THE UNIVERSITY OF ARIZONA
UA South

CYBV 471 Assembly Programming for Security Professionals
Week 1

Data Presentation, Number Systems, Boolean Operations

Agenda

- **Data Presentation**
  - Decimal numbers
  - Binary numbers
  - Floating point numbers
  - Hexadecimal numbers
- **Floating-point (fraction) Presentation**

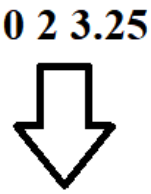
Data Representation

- Decimal Number System
- Binary Numbers
  - What is a binary number?
  - Converting decimal numbers to binary numbers
  - Converting binary numbers to decimal numbers
- Hexadecimal numbers
  - Converting decimal numbers to hexadecimal numbers
  - Converting binary numbers to hexadecimal numbers
  - Converting binary numbers to hexadecimal numbers

Decimal Number System

- Each digit could have a value from 0 to 9 (10 different values)
- Since each digit could have 10 different values, the decimal number system is a base-10 number system
- Digits are normally combined together in groups to create larger numbers.
- A number represented in the base-10 system consists of multiple ordered digits.
  - Each digit to the left and right of the decimal point is given a name (ones, tens, hundreds, etc.) which identifies that digit's placeholder.
  - Each placeholder is a multiple of ten.

Decimal Number System



	5	0	2	3	.2	5
Weigh of each digit	10^{3}	10^{2}	10^{1}	10^{0}	10^{-1}	10^{-2}

The value of (5023.25) is calculated as follows:

$$5 * 10^{3} + 0 * 10^{2} + 2 * 10^{1} + 3 * 10^{0} + 2 * 10^{-1} + 5 * 10^{-2}$$

$$5000 + 20 + 3 + 0.2 + 0.05 = 5023.25$$

Binary number, Bits and Bytes

- Each bit is either 1 (True) or 0 (False)
- The binary number system is base 2 system since each digit could be be 0 or 1.
- Byte: 8 Bits
- Byte = a unit of storage
  - 1KB = 2^{10} = 1024 Bytes
  - 1MB = 2^{20} = 1,048,576 Bytes
  - 1GB = 2^{30} = 1,099,511,627,776 Bytes
  - Main memory (RAM) is measured in GB
  - Disk storage is measured in GB for small systems, TB (Tera Bytes = 2^{40}) for large systems

Binary Numbers

- Value of bit depends on the position of the bit in the binary number

Binary Bit Position Values.

2^n	Decimal Value	2^n	Decimal Value
2^0	1	2^8	256
2^1	2	2^9	512
2^2	4	2^{10}	1024
2^3	8	2^{11}	2048
2^4	16	2^{12}	4096
2^5	32	2^{13}	8192
2^6	64	2^{14}	16384
2^7	128	2^{15}	32768

Converting Binary to Decimal

- Example-1: What is the decimal value of 0101101?

2^n	Decimal Value	2^n	Decimal Value
2^0	1	2^8	256
2^1	2	2^9	512
2^2	4	2^{10}	1024
2^3	8	2^{11}	2048
2^4	16	2^{12}	4096
2^5	32	2^{13}	8192
2^6	64	2^{14}	16384
2^7	128	2^{15}	32768

Value of each bit (1 or 0)	**0**	**1**	**0**	**1**	**1**	**0**	**1**
Weight of each bit	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Decimal value of 1-bit		**32**	0	**8**	**4**	0	1

Total Decimal value = $32 + 8 + 4 + 1 = 45$

Converting Binary to Decimal

- Example-3: What is the decimal value of 101.101?

2^n	Decimal Value	2^n	Decimal Value
2^0	1	2^8	256
2^1	2	2^9	512
2^2	4	2^{10}	1024
2^3	8	2^{11}	2048
2^4	16	2^{12}	4096
2^5	32	2^{13}	8192
2^6	64	2^{14}	16384
2^7	128	2^{15}	32768

Value of each bit (1 or 0)	**1**	**0**	**1**	**.1**	**0**	**1**
Weight of each bit	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}
Decimal value of 1-bit	**4**		**1**	**1/2**		**1/8**

Total Decimal value = 4 + 1 + 1/2 + 1/8 = 5.625

Converting Decimal to Binary

- What is the binary representation of 97?
- STEPS

1- Divide the decimal number by 2 and calculate the “quotient” and the “reminder (1 or 0)”.

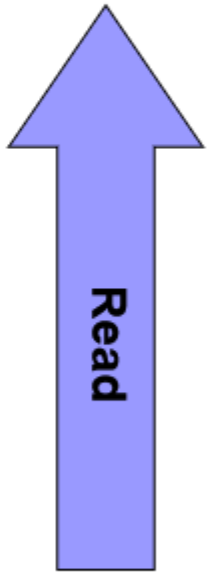
2- Keep the reminder in a separate column

PS: The remainder column only has ones or zeros.

3- If the quotient value greater than 1, repeat the previous step until the last quotient is 1 or 0.

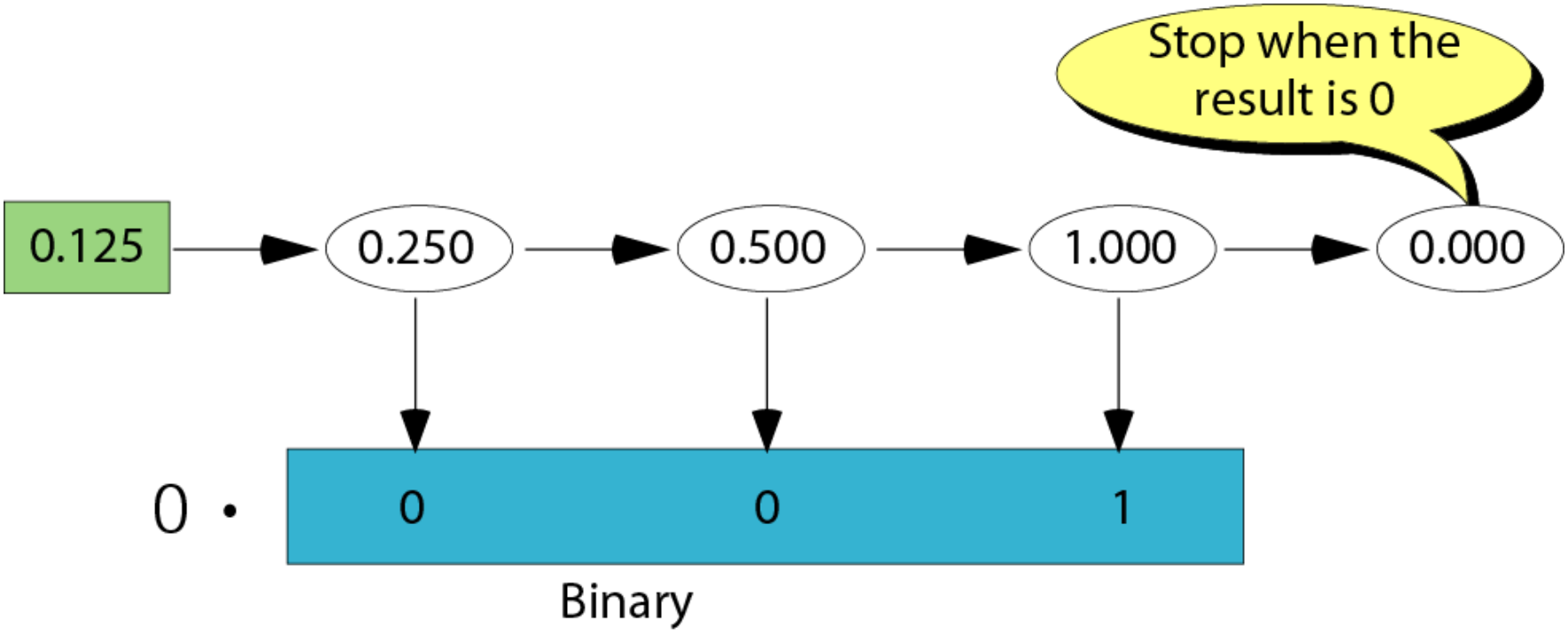
4- Read the 1s and 0s in the remainder column from the bottom to the top, we'll have our binary number!

Converting Decimal to Binary

Decimal Number=97			
Division Expression	Quotient	Remainder	Direction
97/2	48	1	
48/2	24	0	
24/2	12	0	
12/2	6	0	
6/2	3	0	
3/2	1	1	
1/2	0	1	
Binary Number=1100001			

Floating-point (fraction) Presentation
Changing fractions to binary

- Multiply the fraction by 2,…



Example: Transform the fraction 0.875 to binary

Solution: Write the fraction at the left corner. Multiply the number continuously by 2 and extract the integer part as the binary digit. Stop when the number is 0.0.

0.875 → 1.750 → 1.5 → 1.0 → 0.0

0 . 1 1 1

Example: Transform the fraction 0.4 to a binary of 6 bits.

Write the fraction at the left cornet. Multiply the number continuously by 2 and extract the integer part as the binary digit.

If you can never get the exact binary representation. Stop when you have 6 bits.

0.4 → 0.8 → 1.6 → 1.2 → 0.4 → 0.8 → 1.6

0 . 0 1 1 0 0 1

Hexadecimal Number System

- Each digit could have a value from 0 to 15 (16 different values)
- The number system is base 16 system.
- It is easier to work with hexadecimal values than decimal or binary.
  - One Hexadecimal digit is represented by 4bits
  - Two hexadecimal digits is represented by 8 bits (one byte)
  - This makes conversions between hexadecimal and binary very easy

Hexadecimal Number System

Decimal	Hexadecimal
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

Convert Hexadecimal to Decimal

Example: Convert 11A8 to decimal.

1	1	A =10	8
16^3	16^2	16^1	16^0
4096*1	256*1	16*10	8*1
4096	256	160	8
4096+256+160+8= 4520			

Hexadecimal number 11A8 = 4520

It is much easier to work with large numbers using hexadecimal values than decimal or binary

Convert Hexadecimal to Decimal

Example: Convert 11A8 to decimal.

1	1	A =10	8
16^3	16^2	16^1	16^0
4096*1	256*1	16*10	8*1
4096	256	160	8
4096+256+160+8= 4520			

Hexadecimal number 11A8 = 4520

It is much easier to work with large numbers using hexadecimal values than decimal or binary

Convert Hexadecimal to Decimal

Example: Convert 11A8 to decimal.

1	1	A =10	8
16^3	16^2	16^1	16^0
4096*1	256*1	16*10	8*1
4096	256	160	8
4096+256+160+8= 4520			

Hexadecimal number 11A8 = 4520

It is much easier to work with large numbers using hexadecimal values than decimal or binary

Convert Hexadecimal to Decimal

Example: Convert 11A8 to decimal.

1	1	A =10	8
16^3	16^2	16^1	16^0
4096*1	256*1	16*10	8*1
4096	256	160	8
4096+256+160+8= 4520			

Hexadecimal number 11A8 = 4520

It is much easier to work with large numbers using hexadecimal values than decimal or binary

Convert Hexadecimal to Decimal

1	1	A =10	8
16^3	16^2	16^1	16^0
4096*1	256*1	16*10	8*1
4096	256	160	8
4096+256+160+8= 4520			

Converting Decimal to Hexadecimal

- What is the hexadecimal value of 4520?
- STEPS

1- Divide the decimal number by 16 and calculate the “quotient” and the “reminder”.

2- Keep the reminder in a separate column

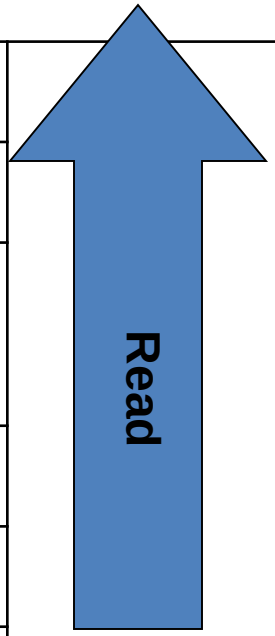
PS: The remainder column could be between 0 to 15

3- If the quotient value greater than 16, repeat the previous step until the last quotient is less than 16.

4- Read the remainder column from the bottom to the top, we'll have our hexadecimal number!

Convert Decimal to Hexadecimal

4520		
Hexadecimal	Quotient	Reminder
4520/16	282	8
282/16	17	10=A
17/16	1	1
1/16	0	1
11A8		



- Quotient must be a whole number.
- Remainder must be a whole number.

Convert Binary to Hexadecimal

What is the hexadecimal value for 110101011?

- Divide the binary number into groups. Each group has 4 bits.
- (if necessary, add zeros to the left to make a complete 4-bit groups)
- Convert *each* 4-bit binary group into its *hexadecimal value*.
- 110101011 can be divided into 1 1010 1011
- Add zeros to the left group: 0001 1010 1011

Binary	0001	1010	1011
Hex	1	10 =A	11= B
1AB			

Convert Hexadecimal to Binary

What is the binary value for 1AB?

- Convert each digit to its 4-bit binary value.

Hex	1	A (=10)	B (=11)
Binary	1	1010	1011
10101011			

Hexadecimal vs other system numbers

- It is much easier to work with large numbers using hexadecimal values than decimal or binary.
  - One Hexadecimal digit = 4bits
  - Two hexadecimal digits = 8 bits
  - Eight bits=1 byte
  - This makes conversions between hexadecimal and binary very easy

Putting It All Together

You should know:

- **How you convert from one number system to another number system. From example,**
  - Decimal numbers to binary numbers
  - Binary numbers to decimal numbers
  - Hexadecimal numbers to binary numbers
  - Binary numbers to Hexadecimal numbers

Questions?

Coming Next Week
x86 Processor Architecture