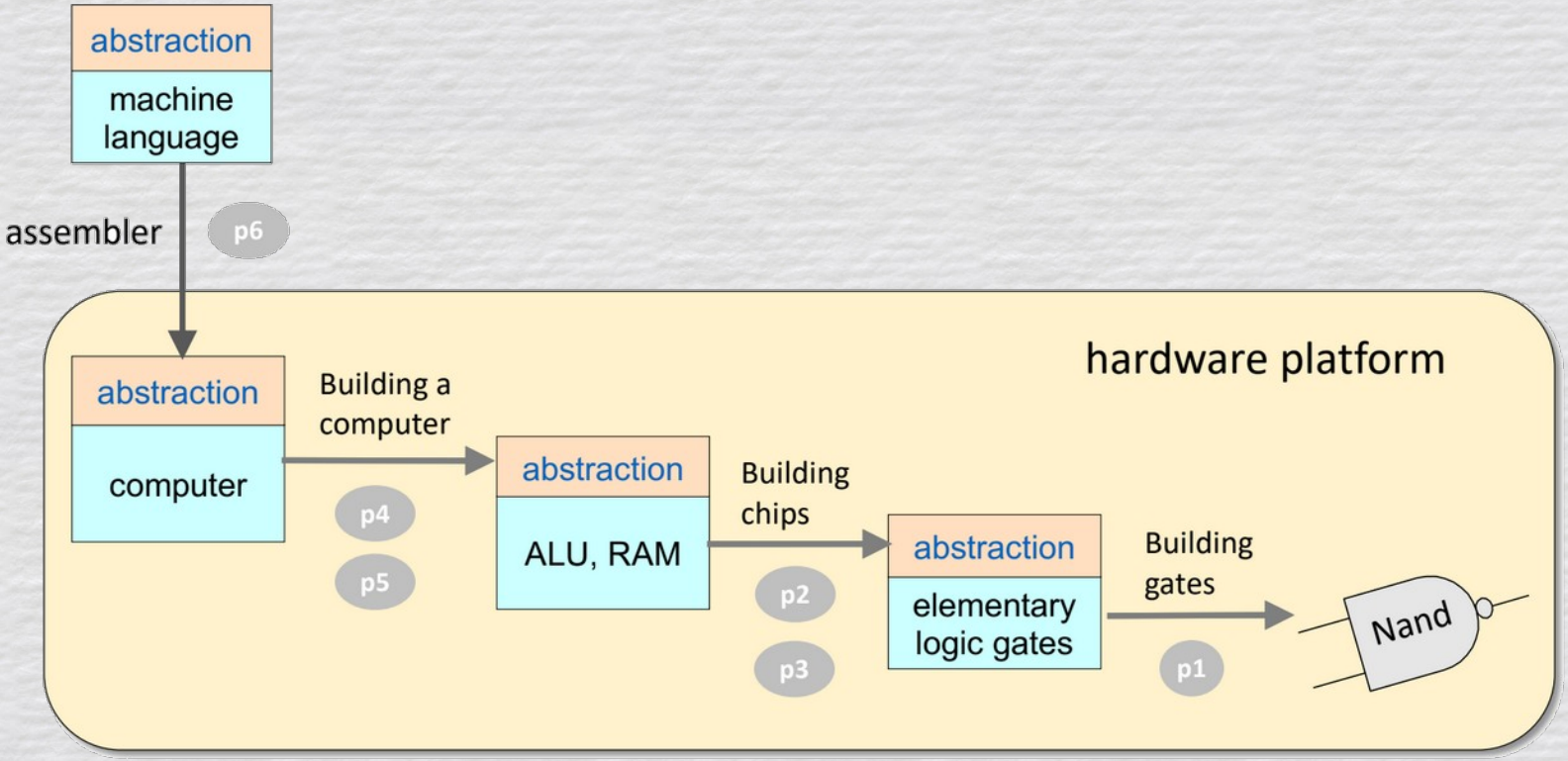
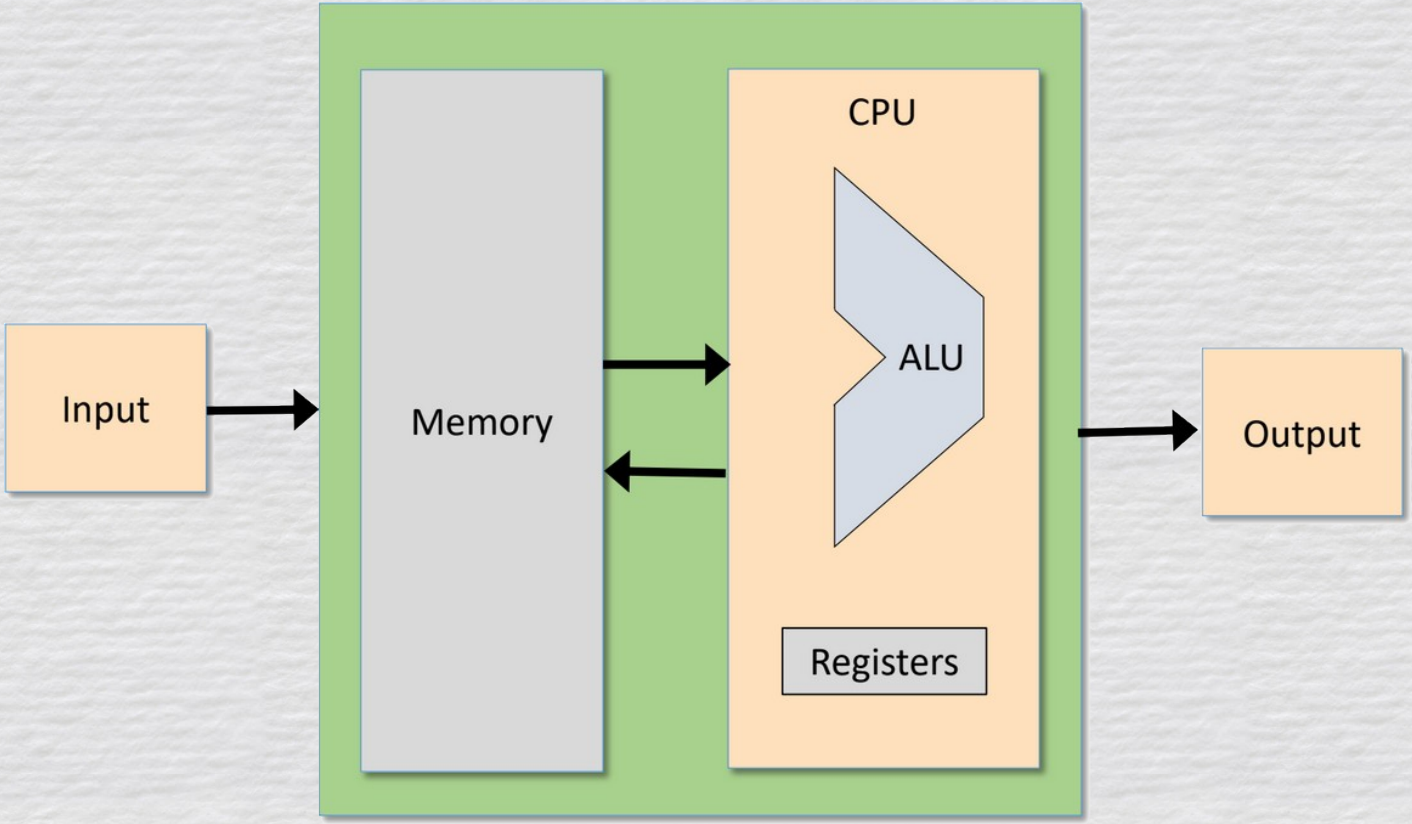
# Computer Organization

## Number Systems

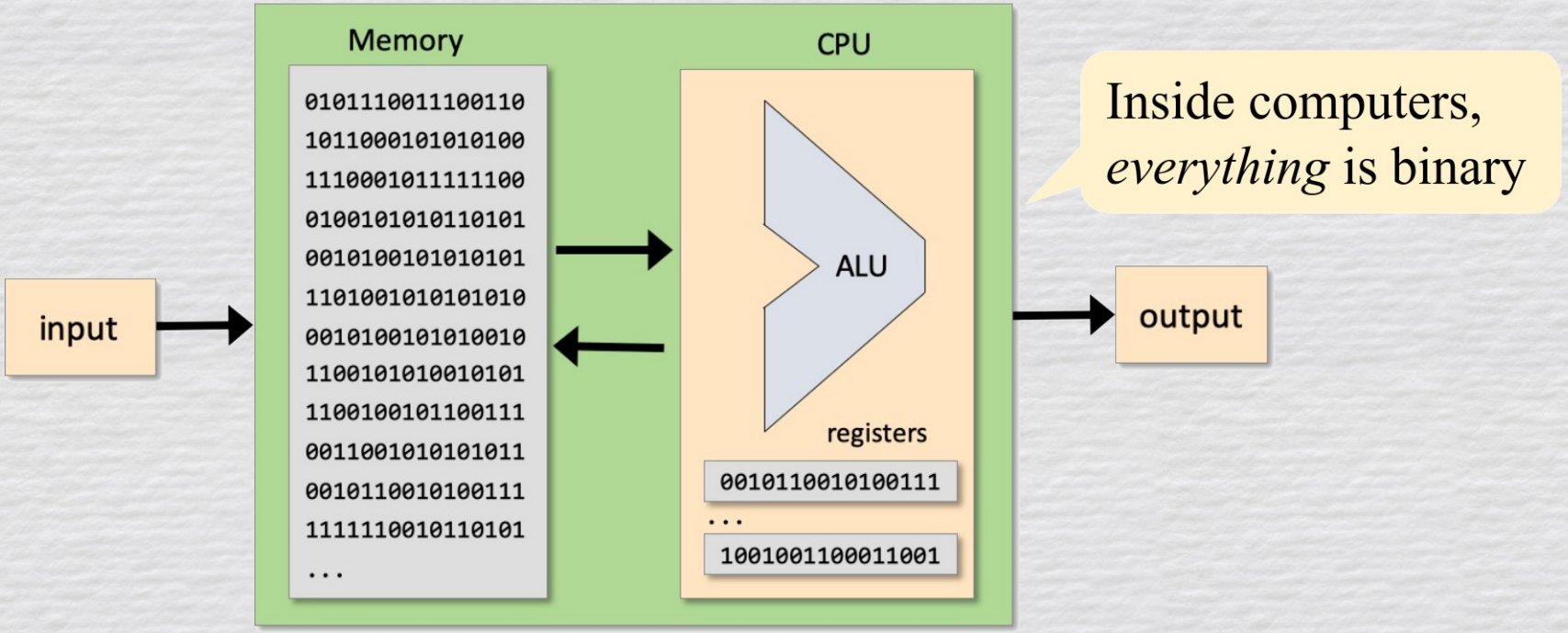
# Roadmap


abstraction
machine language
assembler
p6
hardware platform
abstraction
computer
Building a computer
p4
p5
abstraction
ALU, RAM
Building chips
p2
p3
abstraction
elementary logic gates
Building gates
p1
Nand

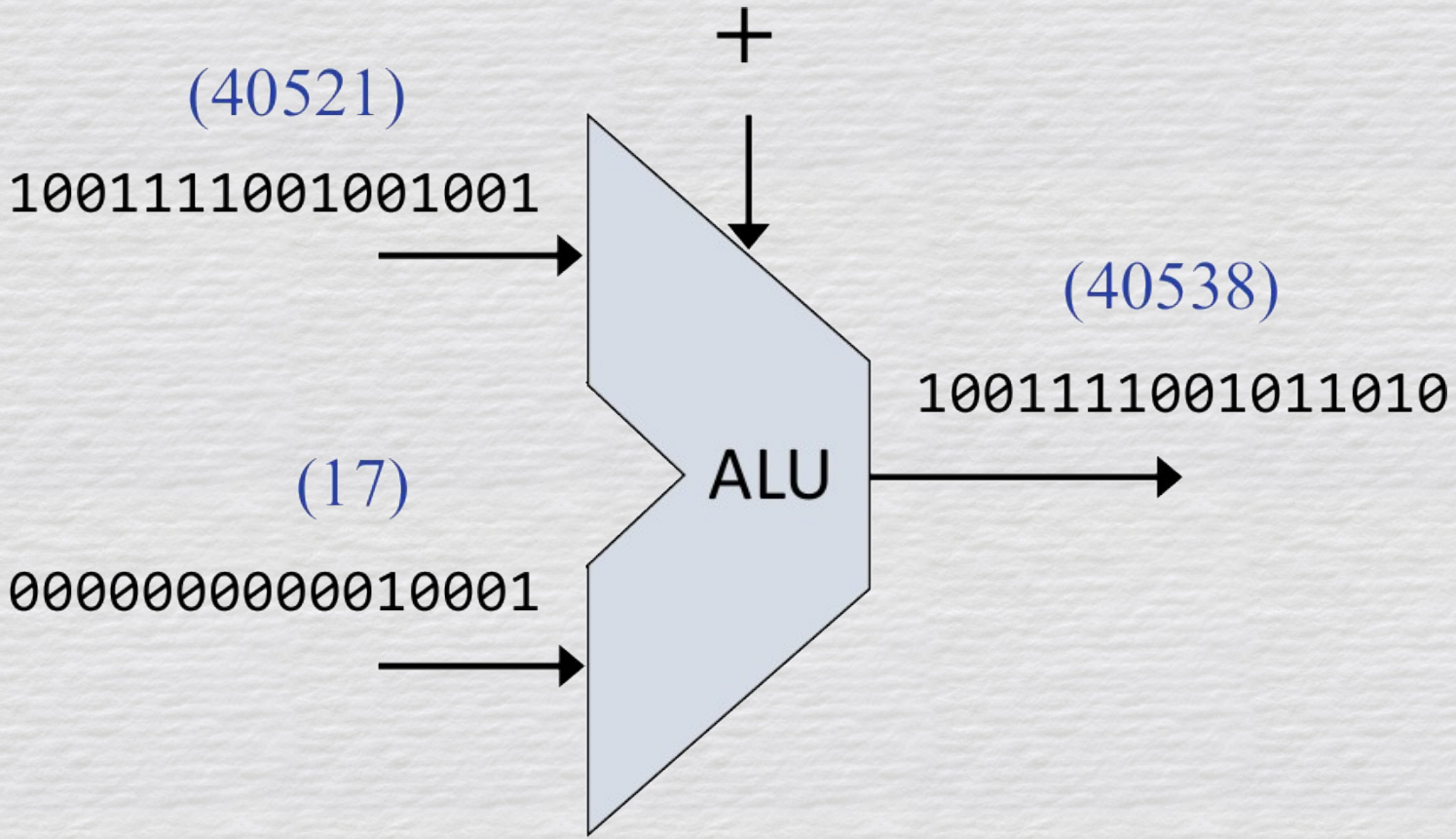
# Computer System



# Computer System – Binary



# Arithmetic Logical Unit



# Arithmetic Logical Units – cont.

- The ALU computes a given function on two given n-bit values, and outputs an n-bit value

- ALU functions ()
  - Arithmetic: x + y, x – y, x + 1, x – 1, ...
  - Logical: x & y, x | y, !x , ...

# Number Systems – Base

- $10_2$
- $10_{10}$

# Positional Numeral System – Decimal

Decimal (base 10) system:
Human friendly

3 2 1 0
$7\,0\,5\,3_{10}$

$$\sum_{0}^{n-1} d_i \cdot 10^i = 7 \cdot 10^3 + 0 \cdot 10^2 + 5 \cdot 10^1 + 3 \cdot 10^0 = 7053$$

# Positional Numeral System – Binary

Binary (base 2) system:
Computer friendly

12 11 10 . . . 3 2 1 0

$1\ 1\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\ 0\ 1_2$

$$\sum_{0}^{n-1} d_i \cdot 2^i = 1 \cdot 2^{12} + 1 \cdot 2^{11} + 0 \cdot 2^{10} + \cdots + 1 \cdot 2^0 = 7053$$

# Binary ↔ Decimal Conversion

$2^0 = 1$
$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$
$2^6 = 64$
$2^7 = 128$
$2^8 = 256$
$2^9 = 512$
$2^{10} = 1024$
. . .

Binary to decimal:

$$decimal\,(\overset{5\ 4\ 3\ 2\ 1\ 0}{110101_2}) = 2^5 + 2^4 + 2^2 + 2^0 = 53_{10}$$

Decimal to binary:

$$binary\,(53_{10}) = 2^5 + 2^4 + 2^2 + 2^0 = \overset{5\ 4\ 3\ 2\ 1\ 0}{110101_2}$$

# Binary ↔ Decimal Conversion

$2^0 = 1$
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$2^8 = 256$
$2^9 = 512$
$2^{10} = 1024$
. . .

Binary to decimal:

$$decimal\ (\texttt{1011010}_2) = \ ?$$

Decimal to binary:

$$binary\ (523_{10}) = \ ?$$

# Binary ↔ Decimal Conversion

$2^0 = 1$
$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$
$2^6 = 64$
$2^7 = 128$
$2^8 = 256$
$2^9 = 512$
$2^{10} = 1024$
. . .

Binary to decimal:

$$decimal\ (1011010_2) = 2^6+2^4+2^3+2^1 = 90$$

Decimal to binary:

$$binary\ (523_{10}) = 2^9+2^3+2^1+2^0 = 1000001011$$