CSE 20
Discrete Mathematics

Instructor

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http://cseweb.ucsd.edu/classes/wi10/cse20/

Textbooks

- A Short Course in Discrete Mathematics
  Edward A. Bender and S. Gill Williamson, Dover, 2005.

- Discrete Mathematics
  Seymour Lipschutz and Marc Lipson, Schaum's Outline Series, Third Edition, McGraw Hill, 2007

Grading

• Quizzes and Scripts	5%
• Midterm 1 01/21/2010	25%
• Midterm 2 02/16/2010	30%
• Final Exam 03/16/2010 Tuesday from 7:00-10:00	40%

Administrative

- **Schedule**
  – Lectures: 6:30-7:50PM TTh, CSB001.
  – Discussion: 10:00-10:50AM W, Center 113.

- **First Discussion Section: Wednesday, Jan. 13**
  – Office hours: 10:30-11:30AM T, 11:00-12:00PM Th, CSE 2130.

Course Outline

Part 1. Numbers: choice of number systems, binary, Gray code, one's complement, two's complement, residual number system, theorems of primes and modulations.

Part 2. Boolean Algebra: manipulation of logic and gates, laws and theorems, tautology, SAT, multiple elements, minimization.

Part 3. Functions and Recursion: function definition and calculation, induction process, k'th order series, Factorial, Fibonacci, Ackerman, division, square root iterations.

Part I. Number Systems

1. Introduction
2. Binary Number B.F. Section 2
3. Gray Code
4. Negative Numbers B.F. Section 2
5. Residual Numbers N.F. Section 1, Shaum Ch. 11

I. Introduction

1. Examples of different number systems
2. Efficiency of the systems
3. Remarks

1. Example of Number Systems

Radices (or Bases)

- Decimal
  - Each digit has a weight of 0-9 with each place multiplied by 9
  - Radix 10 → increase each place holder by 10
  - Example: $250=2*10^2 + 5*10$
- Binary
  - Each place has a weight of 2
  - Radix 2
  - Example: 11010, can sum weights → $2^4 + 2^3 + 2 = 26$
- Ternary
  - The weight of each place advances by a factor of 3
  - Radix 3
- Hybrid
  - Places have varying weights
  - Example: time
  - 1 year 3 months 2 days 1 hour 4 min 26 seconds

1. Examples (cont.)

- **Binary (radix 2)**
  - 2 symbols possible in each place (0, 1).
  - With n digits, we need 2n tokens with 2 tokens per digit.
  - With n digits, 2^n numbers can be represented
- **Ternary (radix 3)**
  - 3 symbols possible in each place (0, 1, 2).
  - With n digits, we need 3n tokens
  - With n digits, 3^n numbers can be represented
- **(radix 5)**
  - 5 symbols possible in each place (0, 1, 2, 3, 4).
  - With n digits, we need 5n tokens
  - With n digits, 5^n numbers can be represented
- **Decimal (radix 10)**
  - 10 symbols possible in each place (0, 1, 2, 3, 4, 5, 6, 7, 8, 9).
  - With n digits, we need 10n tokens
  - With n digits, 10^n numbers can be represented

2. Efficiency of Number Systems

How many numbers can we represent in each system with 30 symbols?

- **Binary**
  - 30=2n → The length of the number is n=15
  - 2^{15} ~ 33,000
- **Ternary**
  - 30=3n → The length of the number is n=10
  - 3^{10} ~ 60,000
- **Radix 5**
  - 30=5n → The length of the number is n=6
  - 5^{6} ~ 16,000
- **Decimal**
  - 30=10n → n=3
  - 10^{3} ~ 1000

What’s Most Expressive?

- For radix k, with n digits
  - Range is k^n
  - # tokens required is kn=t
  - We maximize the range at a constant #token= t
    - $k^n = k^{t/k}$ → In real space, the solution is k=e
    - e is closest to the integer 3
  - As seen in previous slide, ternary number systems can represent the most numeric values for a given number of tokens.
  - However ternary is difficult to implement, so binary is used in computer systems.

3. Remarks

- We design number systems according to the usages and technologies.
- For VLSI designs, binary number system is consistent with the technology.
- Various number systems are possible for different goals and technologies, e.g. low power, reliability, security, bandwidth.