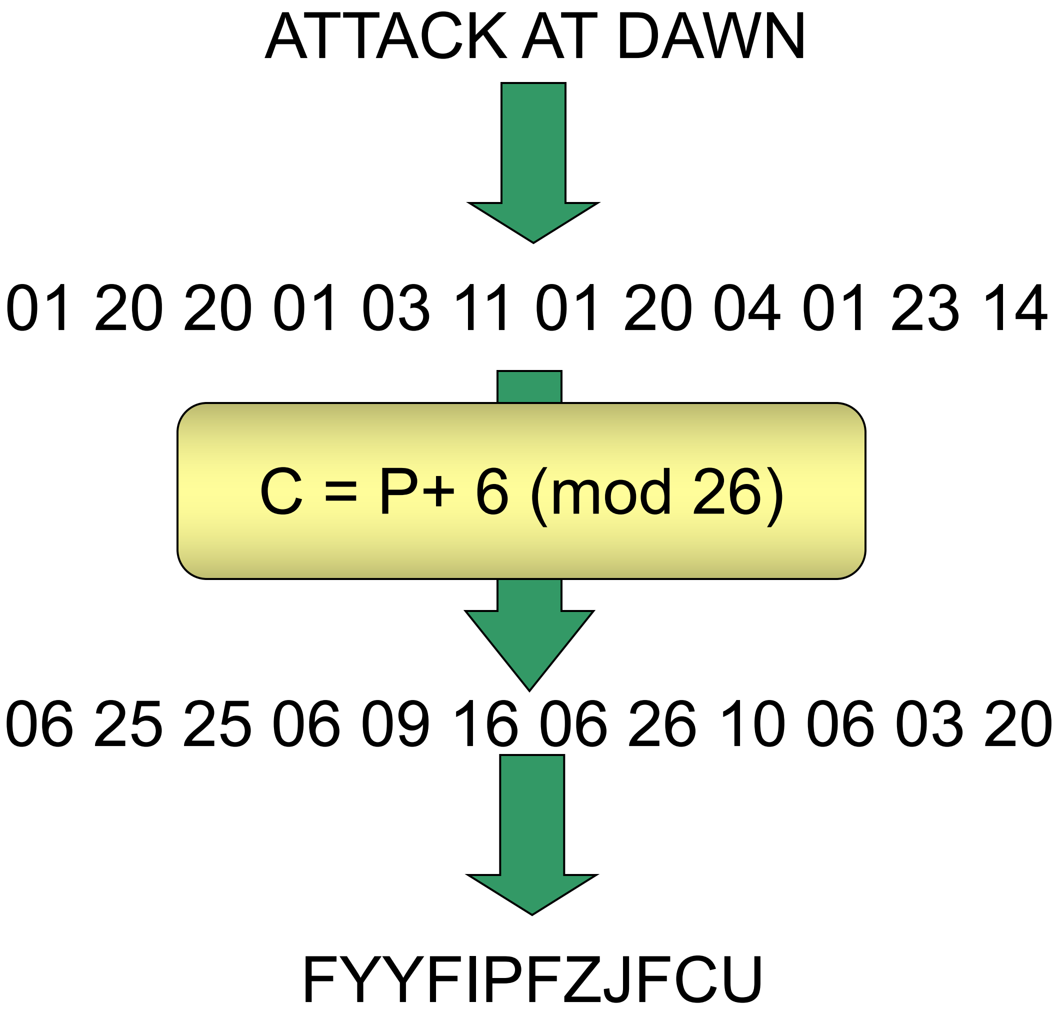


Computer graphics

Integers and Modular Arithmetic

```
  0111 0101 0110 1011
+ 0101 1001 1110 0001
---------------------
  1100 1111 0100 1100
```

Binary arithmetic and bitwise operations



ATTACK AT DAWN

01 20 20 01 03 11 01 20 04 01 23 14

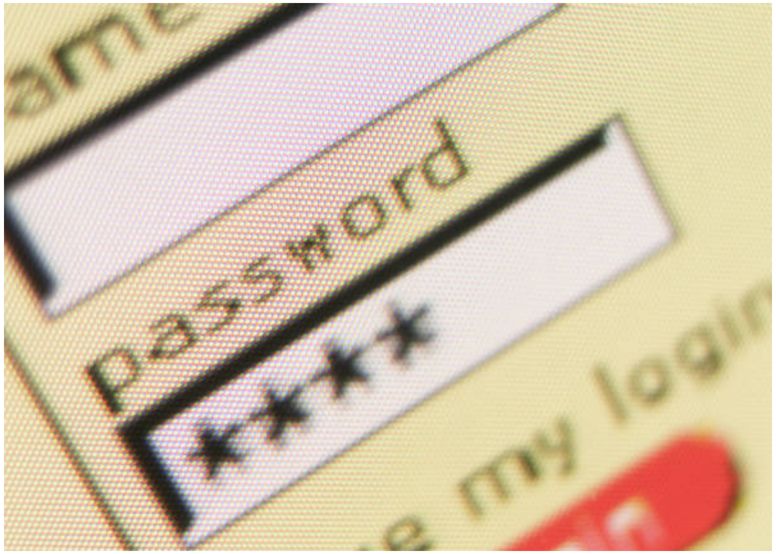
C = P+ 6 (mod 26)

06 25 25 06 09 16 06 26 10 06 03 20

FYYFIPFZJFCU

Cryptography

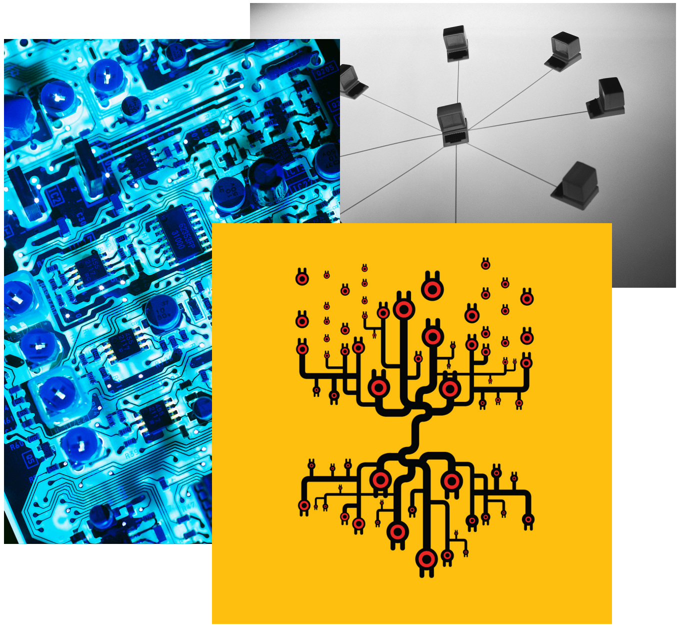
Counting



How many valid passwords exist for a given set of rules?

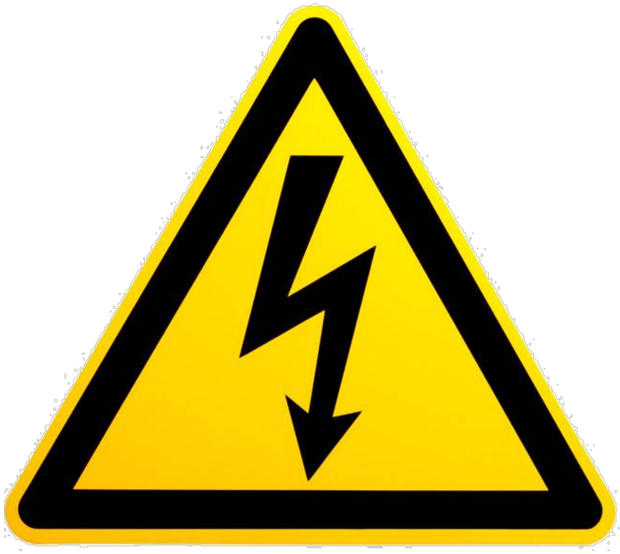
How many IP addresses can be assigned within a network segment? Will we run out?

Probability and Expectation



Hardware, software, and network simulation

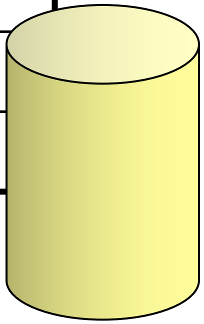
Spam classification



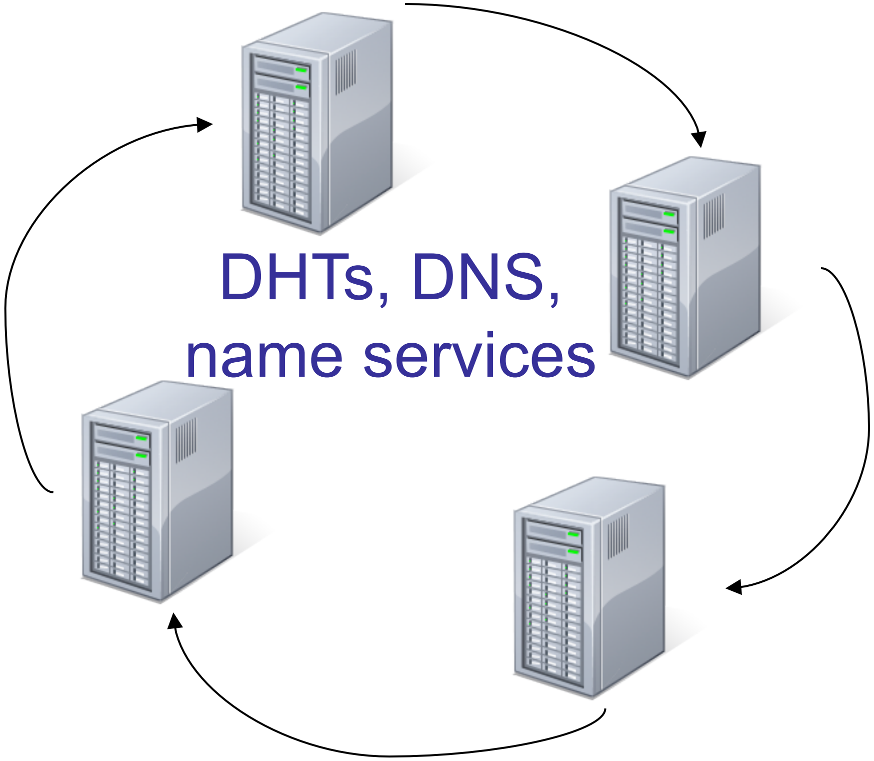
Risk assessment

Relations

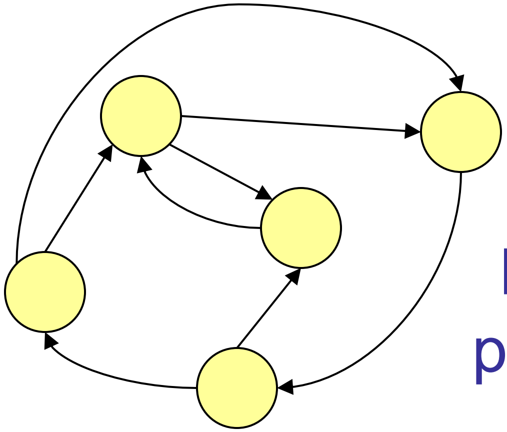
Name	Age	Phone
Alice	19	555-1234
Danielle	33	555-5353
Zach	27	555-3217
Charlie	21	555-2335



Relational databases



DHTs, DNS, name services



Route planning

Syllabus, redux

- Logic and proofs
- Sets
- Functions
- Integers and modular arithmetic
- Counting
- Probability and expectation
- Relations

Are these topics really useful?

Yes

Mastering discrete mathematics requires practice!

- Succeeding in this class requires practicing the skills that we will acquire, thinking critically, and asking questions

- Keys to success:
  - Attend class and take notes
  - Do your homework
  - Work extra problems when you’re unsure
    - Solutions to odd-numbered exercises provided in textbook
  - Go to your recitation every week
  - Take advantage of office hours

Final thoughts

- Our goal is to prepare you to be stronger computer scientists by:
  - Exploring the formal underpinnings of computer science
  - Developing critical thinking skills
  - Articulating ties between theory and practice

- Next: Propositional logic