Theoretical Computer Science
CS 310

Chadd Williams

Office Hours:

Mon 3:00 – 4:00 PM

Tues 2:00 – 4:00 PM

Fri 11:00 – 12:00 PM

and by appointment

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http://zeus.cs.pacificu.edu/chadd/cs310f06/

Syllabus

http://zeus.cs.pacificu.edu/chadd/cs310f06/syllabus.html

- *Introduction to the Theory of Computation* by Michael Sipser, (Second Edition)
  - I will assign problems out of this book

Grades:

- Homework: 15%
- 2 Exams: 25% each
- 1 Final 35% (Comprehensive)

Dates:

- Midterm 1, Wed Oct 11, 2006
- Midterm 2, Wed Nov 13, 2005
- Final, Tue Dec 5 (8:30 – 11:00 AM)

Policies:

- Assignments are due at the beginning of class. Late assignments will not be accepted.
- The cheating policy is defined in the Pacific Catalog
- Silence all electronic devices

Today

- Overview of class
- Mathematical Notation
- Proof by Induction
- Who Am I?

Overview

- What are the fundamental capabilities and limitations of computers?
- Computer Science is really the science of computation, not of computers.
- How does theory related to programming?
- Complexity Theory
- Computability Theory
- Automata Theory

Mathematical Notation

- Basic notations we will use in this class
  - Page 16 of your book has a partial list (no symbols!)
- Set

  { 7, 21, 57 } { 1, 2, 3, … } { gold, blue }
- Subset
- Proper Subset

Sets

- Shorthand for describing a set

  $\{ n \mid \text{rule about } n \}$

  $\{ n \mid n = m^2 \text{ for some } m \in N \}$

  $\{ \{i, i^2\} \mid i \in N \}$

Set Operations

- What can we do with sets?
- Union
- Intersection
- Complement

Sets

- Power Set

  $\{ 0, 1 \}$

- Cartesian Product (Cross Product)

  $\{ 0, 1 \} \times \{ a, b \}$

Sequences/Tuples

- Sequence

  (7, 21, 57) (21, 7, 57) (gold, blue)

- Tuple

  K-tuple

Functions

- Object that takes input, produces output

  f (a) = b

- Domain and Range

  $f : D \rightarrow R$

- Onto

Functions

- $f : A_1 \times A_2 \times \ldots \times A_k \rightarrow R$

  $(a_1, a_2, \ldots, a_k)$

  k-ary

  arity

  unary (k=1) binary (k=2)

- Notation

  Infix notation: a + b

  Prefix notation: add(a,b)

Relations

- Predicate (property)

  $f : D \rightarrow \{TRUE, FALSE\}$

- Relation

  $f : A_1 \times A_2 \times \ldots \times A_n \rightarrow \{TRUE, FALSE\}$

- Notation

  table

  Set

Equivalence Relations

binary relation

shows that two objects are equal

must satisfy 3 conditions:

1. R is ***reflexive*** if for every x, xRx;
2. R is ***symmetric*** if for every x and y, xRy if and only if yRx;
3. R is ***transitive*** if for every x, y, and z, xRy and yRz implies xRz

Proof by Contradiction

- Assume it is false
- Show this leads to a false consequence
- Prove $\sqrt{2}$ is irrational
  - Assume it is rational: $\sqrt{2} = m/n$
  - Reduce m/n to lowest terms: m and n are not both even (could reduce out a 2)
  - sometimes tricky to pick exactly what false consequence to show

Proof by Induction

- Basis

  Prove P(1) is true

- Induction Step

  Prove that for each i>=1, if P(i) is true,

  then so is P(i+1); *assume P(i) is true*

- Basis + Induction Step

  P(1) is true, i = 1

  P((i+1)) is true

  P((i+1) +1) is true …

Proof by Induction

- Prove: $1 + 2 + \ldots + n = n(n+1) / 2$

  for $n >= 1$

  Basis:

  Induction:

Chadd Williams

- New Computer Science Professor!
- Education
  - West Virginia University (BS)
  - University of Maryland, College Park (MS,PhD)
- Research
  - Systems
    - Runtime code patching
    - modify instructions in a running executable
  - Programming languages/Software Engineering
    - Studying software change history to learn about the source code

Graphs

- Graph

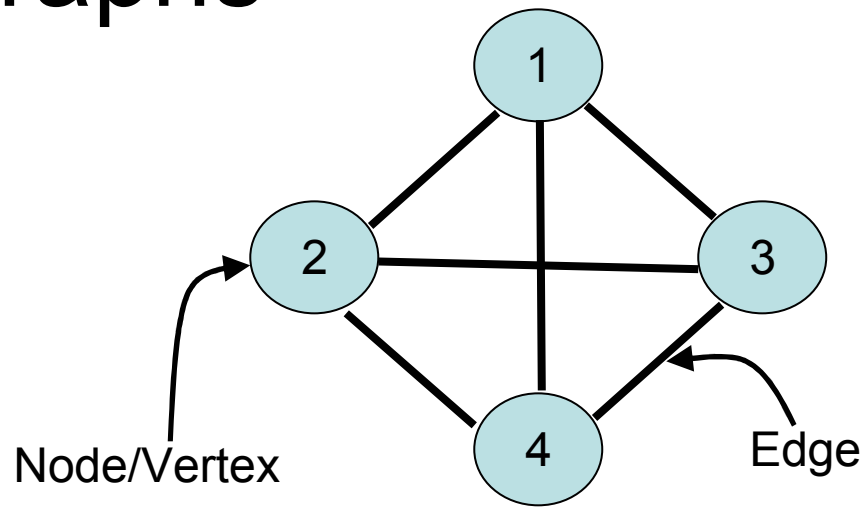
  Collection of nodes

  and edges

  G = (V,E)

  E =

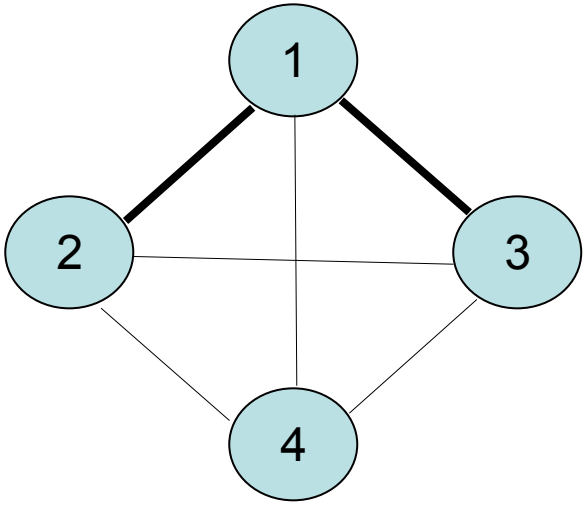
  undirected



- Degree of a node

Graphs

- Subgraph



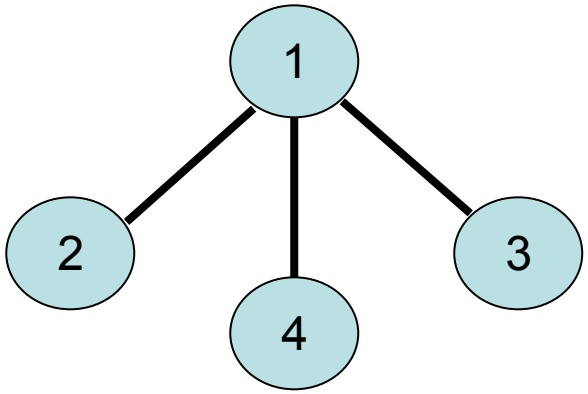
- Path

Connected graph

- Cycle

Trees

- Connected graph with no simple cycles
- Leaves
- Root



Directed Graph

- Arrows denote which way an edge goes

  outdegree/indegree

  G=(V,E)

  V=

  E=

  Directed path

  Strongly connected