DLD Lecture 2
Number System

Week 2

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Introduction

- A set of values used to represent different quantities
    - For example, a number student can be used to represent the number of students in the class
- Digital computer represent all kinds of data and information in binary numbers
    - Includes audio, graphics, video, text and numbers
- Total number of digits used in the number system is called its base or radix

Number Systems

- Decimal Number System
- Binary Number System
- Octal Number System
- Hexadecimal Number System
  - Decimal number system is used in general
  - Computers used binary number system
  - Octal and hexadecimal number system are also used in computer systems

Number Systems

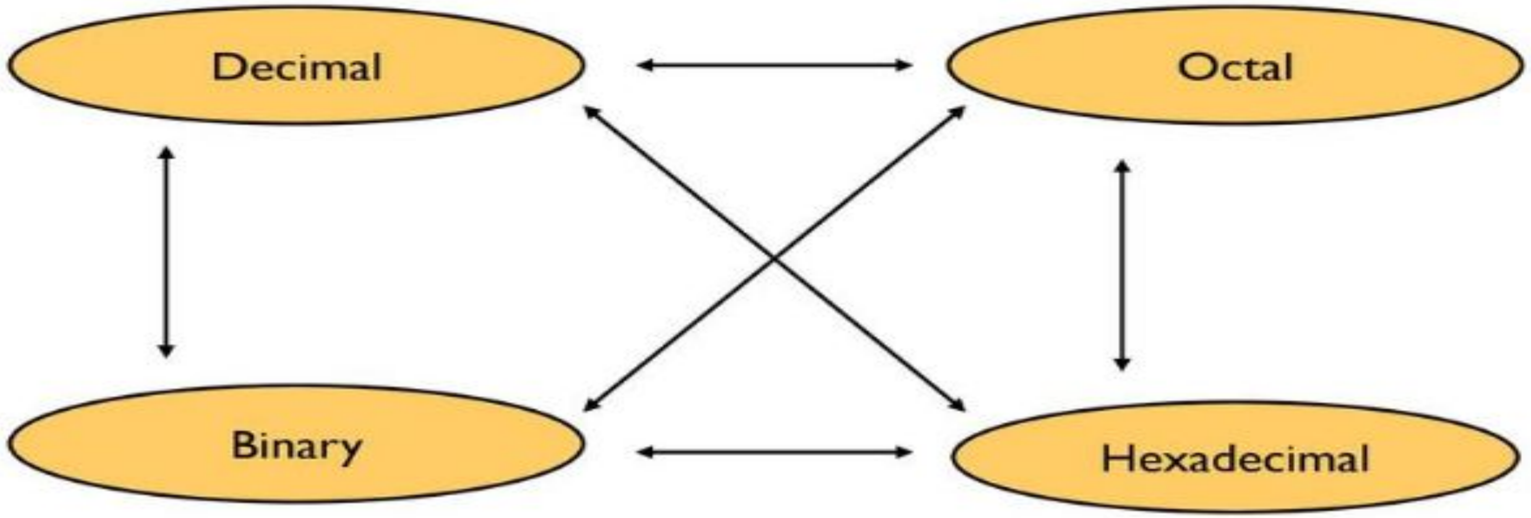
Number System	Base	Symbol
Binary	Base 2	B
Octal	Base 8	O
Decimal	Base 10	D
Hexadecimal	Base 16	H

Table of Number Systems

DECIMAL	BINARY	HEXADECIMAL	OCTAL
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	8	10
9	1001	9	11
10	1010	A	12
11	1011	B	13
12	1100	C	14
13	1101	D	15
14	1110	E	16
15	1111	F	17

Conversion Among Bases

- The possibilities:

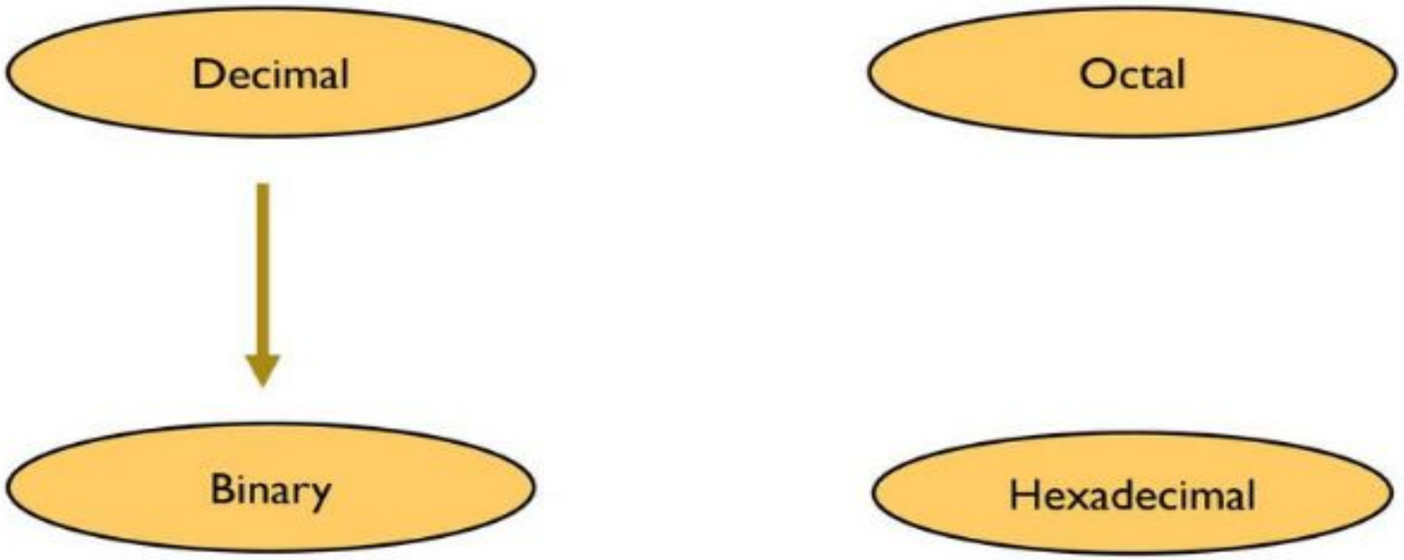


Quick Example

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

Base

Decimal to Binary



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.

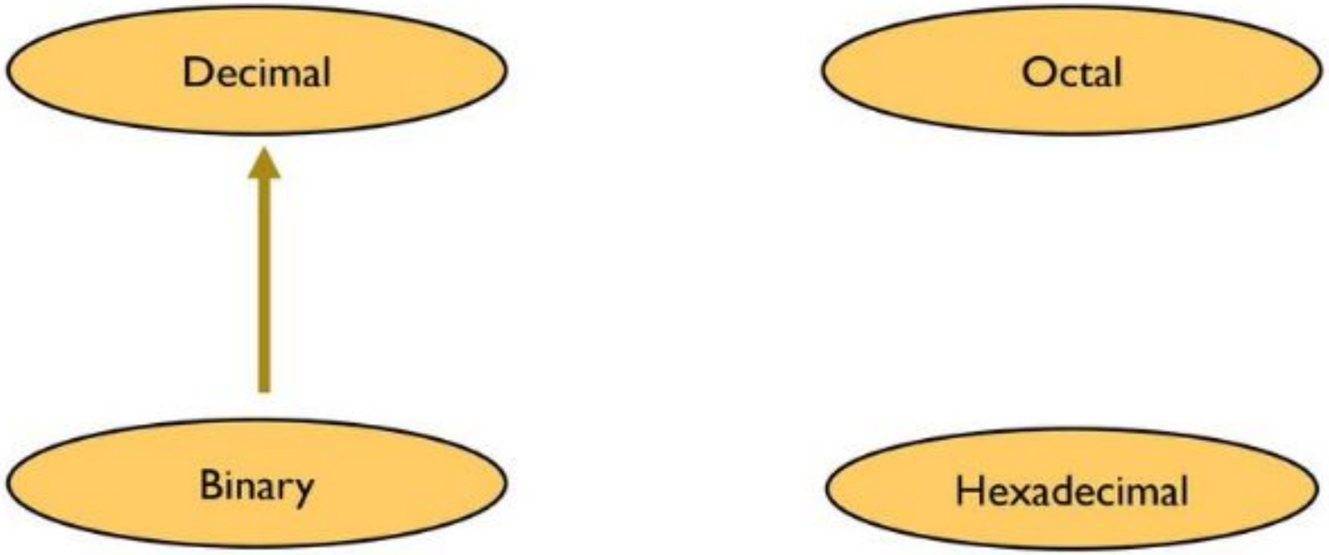
Example

$125_{10} = ?_2$

$$
\begin{array}{r|ll}
2 & 125 & \\
2 & 62 & 1 \\
2 & 31 & 0 \\
2 & 15 & 1 \\
2 & 7 & 1 \\
2 & 3 & 1 \\
2 & 1 & 1 \\
 & 0 & 1
\end{array}
$$

$125_{10} = 1111101_2$

Binary to Decimal



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

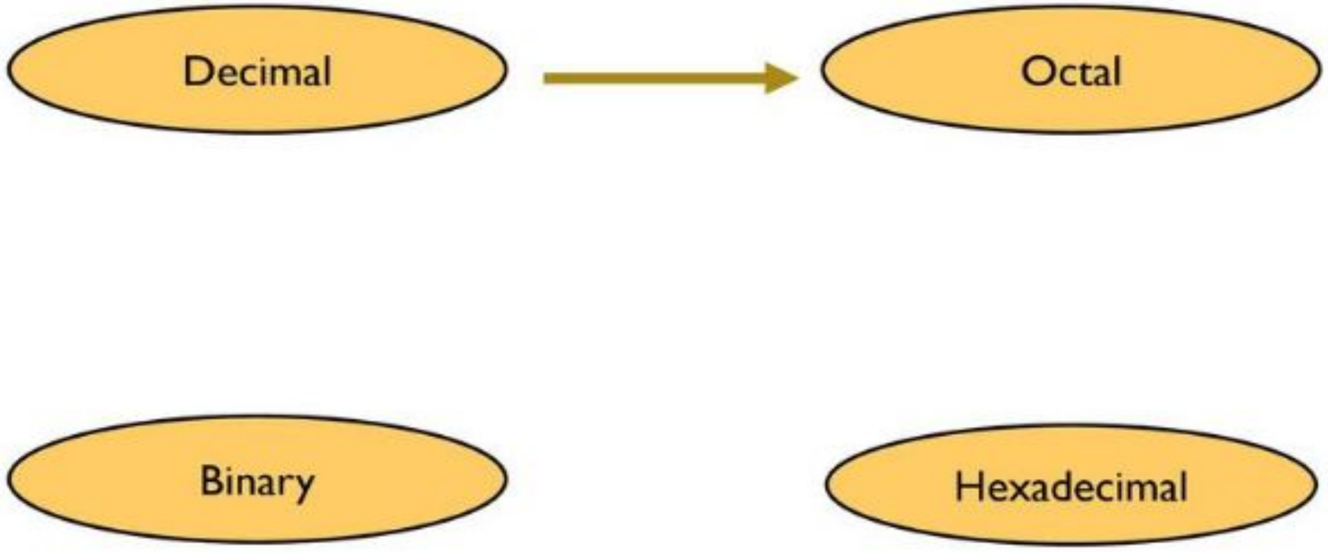
Example

Bit "0"

$101011_2 \Rightarrow$

$$
\begin{array}{rr}
1 \times 2^0 = & 1 \\
1 \times 2^1 = & 2 \\
0 \times 2^2 = & 0 \\
1 \times 2^3 = & 8 \\
0 \times 2^4 = & 0 \\
1 \times 2^5 = & 32 \\
\hline
 & 43_{10}
\end{array}
$$

Decimal to Octal



Decimal to Octal

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

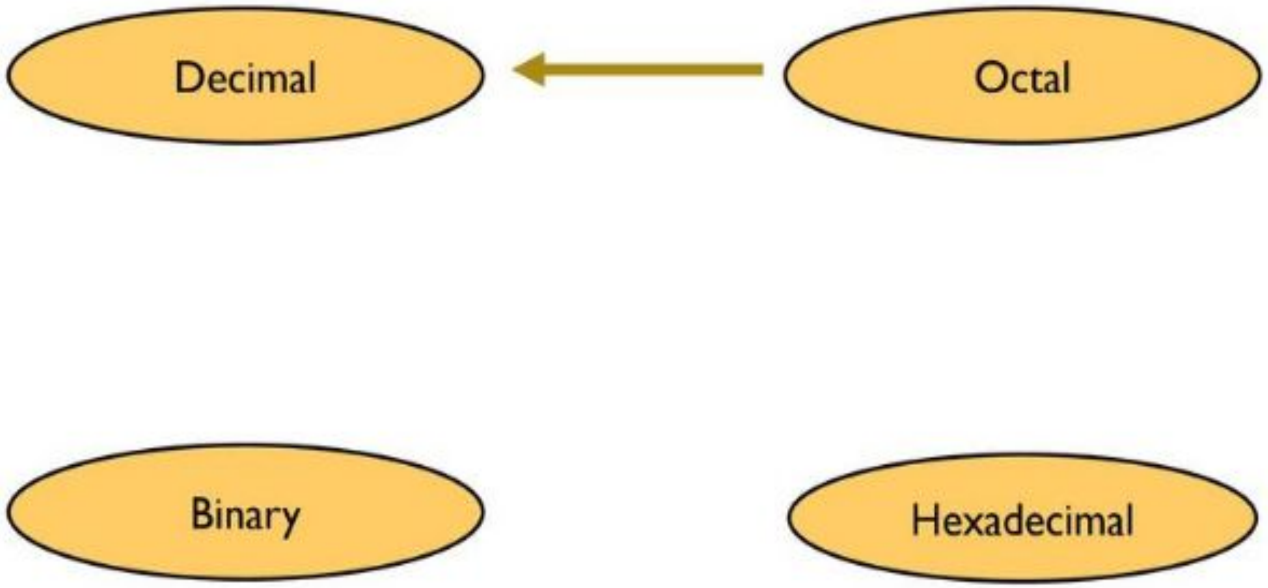
Example

$1234_{10} = ?_8$

$$
\begin{array}{r|ll}
8 & 1234 & \\
\hline
8 & 154 & 2 \\
\hline
8 & 19 & 2 \\
\hline
8 & 2 & 3 \\
\hline
 & 0 & 2
\end{array}
$$

$1234_{10} = 2322_8$

Octal to Decimal



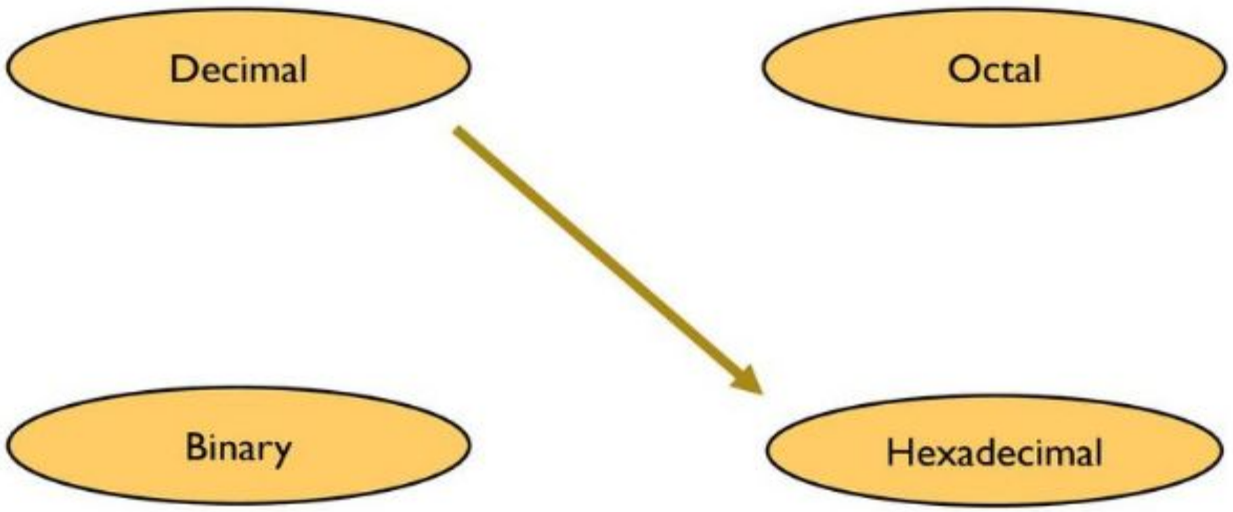
Octal to Decimal

- 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

Example

$$
724_8 \Rightarrow \quad
\begin{array}{rr}
4 \times 8^0 = & 4 \\
2 \times 8^1 = & 16 \\
7 \times 8^2 = & \underline{448} \\
 & 468_{10}
\end{array}
$$

Decimal to Hexadecimal



Decimal to Hexadecimal

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

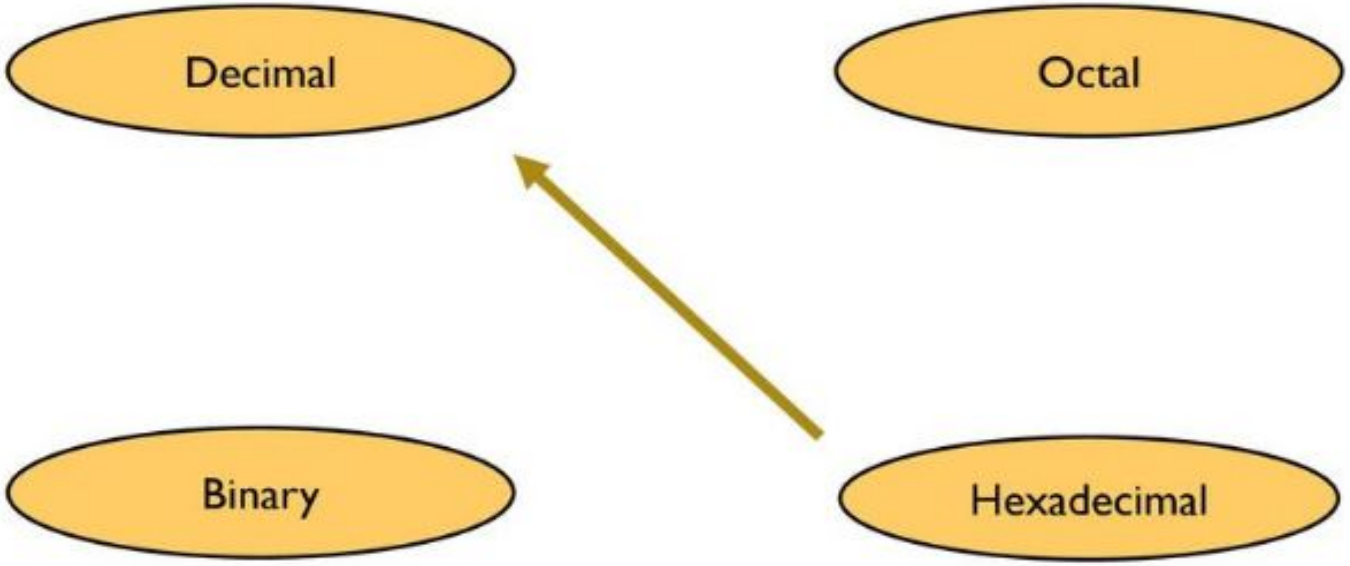
Example

$1234_{10} = ?_{16}$

$$
\begin{array}{r|ll}
16 & 1234 & \\
16 & 77 & 2 \\
16 & 4 & 13 = D \\
 & 0 & 4
\end{array}
$$

$1234_{10} = 4D2_{16}$

Hexadecimal to Decimal



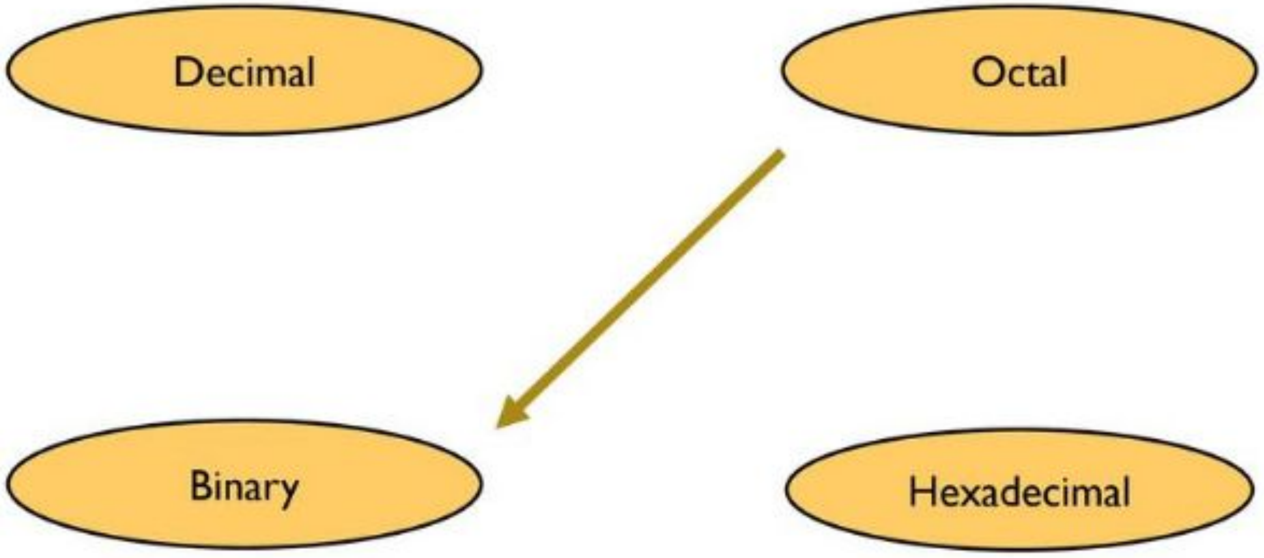
Hexadecimal to Decimal

- 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

Example

$$
\begin{array}{llr}
ABC_{16} \Rightarrow & C \times 16^0 = 12 \times 1 = & 12 \\
& B \times 16^1 = 11 \times 16 = & 176 \\
& A \times 16^2 = 10 \times 256 = & 2560 \\
\hline
& & 2748_{10}
\end{array}
$$

Octal to Binary



Octal to Binary

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

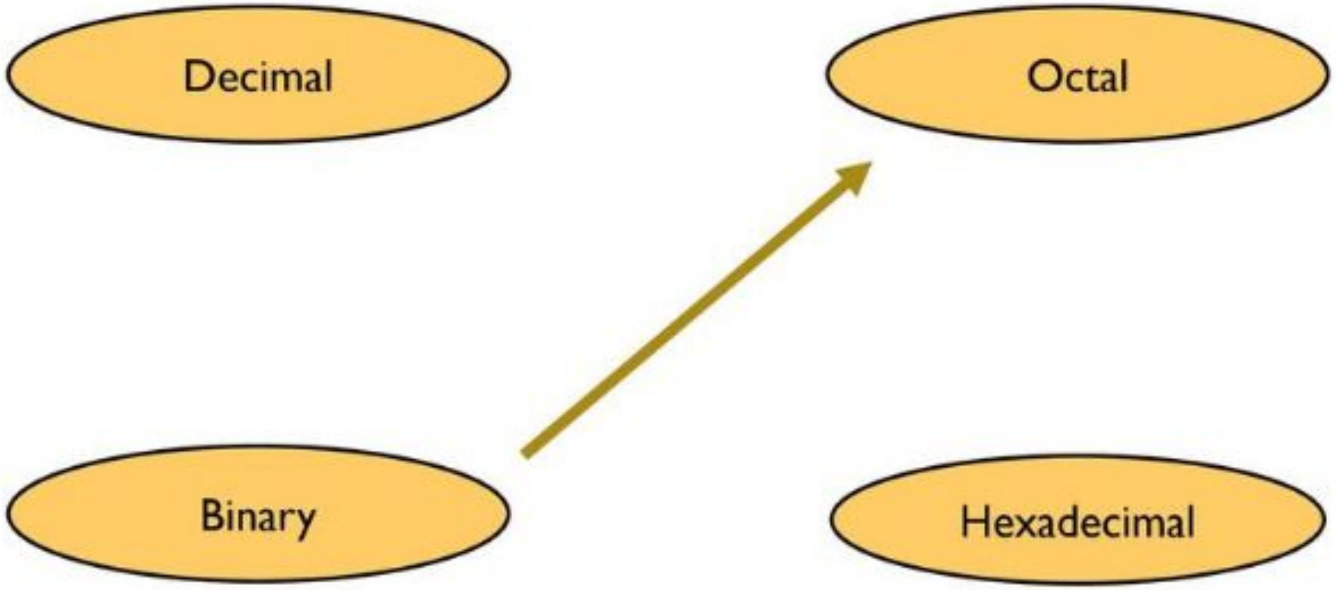
Example

$$705_8 = ?_2$$

$$\begin{array}{ccc} 7 & 0 & 5 \\ \downarrow & \downarrow & \downarrow \\ 111 & 000 & 101 \end{array}$$

$$705_8 = 111000101_2$$

Binary to Octal



Binary to Octal

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

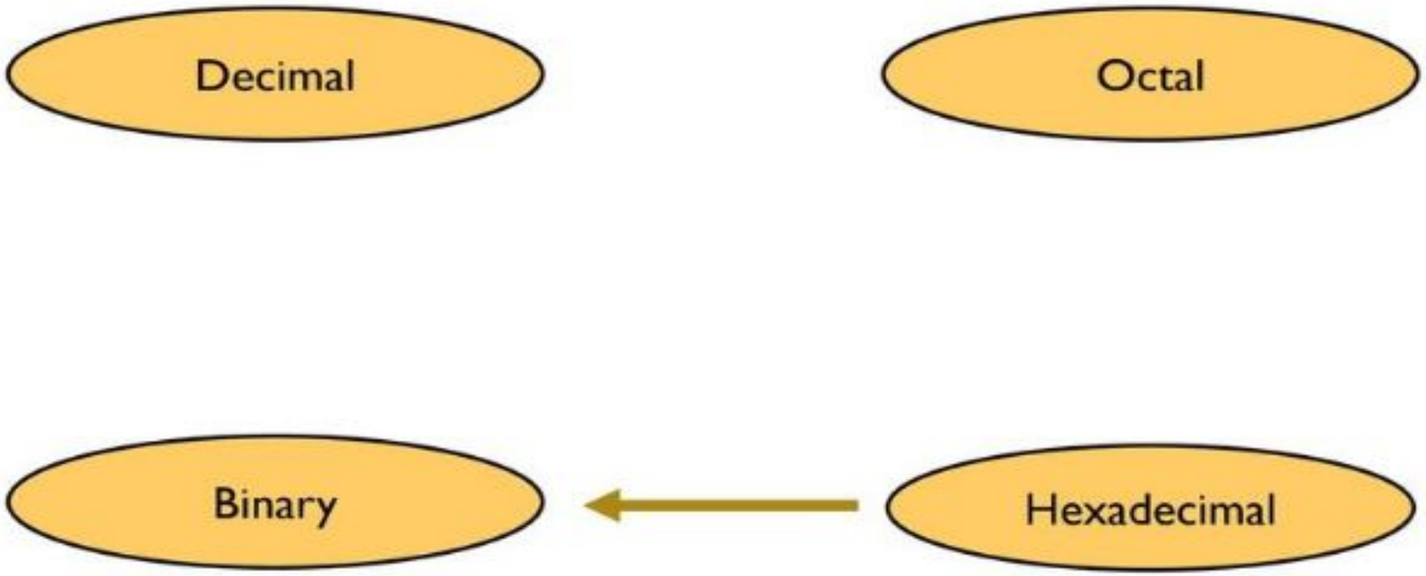
Example

$1011010111_2 = ?_8$

$$\begin{array}{cccc} 1 & 011 & 010 & 111 \\ \downarrow & \downarrow & \downarrow & \downarrow \\ 1 & 3 & 2 & 7 \end{array}$$

$1011010111_2 = 1327_8$

Hexadecimal to Binary



Hexadecimal to Binary

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

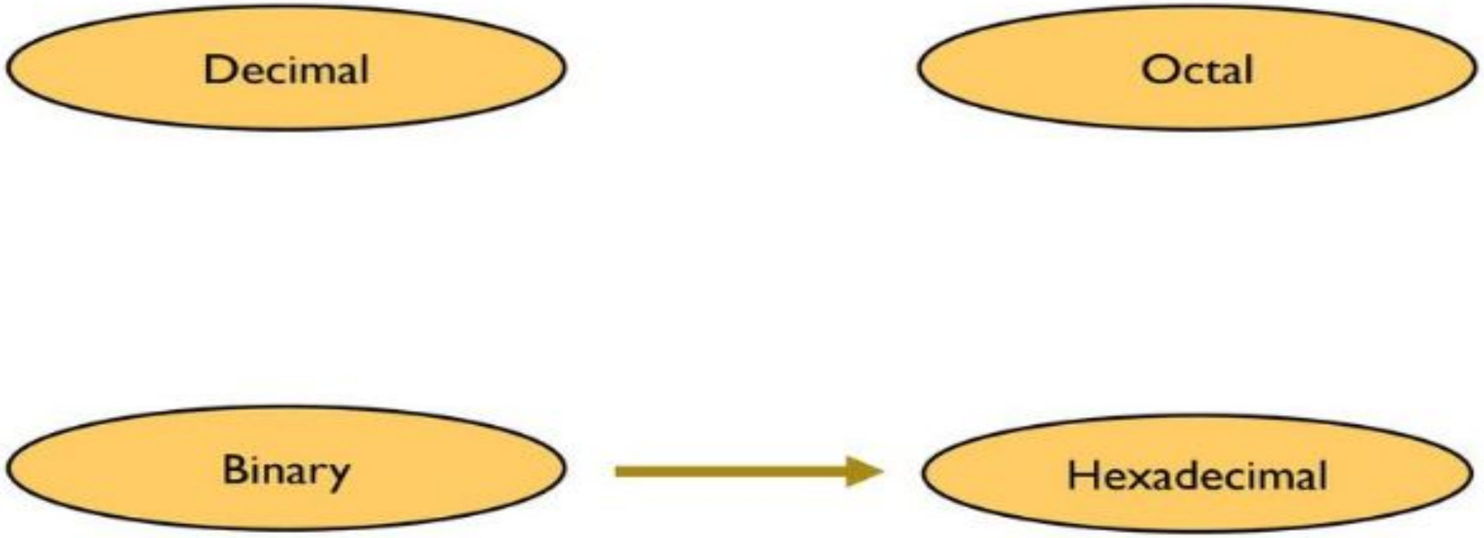
Example

$$10AF_{16} = ?_2$$

$$\begin{array}{cccc} 1 & 0 & A & F \\ \downarrow & \downarrow & \downarrow & \downarrow \\ 0001 & 0000 & 1010 & 1111 \end{array}$$

$$10AF_{16} = 0001000010101111_2$$

Binary to Hexadecimal



Binary to Hexadecimal

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

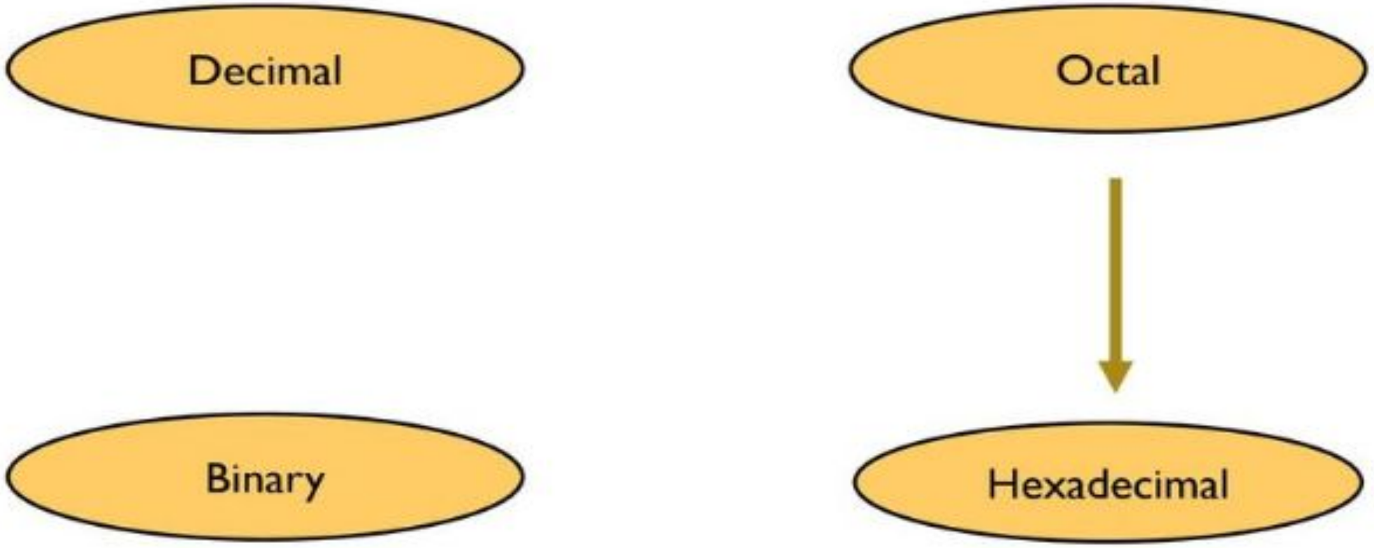
Example

$1010111011_2 = ?_{16}$

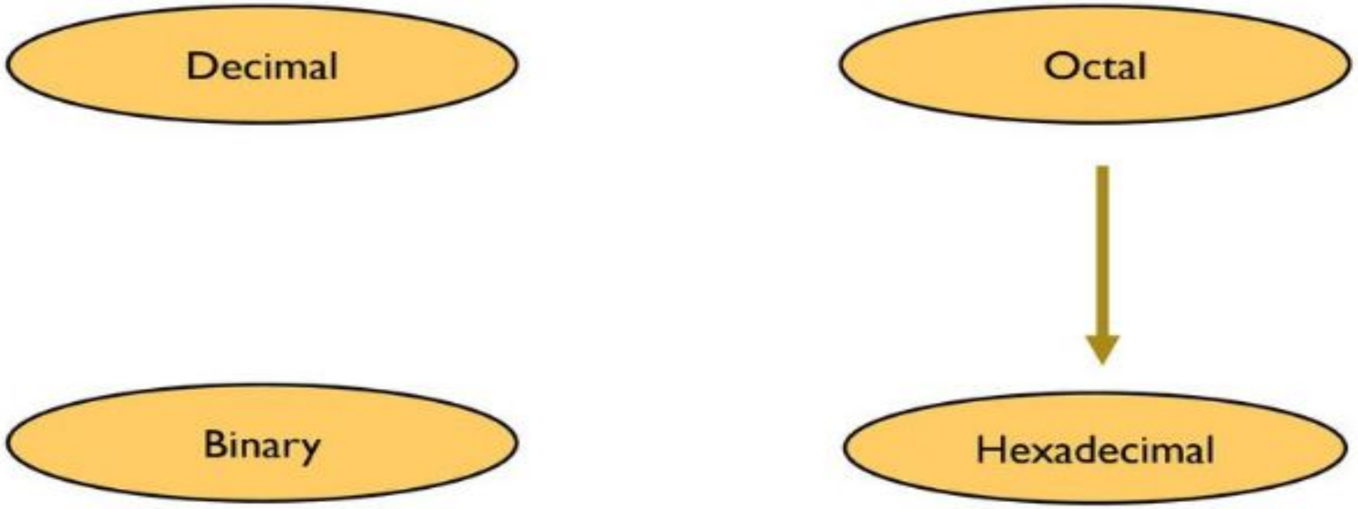
$$\begin{array}{ccc} 10 & 1011 & 1011 \\ \downarrow & \downarrow & \downarrow \\ 2 & \mathrm{B} & \mathrm{B} \end{array}$$

$$1010111011_2 = 2\mathrm{BB}_{16}$$

Octal to Hexadecimal



Octal to Hexadecimal



Octal to Hexadecimal

- Technique
  - Use binary as an intermediary

Example

$1076_8 = ?_{16}$

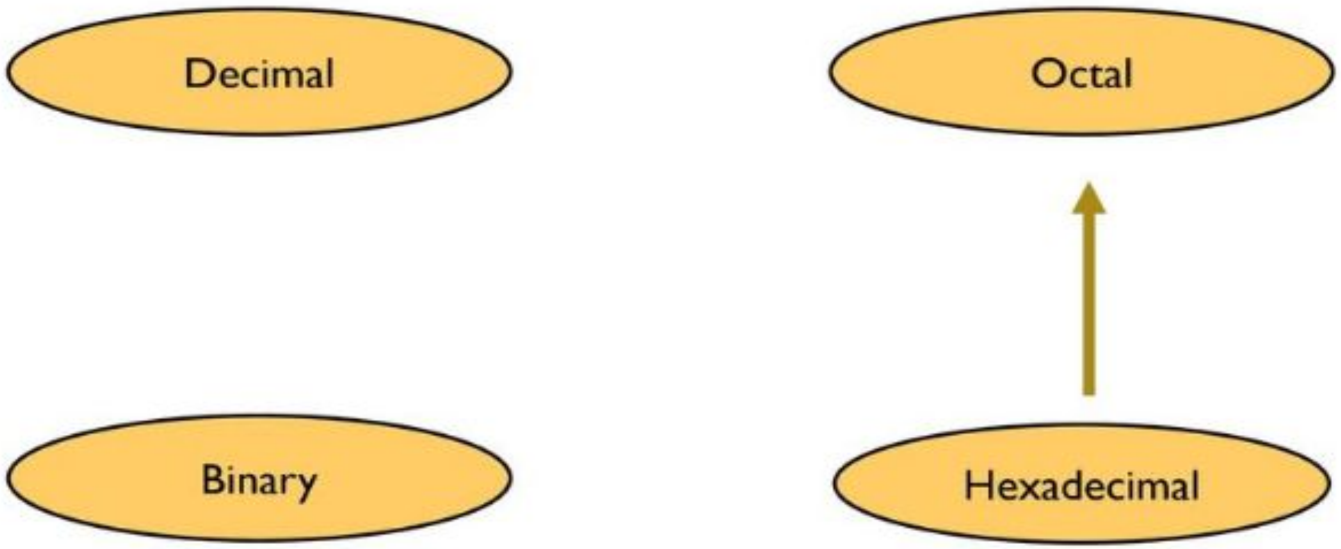
1 0 7 6

001 000 111 110

2 3 E

$1076_8 = 23E_{16}$

Hexadecimal to Octal



Hexadecimal to Octal

- Technique
  - Use binary as an intermediary

Example

$1F0C_{16} = ?_8$

1	F	0	C
0001	1111	0000	1100

0001	111	1 000	0 1	100
1	7	4	1	4

$1F0C_{16} = 17414_8$