Introduction to Computing

Lecture 3

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Arithmetic's on Binary Number System

Binary Addition

- **Four things to remember:**

$$\begin{array}{r} 0 \\ +\ 0 \\ \hline 0 \end{array} \qquad \begin{array}{r} 1 \\ +\ 0 \\ \hline 1 \end{array} \qquad \begin{array}{r} 1 \\ +\ 1 \\ \hline 1\ 0 \end{array} \qquad \begin{array}{r} 1 \\ 1 \\ +\ 1 \\ \hline 1\ 1 \end{array}$$

$$\begin{array}{r} 1100 \\ +\ 1001 \\ \hline 10101 \end{array}$$

Exercise

- **Add following binary numbers:**

1110	14	1111	15	1111	15
+ 1011	11	+ 1010	10	+ 1111	15
11001	**25**	**11001**	**25**	**11110**	**30**

Binary Multiplication

1100	12
x 1001	9
1100	
0000x	
0000xx	
1100xxx	
1101100	108

Binary Multiplication

- **Multiply following binary numbers:**

1101	1001	11011
x 10	x 101	x 1001
11010	**101101**	**11110011**

How do we write negative binary numbers?

Binary Number System

- Historically: 3 approaches
  - Sign-and-magnitude
  - Ones-complement
  - **Twos-complement**
- For all 3, the most-significant bit (MSB) is the sign digit
  - 0 ≡ positive
  - 1 ≡ negative
- Two's-complement is the important one
  - Simplifies arithmetic
  - Used almost universally

Sign-and-magnitude

- The most-significant bit (MSB) is the sign digit
  - 0 ≡ positive
  - 1 ≡ negative
- The remaining bits are the number's magnitude

0101 (5) **1101 (-5)**

Problem 1: Two representations for zero
0 = 0000 and also –0 = 1000

Problem 2: Arithmetic is incorrect

Binary Number System

0100	4	0100	4	1100	-4
+ 0011	3	+ 1011	-3	+ 0011	3
0111	7	1111	1	1111	-1
		-7		-7	