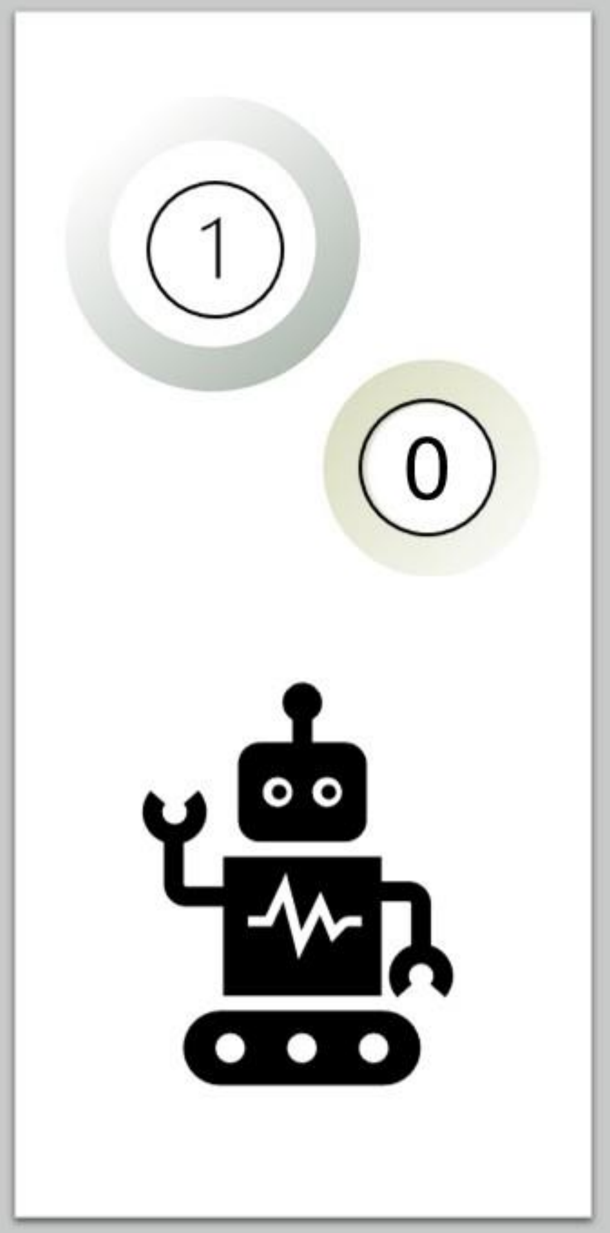
UD01.Information Representation

Computer Systems

Desarrollo de Aplicaciones Web
1er Curso
Curso 2020-2021
Autor: Vicent Bosch
vicent.bosch@ceedcv.es



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To *bit* or Not to *bit*

binary digit

How a *position*al numeric system works?

2
8
16

2 7 3

$$2 \times 10^{2} + 7 \times 10^{1} + 3 \times 10^{0}$$

The binary system

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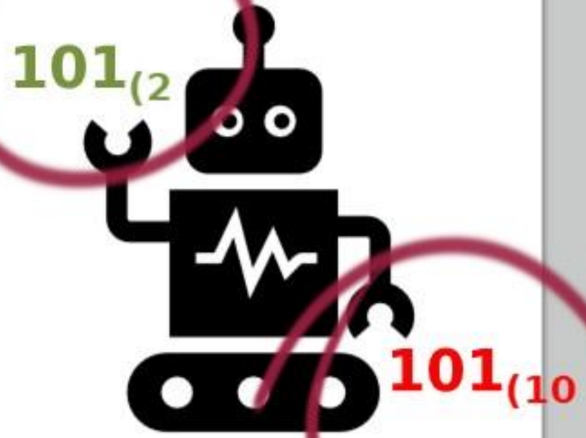


Read from right to left:

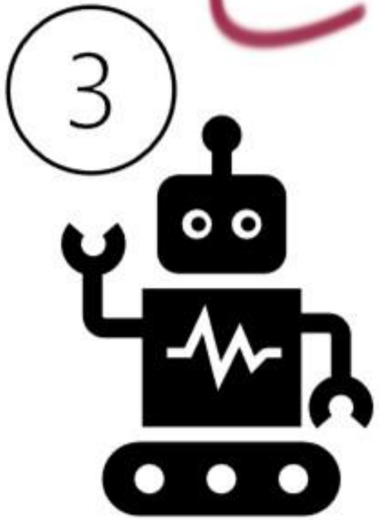
- **the leftmost bit MSB**
- **the rightmost bit LSB**
- **In the number 1100 → $1_{msb}10 0_{lsb}$**

Assign each bit a position number (from zero to N−1) → N is the number of bits used in the representation:

1→ position 3 → 2^3 → 8 → x 1 → 8
1→ position 2 → 2^2 → 4 → x 1 → 4
0→ position 1 → 2^1 → 2 → x 0 → 0
0→ position 0 → 2^0 → 1 → x 0 → 0

$1100_{(2}$ → 12

2^N



N= 3 bits

How many numbers can be represented with 3 bits?

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0 0 0	0
0 0 1	1
0 1 0	2
0 1 1	
1 0 0	
1 0 1	
1 1 0	
1 1 1	7

8

Let’s start playing

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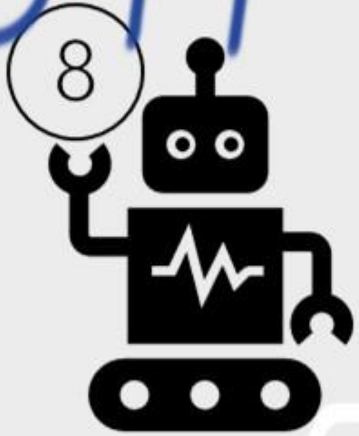
How old are you?

128 64 32 16 8 4 2 1

0 0 1 0 1 0 1 1

43



N= 8 bits

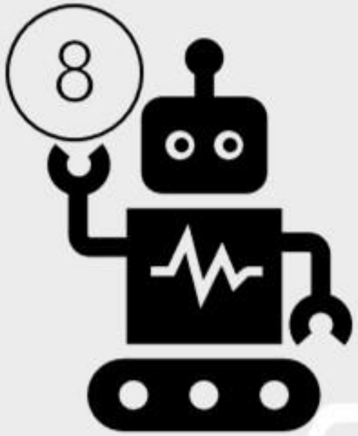
255

nº max

_ _ _ _ _ _ _ _

Let’s start playing

Which is …….?

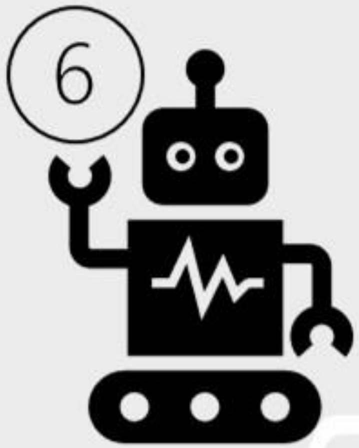


N= 8 bits

_ _ _ _ _ _ _ _

Let’s start playing

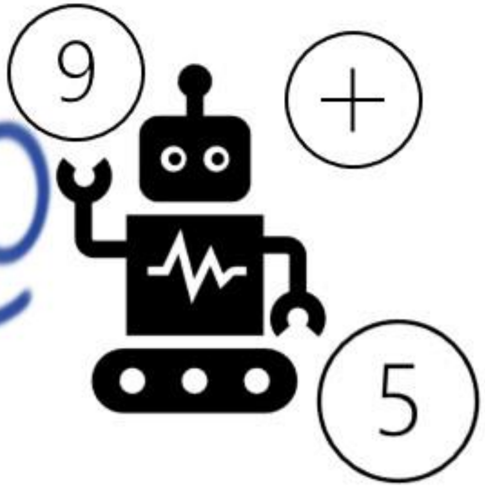
How many …….?



N= 6 bits

_ _ _ _ _ _

Let's do this operation:



$1+1=10$

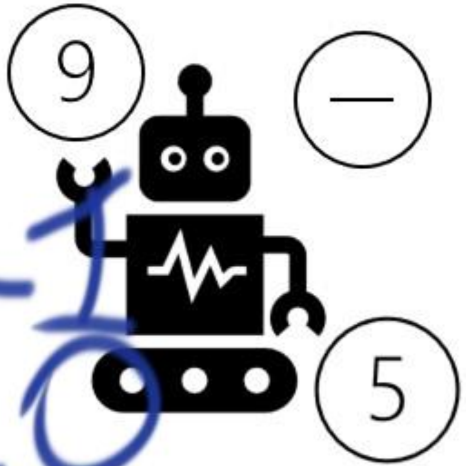
N= 4 bits

$$\begin{array}{r} 1 \\ 1001 \\ +\,0101 \\ \hline 1110_2 \end{array}$$

$14 \leftarrow 1110_2$

Can we use arithmetic operations?

Let's do this operation:



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$0-1=-1$

$0-0=0$

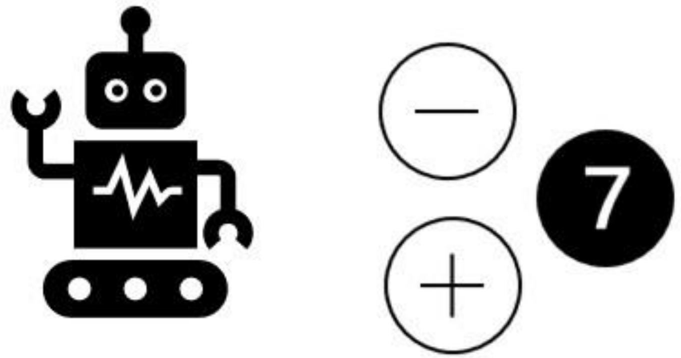
$1-1=0$

$1-0=1$

N= 4 bits

$$\begin{array}{r} 1001 \\ -\;0101 \\ \hline 0100 \end{array}$$

Can we use arithmetic operations?



Represent signed numbers (1)

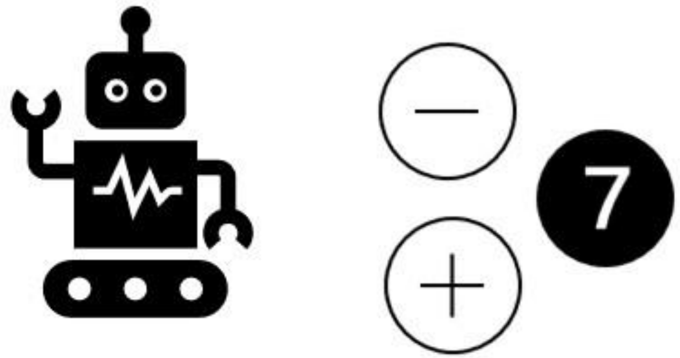
Using MSB

Signed Magnitude	Decimal Value	Signed Magnitude	Decimal Value
0 (MSB) 000 …. 000	+0	**1 (MSB)**000 ….000	-0
0 000 …. 001	+1	1 000 …. 001	-1
…	…	…	…
0 111 …. 110	$2^{n-1} - 2$	1 111 …. 110	$-(2^{n-1} - 2)$
0 111 …. 111	$2^{n-1} - 1$	1 111 …. 111	$-(2^{n-1} - 1)$

-7

1 111

n=4



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Represent signed numbers (2)

One's Complement *of a* ***Signed*** *Binary Number*

Binary	Decimal Value	Ca1	Decimal Value
0 000 …. 000	+0	1 000 …. 000	-2^{n-1}
0 000 …. 001	+1	……………	*Negative numb*
……….. ….	*Positive numb*	1 111.. .. 110	-1
0 111.. .. 111	$2^{n-1}-1$	1 111.. .. 111	-0

-10 → 10 → 1010
10101

Represent signed numbers (3)

Two's Complement of a Signed Binary Number

Binary Value	Decimal Value	Ca2	Decimal Value
0 000 …. 000	+0	1 000 …. 000	-2^{n-1}
0 000 …. 001	+1	………. ….	*Negative numb*
………. ….	*Positive numb.*	1 111.. .. 110	-2
0 111.. .. 111	$2^{n-1}-1$	1 111.. .. 111	-1

Example: -23, with n=8

23 in binary → 00010111

23 in Ca1 → 11101000

Add(1) → 1

23 in Ca2 → 11101001

Advantages: The ALU (*will see in Unit 2*) will use an adder to perform substractions. It will "add" negative binary numbers.

7 Represent signed numbers (4)

Excess-K

Add K value to the number (**$K=2^{n-1}$** , n bits used to represent).

Negative numbers are turned to positive → no bit to specify the sign → Just binary representation

For example, using 8 bits (n=8):

Excess 2^{8-1}=128		
+45	$+45+128=173_{(10}$	$10101101_{(2}$
-45	$-45+128=83_{(10}$	$01010011_{(2}$

Represent decimal numbers

IEEE754 Simple precision

Example: 23,75

First, convert to binary both parts: 23 and ,75. And the sign: 0 positive, 1 negative

10111 ,11

Secondly, normalize by moving the decimal separator to the MSB to get the mantissa part

10111,11 → 1,011111 Exponent is 4 (4 movements)

Finally, calculate the exponent using the Excess K

Exp= 4 **Excess K= 2^{8-1} -1 = 127** **Exp= 127+4=131**
N=8

S	EXPONENT								MANTISSA																						
0	1	0	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[Check results here]

Represent decimal numbers

IEEE754 Simple precision

1 + 8 + 23

Example: 23,75

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10111,11 → 1,011111 Exponent is 4 (4 movements)

Finally, calculate the exponent using the Excess K

Exp= 4 **Excess K= 2^{8-1} -1 = 127** **Exp= 127+4=131**

N=8

4 1 B E 0 0 0 0

S	EXPONENT															MANTISSA															
0	1	0	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Check results here

Example: 10,7

1010,1011 → (4 bits fractional part) → **10.6875**

1010,10110011 → (8 bits fractional part) → **10.69921875**

Exercises:

10,7

1010

$0,7 \times 2 = 1,4$

$0,4 \times 2 = 0,8$

$0,8 \times 2 = 1,6$

$0,6 \times 2 = 1,2$

Exercises:

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