

COS 126 Precept

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March 3, 2009

Agenda

- ▶ Exam Information
- ▶ Number Systems
 - ▶ Converting between Binary, Decimal, and Hex
 - ▶ Two's Complement
- ▶ Toy
 - ▶ Basics of TOY
 - ▶ Trace through some code



Exam 1

- ▶ **Tuesday March 10**
 - ▶ 2 Parts
 - ▶ In class
 - 10am McCosh 50
 - 11am Friend 101
 - ▶ Programming: In Precept
 - Volunteers to take it in Friend 017?
- ▶ **Cheat Sheet**
 - ▶ Single sided
 - ▶ Hand Written (pen or pencil)
- ▶ **Q & A**
 - ▶ Sunday March 8, 7:30pm in CS 104



Number Systems

- ▶ **Computers represent data as bits**
 - ▶ A bit is either 0 or 1 (this is why it is called binary)
- ▶ **We can convert from binary to:**
 - ▶ Decimal (0 – 9)
 - ▶ Hexadecimal (0-9,A-F)



Number Systems

- ▶ How big is this decimal number: 1048
- ▶ How do you know?



What does a binary number mean

- ▶ A 4 bit number: 1001

Bit Value	1	0	0	1
Bit Position	3	2	1	0

- ▶ What is this number in decimal?

$$9 = 8 + 0 + 0 + 1 = 1*2^3 + 0*2^2 + 0*2^1 + 1*2^0$$

- ▶ What about the number: 1011?

$$11 = 8 + 0 + 2 + 1 = 1*2^3 + 0*2^2 + 1*2^1 + 1*2^0$$



Binary to Hexadecimal

- ▶ A 4 bit number: 1001
- ▶ What is this number in Hex?
 - ▶ 9
- ▶ What about the number: 1011?
 - ▶ B
- ▶ What about 10011011?
 - ▶ 9B

Binary	Hex Digit
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F



What is binary representation of 100

▶ 16-bit binary number

0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

- ▶ $32768 = 2^{15} \leq 100$
- ▶ $16384 = 2^{14} \leq 100$
- ▶ $8192 = 2^{13} \leq 100$
- ▶ $4096 = 2^{12} \leq 100$
- ▶ $2048 = 2^{11} \leq 100$
- ▶ $1024 = 2^{10} \leq 100$
- ▶ $512 = 2^9 \leq 100$
- ▶ $256 = 2^8 \leq 100$
- ▶ $128 = 2^7 \leq 100$
- ▶ $64 = 2^6 \leq 100$ (YES!)
- ▶ $32 = 2^5 \leq 36$ (YES)
- ▶ $16 = 2^4 \leq 4$
- ▶ $8 = 2^3 \leq 4$
- ▶ $4 = 2^2 \leq 4$ (YES)
- ▶ $2 = 2^1 \leq 0$
- ▶ $1 = 2^0 \leq 0$



Two's Complement

- ▶ The representation of signed numbers used in most computers today
- ▶ One bit is reserved for the sign bit
- ▶ The remainder of the bits are interpreted based on the sign bit

- ▶ [Sign][Magnitude of Number]

- ▶ We use this representation because it makes adding and subtracting easier
 - ▶ No need to examine sign bit when performing addition or subtraction



What do two's complement Numbers look like?

- ▶ For an N-bit two's complement number, we can represent
- ▶ -2^{N-1} to $2^{N-1} - 1$

sign bit									
0	1	1	1	1	1	1	1	1	= 127
0	0	0	0	0	0	1	0		= 2
0	0	0	0	0	0	0	1		= 1
0	0	0	0	0	0	0	0		= 0
1	1	1	1	1	1	1	1		= -1
1	1	1	1	1	1	1	0		= -2
1	0	0	0	0	0	0	1		= -127
1	0	0	0	0	0	0	0		= -128

8-bit two's-complement integers



How to we represent -100 in two's complement?

- ▶ Magnitude of 100 = **0000 0000 0110 0100**
- ▶ We want -100
 - ▶ Flip all of the bits
 - ▶ 1111 1111 1001 1011
 - ▶ Add 1 to the value
 - ▶ **1111 1111 1001 1100**



Hex representation

- ▶ 1111 1111 1001 1100
- ▶ F F 9 C
- ▶ FF9C

Binary	Hex Digit
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F



Decimal Representation

- ▶ What is value of hex number: FFFE
 - ▶ 1111 1111 1111 1110
 - ▶ Which bit is sign bit?
 - ▶ 1111 1111 1111 1110
 - ▶ Flip all non-sign bits
 - ▶ S000 0000 0000 0001
 - ▶ Add 1
 - ▶ S000 0000 0000 0010
 - ▶ Magnitude: $2^1 = 2$
 - ▶ Sign = 1 => Negative
- ▶ Value: -2

Binary	Hex Digit
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F



Hex Representation of -27

- ▶ What is the magnitude part of 27?
 - ▶ 0000 0000 0001 1011
 - ▶ We set Sign bit to 1 (so that it is negative)
 - ▶ 1000 0000 0001 1011
 - ▶ Flip all non-sign bits
 - ▶ 1111 1111 1110 0100
 - ▶ Add 1
 - ▶ 1111 1111 1110 0101
 - ▶ Convert to Hex
 - ▶ F F E 5



Toy

- ▶ Get the Handout
- ▶ Get into groups of 2 or 3
- ▶ Fill out the 7 questions
 - ▶ Use Booksite and Lecture Notes



Toy Instruction Set

- ▶ No need to memorize the chart
- ▶ You will be provided it on the test

