

---

---

# Bits of Architecture

Integer Basics

---

---

# How Do We Represent Numbers?

# Base 10 Numbers (Decimal)

# Decimal Numbers

$724_{10}$

## Decimal Numbers

The diagram illustrates the expansion of the decimal number 724 into its place value components. At the top, the number  $724_{10}$  is shown. Three orange arrows point from the digits 7, 2, and 4 to their respective terms in the expanded form below:  $7 \times 10^2 + 2 \times 10^1 + 4 \times 10^0$ .

$$724_{10}$$
$$7 \times 10^2 + 2 \times 10^1 + 4 \times 10^0$$

## Decimal Numbers

The diagram illustrates the expansion of the decimal number  $724_{10}$  into its place value components. It is structured as a tree diagram with three levels:

- Top Level:** The number  $724_{10}$ .
- Middle Level:** The expanded form  $7 \times 10^2 + 2 \times 10^1 + 4 \times 10^0$ .
  - An orange arrow points from the '7' in  $724_{10}$  to the  $7 \times 10^2$  term.
  - An orange arrow points from the '2' in  $724_{10}$  to the  $2 \times 10^1$  term.
  - An orange arrow points from the '4' in  $724_{10}$  to the  $4 \times 10^0$  term.
- Bottom Level:** The expanded form  $700 + 20 + 4$ .
  - An orange arrow points from the  $7 \times 10^2$  term to the '700' term.
  - An orange arrow points from the  $2 \times 10^1$  term to the '20' term.
  - An orange arrow points from the  $4 \times 10^0$  term to the '4' term.

# Base 2 Numbers (Binary)

## Binary Numbers - Unsigned Integers

$$11 = 1011_2$$



## Binary Numbers - Unsigned Integers

$$11 = 1011_2$$



The diagram illustrates the expansion of the binary number  $1011_2$  into its decimal value. Four orange arrows originate from the bits of the binary number and point to the corresponding terms in the sum below:

- The first arrow points from the leftmost '1' to  $1 \times 2^3$ .
- The second arrow points from the '0' to  $0 \times 2^2$ .
- The third arrow points from the second '1' to  $1 \times 2^1$ .
- The fourth arrow points from the rightmost '1' to  $1 \times 2^0$ .

$$1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$

## Binary Numbers - Unsigned Integers

$$11 = 1011_2$$

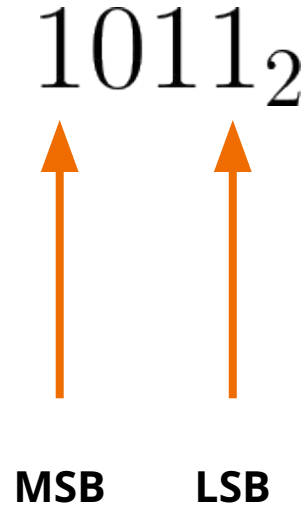
The diagram illustrates the conversion of the binary number  $1011_2$  to the decimal number 11. It shows the expansion of the binary number into a sum of products, where each bit is multiplied by its corresponding power of 2. Arrows indicate the mapping from the binary digits to the terms in the expansion and then to the final sum.

$$1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$
$$8 + 0 + 2 + 1$$

# Some Terminology...

# Binary Numbers

- **Least Significant Bit (LSB)**
  - Rightmost bit
  - Smallest power (typically 0)
- **Most Significant Bit (MSB)**
  - Leftmost bit
  - Largest power




# What About Signed Numbers?

# Binary Numbers - Signed Integers

$$-5 = 1011_2$$

## Binary Numbers - Signed Integers

$$-5 = 1011_2$$


$$-1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$

## Binary Numbers - Signed Integers

$$-5 = 1011_2$$

$$-1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$$

$$-8 + 0 + 2 + 1$$



# What Range of Values Can We Represent?

## Range of Integer Numbers

$$Range_{Unsigned} = 0 \rightarrow 2^n - 1$$

$$Min_{4bit} = 0000_2 \quad Max_{4bit} = 1111_2$$

## Range of Integer Numbers

$$Range_{signed} = -2^{n-1} \rightarrow 2^{n-1} - 1$$

$$Min_{4bit} = 1000_2 \quad Max_{4bit} = 0111_2$$