The Islamia University of Bahawalpur Pakistan

Introduction to Computer

Computer System Architecture

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بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ

ترجمہ: شُروع اَللہ کے پاک نام سے جو بڑا مہربان نہایت رحم والا ہے۔

رَّبِّ زِدۡنِیۡ عِلۡمًا

ترجمہ: اے میرے رب! میرے علم میں اضافہ فرما۔

سورہ طٰہٰ: ﴿۱۱۴﴾ پارہ نمبر-(16)

NUMBERS

- **Natural Numbers**
- Zero and any number obtained by repeatedly adding one to it.

- Examples: 100, 0, 45645, 32

- **Negative Numbers**
- A value less than 0, with a – sign

- Examples: -24, -1, -45645, -32

NUMBERS

- **Integers**
- A natural number, a negative number, zero

- Examples: 249, 0, - 45645, - 32

- **Rational Numbers**
- An integer or the quotient of two integers

- Examples: -249, -1, 0, 3/7, -2/5

NUMBER SYSTEM

- Any system of naming or representing numbers, as the decimal system or the binary system.
- Also called *numeral system*.

Common Number Systems

System	Base	Symbols	Used by humans?	Used in computers?
Decimal	10	0, 1, … 9	Yes	No
Binary	2	0, 1	No	Yes
Octal	8	0, 1, … 7	No	No
Hexa-decimal	16	0, 1, … 9, A, B, … F	No	No

Quantities/Counting (1 of 3)

Decimal	Binary	Octal	Hexa-decimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7

Quantities/Counting (2 of 3)

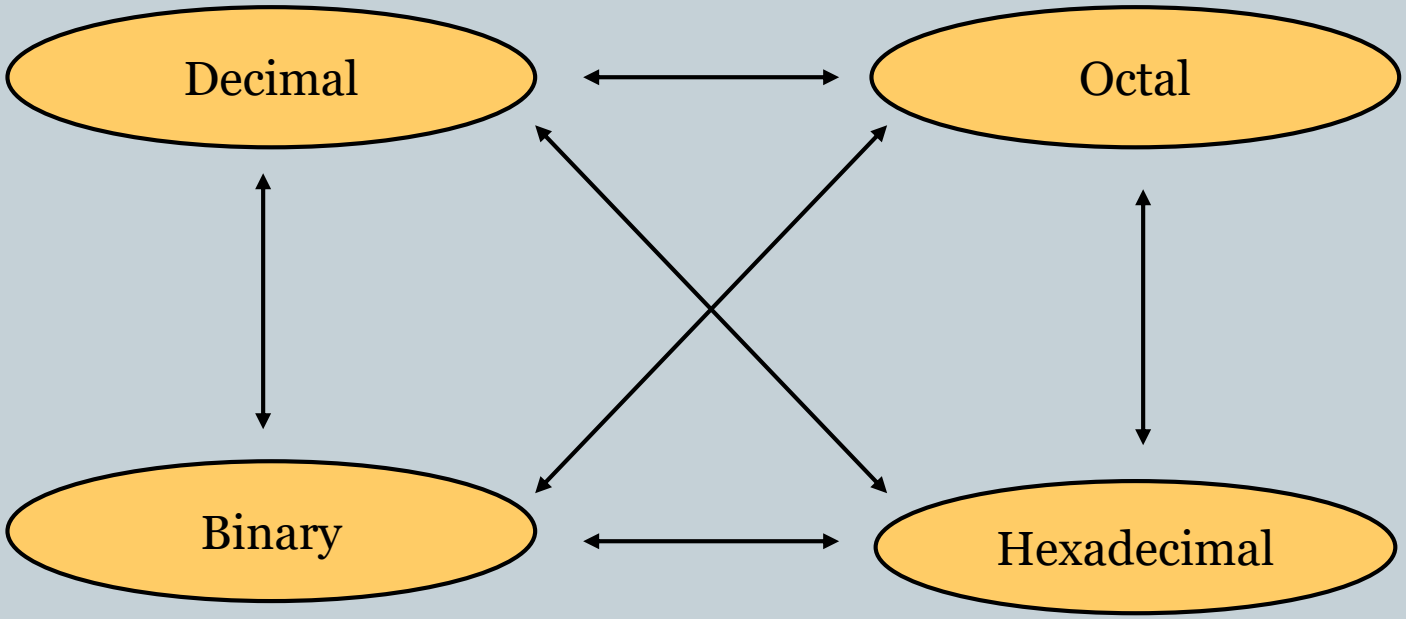
Decimal	Binary	Octal	Hexa-decimal
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Quantities/Counting (3 of 3)

Decimal	Binary	Octal	Hexa-decimal
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14
21	10101	25	15
22	10110	26	16
23	10111	27	17

Conversion Among Bases

- The possibilities:

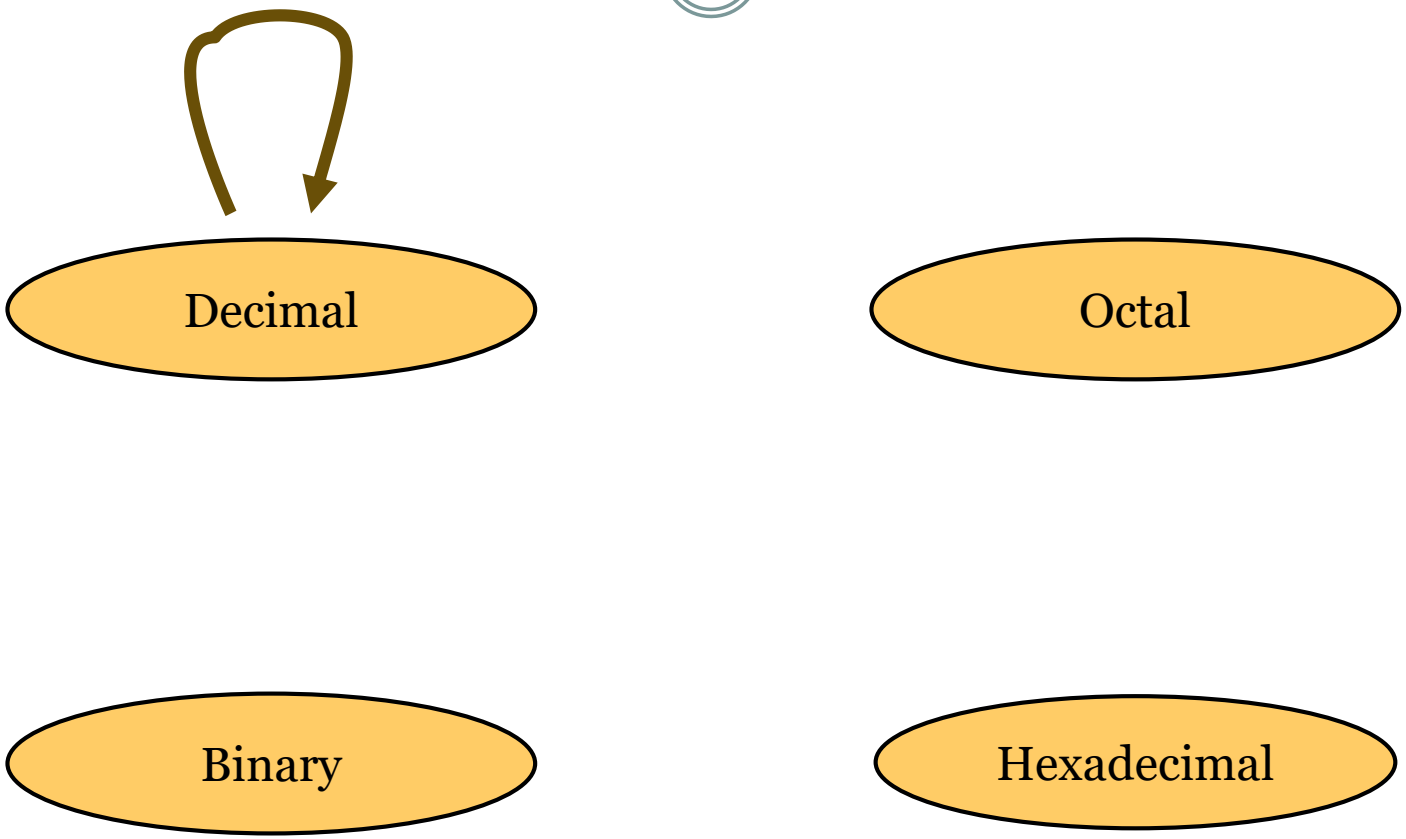


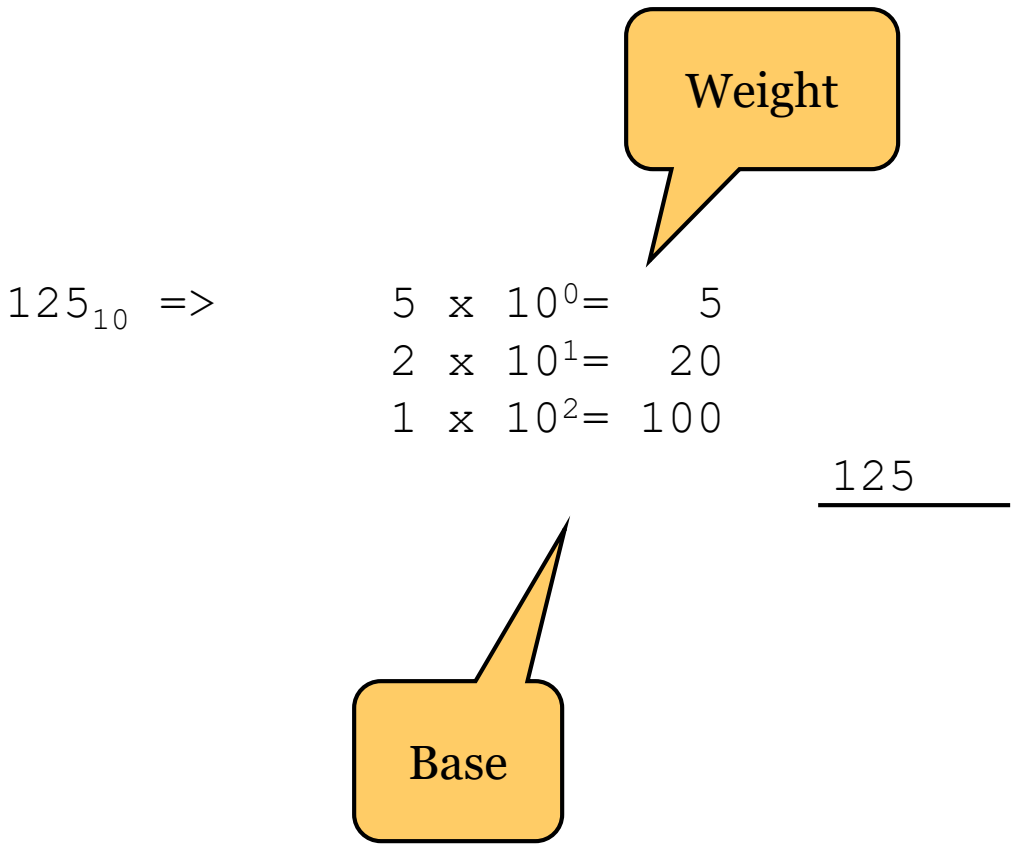
Quick Example

$25_{10} = 11001_2 = 31_8 = 19_{16}$

Base

Decimal to Decimal




Weight
125_{10} =>
5 x 10^0= 5
2 x 10^1= 20
1 x 10^2= 100
125
Base

Binary to Decimal

- Technique
  - Multiply each bit by 2^n, where n is the "weight" of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

Example

Bit “o”

101011_2 => $1 \times 2^0 = 1$

$1 \times 2^1 = 2$

$0 \times 2^2 = 0$

$1 \times 2^3 = 8$

$0 \times 2^4 = 0$

$1 \times 2^5 = 32$

43_{10}

Octal to Decimal (with example)

- Technique
  - Multiply each bit by 8^n, where n is the "weight" of the bit
  - The weight is the position of the bit, starting from 0 on the right
  - Add the results

724_8 =>

$4 \times 8^0 = 4$

$2 \times 8^1 = 16$

$7 \times 8^2 = 448$

468_{10}

Hexadecimal to Decimal (with example)

Technique

Multiply each bit by 16^n, where n is the "weight" of the bit

The weight is the position of the bit, starting from 0 on the right

Add the results

ABC_{16} =>

$C \times 16^0 = 12 \times 1$

$= 12$

$B \times 16^1 = 11 \times 16$

$= 176$

$A \times 16^2 = 10 \times 256$

$= 2560$

2748_{10}

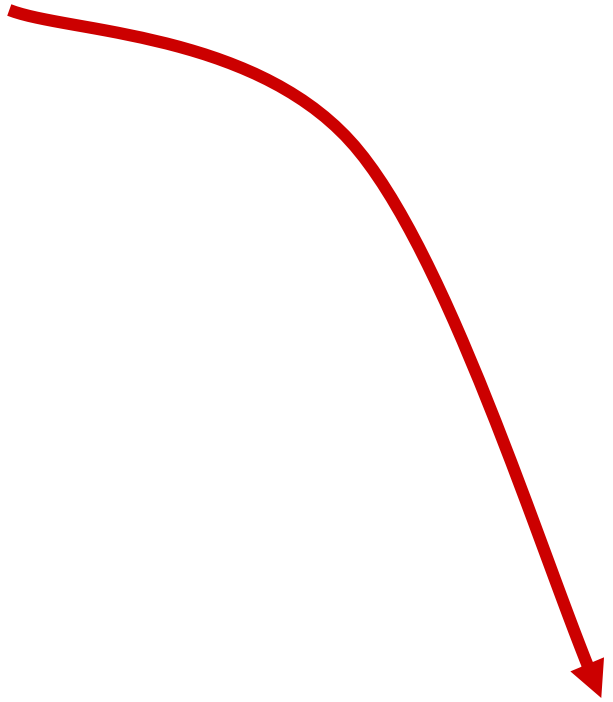
Decimal to Binary

- Technique
  - Divide by two, keep track of the remainder
  - First remainder is bit 0 (LSB, least-significant bit)
  - Second remainder is bit 1
  - Etc.

Example

$125_{10} = ?_2$

2	125	
2	62	1
2	31	0
2	15	1
2	7	1
2	3	1
2	1	1
	0	1



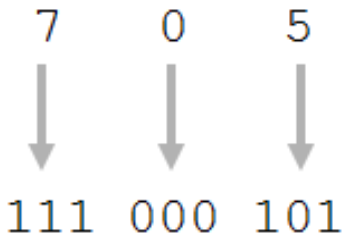
$125_{10} = 1111101_2$

Octal to Binary (with example)

Technique

Convert each octal digit to a 3-bit equivalent binary representation

$705_8 = ?_2$



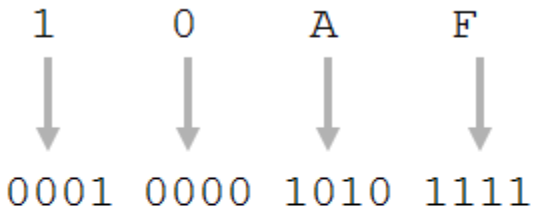
$705_8 = 111000101_2$

Hexadecimal to Binary (with example)

Technique

Convert each hexadecimal digit to a 4-bit equivalent binary representation

$10AF_{16} = ?_2$



$10AF_{16} = 0001000010101111_2$

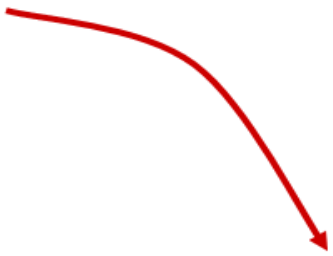
Decimal to Octal (With examples.)

- Technique
  - Divide by 8
  - Keep track of the remainder

Example

$1234_{10} = ?_8$

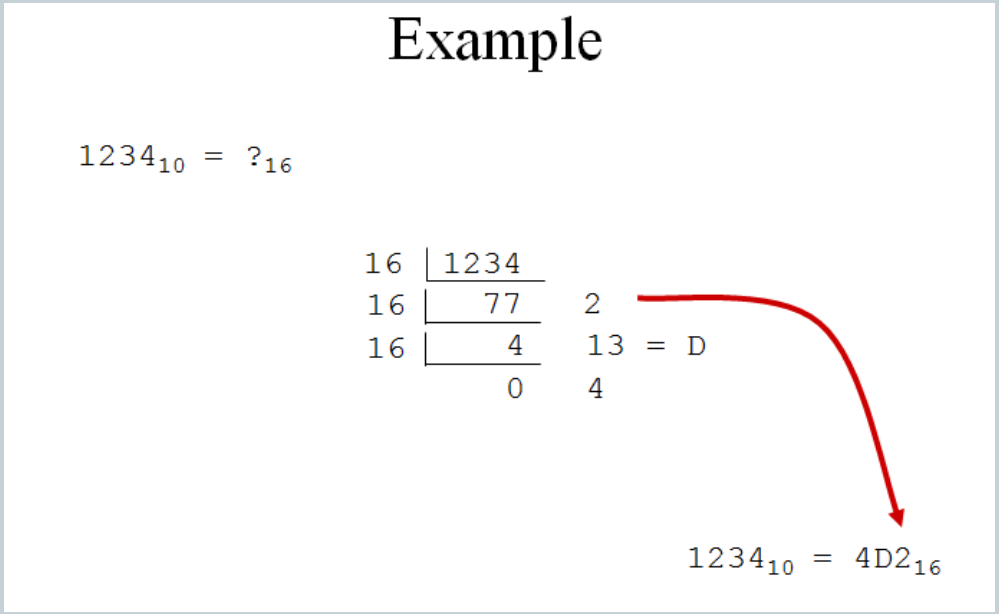
8 |	1234	
8 |	154	2
8 |	19	2
8 |	2	3
	0	2



$1234_{10} = 2322_8$

Decimal to Hexadecimal

- Technique
  - Divide by 16
  - Keep track of the remainder



Binary to Octal with Example.

- Technique
  - Group bits in threes, starting on right
  - Convert to octal digits

Example

$1011010111_2 = ?_8$

1 011 010 111

1 3 2 7

$1011010111_2 = 1327_8$

Binary to Hexadecimal

- Technique
  - Group bits in fours, starting on right
  - Convert to hexadecimal digits

Example

$1010111011_2 = ?_{16}$

10 1011 1011

↓ ↓ ↓

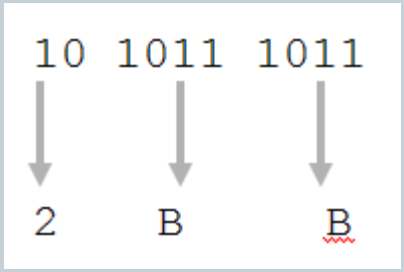
2 B B

$1010111011_2 = 2BB_{16}$

Binary to Hexadecimal

- Technique
  - Group bits in fours, starting on right
  - Convert to hexadecimal digits

Example: 1010111011_2 **= ?**$_{16}$

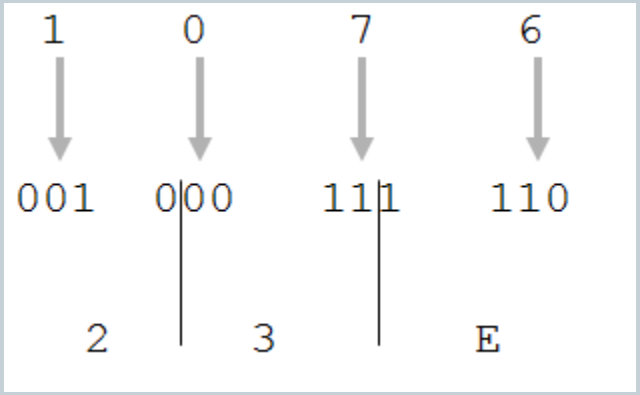


$1010111011_2 = 2BB_{16}$

Octal to Hexadecimal

- Technique
  - Use binary as an intermediary

Example: $1076_8 = ?_{16}$

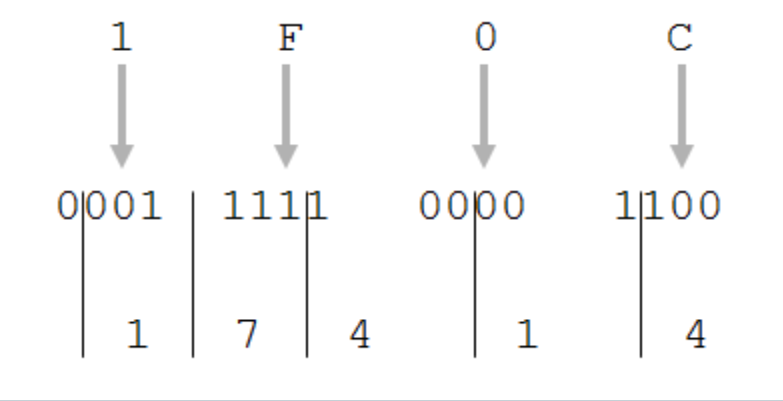


$1076_8 = 23E_{16}$

Hexadecimal to Octal with Example.

- Technique
  - Use binary as an intermediary

$1F0C_{16} = ?_{8}$



$1F0C_{16} = 17414_{8}$

Binary Addition (1 of 2)

- Two 1-bit values

- Two 1-bit values

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

"two"

Binary Addition (2 of 2)

- Two *n*-bit values
  - Add individual bits
  - Propagate carries
  - E.g.,

```
  1   1
  10101      21
+ 11001    + 25
 101110      46
```

Multiplication (2 of 3)

- Binary, two 1-bit values

A	B	A × B
0	0	0
0	1	0
1	0	0
1	1	1

Multiplication (3 of 3)

Binary, two *n*-bit values

As with decimal values

E.g.,

```
    1110
  x 1011
  ------
    1110
   1110
  0000
 1110
------
10011010
```

Fractions

- Binary to decimal

$$
\begin{aligned}
10.1011 \Rightarrow \quad & 1 \times 2^{-4} = 0.0625 \\
& 1 \times 2^{-3} = 0.125 \\
& 0 \times 2^{-2} = 0.0 \\
& 1 \times 2^{-1} = 0.5 \\
& 0 \times 2^{0} = 0.0 \\
& 1 \times 2^{1} = 2.0 \\
& \qquad\qquad\quad 2.6875
\end{aligned}
$$

Fractions

- Decimal to binary