Number Systems and Data Representation

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Addition and Subtraction in Binary

```
1   11   ←carry                          1   ←carry
 10011        →        1+2+16 =   19
+11001        →        1+8+16 =  +25
101100        →        4+8+32 =   44
```

```
  1  1    ←borrow
 10101                1+4+16 =   21
-  1011               1+2+ 8  =  -11
  1010                 2+8     =   10
```

Power of Two Number Systems

1 digit in Base $8=2^3$ (octal) corresponds to

3 digits in Base 2 (binary):

$0_8 = 000_2$

$1_8 = 001_2$

$2_8 = 010_2$

$3_8 = 011_2$

$4_8 = 100_2$

$5_8 = 101_2$

$6_8 = 110_2$

$7_8 = 111_2$

Example of conversion:

$11001110_2 = (011)(001)(110) = 316_8$

Indeed, $2+4+8+64+128=206_{10}$ and

$6+1*8+3*8^2 = 206_{10}$

Power of Two Number Systems (cont'd)

1 digit in Base 16=2^4 (hexadecimal) corresponds to 4 digits in Base 2 (binary):

$0_{16} = 0000_2$ $8_{16} = 1000_2$
$1_{16} = 0001_2$ $9_{16} = 1001_2$
$2_{16} = 0010_2$ $A_{16} = 1010_2$
$3_{16} = 0011_2$ $B_{16} = 1011_2$
$4_{16} = 0100_2$ $C_{16} = 1100_2$
$5_{16} = 0101_2$ $D_{16} = 1101_2$
$6_{16} = 0110_2$ $E_{16} = 1110_2$
$7_{16} = 0111_2$ $F_{16} = 1111_2$

Example of conversion:
$11001110_2 = CE_{16}$

Converting from Base 10 to Other Bases

Converting 2849_{10} to hexadecimal (Base 16):

2849/16=178.0625; 178.0625-178=0.0625;

0.0625*16=1, so 1 is the first digit from the right.

178/16=11.125; 11.125-11=0.125;

0.125*16=2, so 2 is the second digit.

11<16, so B is the third and the last digit.

Indeed,

$B21_{16} = 1+2*16+11*16^2 = 2849_{10}$

Bits, Bytes, Words…

1 *bit* is a storage unit that must contain either a 0 or a 1.

1 *byte* is a unit consisting of 8 bits.

A *word* is a group of one or more bytes.

(Pentium 4 is a 32-bit machine, 4 bytes per word.)

Data Representation

Analog (continuous) vs. Digital (discrete)