Computer Maintenance

Numbering Systems

Enabling Objectives

- Introduction to numbering systems
  - Base 10 (decimal)
  - Base 2 (binary)
  - Base 16 (hexadecimal)
- Compare/Contrast decimal and binary counting
- Demonstrate conversions
  - Decimal to binary (2 methods)
  - Binary to decimal (2 methods)
  - Hexadecimal to Decimal

Enabling Objectives Cont.

- Basic hexadecimal numbering
  - Converting hexadecimal to Binary
  - Converting decimal to hexadecimal
  - Converting hexadecimal to decimal
  - Converting decimal to hexadecimal
  - Converting binary to hexadecimal

Numbering Systems

- Decimal (base 10)
  - uses 10 symbols
  - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- Binary (base 2)
  - uses 2 symbols
  - 0, 1
- Hexadecimal (base 16)
  - uses 16 symbols
  - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Numbering Systems

Base 10

10^4	10^3	10^2	10^1	10^0	Decimal
10,000	1,000	100	10	1	
		4	2	6	426

Base 2

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	Decimal
128	64	32	16	8	4	2	1	
			1	0	0	1	1	19

Base 16

16^4	16^3	16^2	16^1	16^0	Decimal
65,536	4,096	256	16	1	
		1	2	A	298

Binary Counting

Decimal	Binary	Decimal	Binary
0	0	13	1101
1	1	14	1110
2	10	15	1111
3	11	16	10000
4	100	17	10001
5	101	18	10010
6	110	19	10011
7	111	20	10100
8	1000	21	10101
9	1001	22	10110
10	1010	23	10111
11	1011	24	11000
12	1100	25	11001

Decimal to Binary Conversion
Method 1

Convert the decimal number **192** into a binary number.

192/2	=	96	with a remainder of	**0**
96/2	=	48	with a remainder of	**0**
48/2	=	24	with a remainder of	**0**
24/2	=	12	with a remainder of	**0**
12/2	=	6	with a remainder of	**0**
6/2	=	3	with a remainder of	**0**
3/2	=	1	with a remainder of	**1**
1/2	=	0	with a remainder of	**1**

Write down all the remainders, backwards, and you have the binary number **11000000**.

Decimal to Binary Conversion
Method 2

Convert the decimal number **192** into a binary number. First find the largest number that is a power of 2 that you can subtract from the original number. Repeat the process until there is nothing left to subtract.

192-128 =	64	128's used	**1**
64-64 =	0	64's used	**1**
		32's used	**0**
		16's used	**0**
		8's used	**0**
		4's used	**0**
		2's used	**0**
		1's used	**0**

Write down the 0s & 1s from top to bottom, and you have the binary number **11000000**.

Decimal to Binary Conversion Method 2

Convert the decimal number **213** into a binary number. First find the largest number that is a power of 2 that you can subtract from the original number. Repeat the process until there is nothing left to subtract.

213-128 =	85	128's used	**1**	
85-64 =	21	64's used	**1**	
*(32 cannot be subtracted from 21)			32's used	**0**
21-16 =	5	16's used	**1**	
*(8 cannot be subtracted from 5)			8's used	**0**
5-4 =	1	4's used	**1**	
*(2 cannot be subtracted from 1)			2's used	**0**
1-1 =	0	1's used	**1**	

Write down the 0s & 1s from top to bottom, and you have the binary number **11010101**.

Binary to Decimal Conversion
Method 1

From right to left, write the values of the powers of 2 above each binary number. Then add up the values where a 1 exist.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	0	1	1	0	1	0	1

128 + 32 + 16 + 4 + 1 = 181

Binary to Decimal Conversion
Method 2

- Start from the left with the first 1 in the binary number. Write down a 1 below it.
- Then look at the next number to the right
  - if it is a 0, double the previous number and write it down
  - if it is a 1, double the previous number and add 1 to it, then write it down
- Continue this until you reach the last 0 or 1 in the binary number.
- The last number you write down is the decimal equivalent of the binary number.

Binary place value	128	64	32	16	8	4	2	1
Binary number					1	1	0	1
Conversion					1	3	6	**13**

Hexadecimal to Decimal Conversion

Base 16

16^4	**16^3**	**16^2**	**16^1**	**16^0**	Decimal
65,536	4,096	256	16	1	
		1	2	A	298

- Each number place represents a power of 16
- Given the hexadecimal number 12A
  - **1** X 256 = 256
  - **2** X 16 = 32
  - **A** X 1 = +10 (A = 10 in hex)

  298

Basic Hexadecimal Numbering

- Hexadecimal is the number system that is used to represent MAC addresses.
- It is referred to as BASE 16 because it uses 16 symbols—0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F.
- Example—Convert hex 2F5A to decimal

16^3	16^2	16^1	16^0
4096	256	16	1
2	F	5	A

(2 x 4096) + ([F]15 x 256) + (5 x 16) + ([A]10 x 1) = 12122

Basic Hexadecimal Numbering

- One hexadecimal character can represent any decimal number between 0 and 15.
- In binary, F (15 decimal) is 1111 and A (10 decimal) is 1010.
- *It follows that 4 bits are required to represent a single hexidecimal character in binary*.
- <u>A MAC address is 48 bits long (6 bytes), which translates to 48/4 = 12 hexadecimal characters required to express a MAC address</u>.
- You can check this by typing **winipcfg** in Windows 95/98 or **ipconfig /all** in Windows NT/2000.

Basic Hexadecimal Numbering

- The smallest decimal value that can be represented by four hexadecimal characters,0000, is 0.
- The largest decimal value that can be represented by four hexadecimal characters, FFFF, is 65,535.
- It follows that the range of decimal numbers that can be represented by four hexadecimal characters (16 bits) is 0 to 65,535, a total of 65,536 or 2^{16} possible values.

Hexadecimal to Binary Conversion

To convert a hex number to a binary number, each hex bit represents 4 binary digits

Given the hex number **A 3**

A is the decimal number 10

10 in binary is 1 0 1 0

8	4	2	1
1	0	1	0

(binary number places - 4 bits)

3 is the decimal number 3

3 in binary is 0 0 1 1

8	4	2	1
0	0	1	1

(binary number places - 4 bits)

hex **A 3** = 1 0 1 0 0 0 1 1 in binary

Converting Decimal to Hexadecimal

Convert the decimal number 24032 to hex:

1. 24032 / 16 = 1502 with a remainder of 0
2. 1502 / 16 = 93 with a remainder of 14 or E
3. 93 / 16 = 5 with a remainder of 13 or D
4. 5 / 16 = 0 with a remainder of 5

By collecting all the remainders backward, you have the hex number **5DE0.**

Converting Hexadecimal to Decimal

Convert the hex number 3F4B to a decimal *(work from left to right):*

1. $3 \times 16^3 = 12288$
2. $F(15) \times 16^2 = 3840$
3. $4 \times 16^1 = 64$
4. $B(11) \times 16^0 = 11$

16203 = decimal equivalent

Converting Decimal to Hexadecimal

Convert the decimal number 2750 to hex:

1. 2750 / 16 = 171 with a remainder of 14 or E
2. 171 / 16 = 10 with a remainder of 11 or B
3. 10 / 16 = 0 with a remainder of 10 or A

By collecting all the remainders backward, you have the hex number **ABE.**

Converting Binary to Hexadecimal

- Converting binary to hexadecimal and hexadecimal to binary is easy because 16 is a power of 2.
- Every four bits correspond to one hexadecimal digit.

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

Converting Binary to Hexadecimal

- So if you have a binary number that looks like 01011011, you break it into two groups of four bits, which looks like this: 0101 and 1011.
- When you convert these two groups to hex, they look like 5 and B (11).
- So converting 01011011 to hex is 5B.
- To convert hex to binary, do the opposite.
- Convert hex AC to binary. (Every hex character is 4 bits.)
- First convert hex A(10) to 1010 binary, and then convert hex C(12) to 1100 binary.
- So the conversion for hex AC is 10101100 binary.

Numbering Systems Summary

- Three numbering systems were discussed:
  - Decimal (base 10)
  - Binary (base 2)
  - Hexadecimal (base 16)
- Binary counting was explained
- Two methods of decimal to binary conversion were shown
- Two methods of binary to decimal conversion were shown

Numbering Systems Summary

- Basic hexadecimal numbering was discussed
- Methods were shown to convert:
  - Hexadecimal to binary
  - Decimal to hexadecimal
  - Hexadecimal to decimal
  - Binary to hexadecimal