Computer Science 1: IT and web

coefficient: 2
credit: 3
continuous control weight: 50%
exam weight: 50%

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Course 2: Number systems

- Coding of information
- Binary arithmetic
- Quantity of information
- Transmission speed
- Frequency

Goals

- Understand what is a number system
- Learn the method of converting from one system to another.
- Learn how to do arithmetic operations in binary

1-Coding of information

1. Coding of information

- Coding is a process necessary for humans to communicate.
- We can define a code as a set of symbols (alphabet of a language for example) representing useful information.

1. Coding of information

- In computing, these symbols boil down to the two objects which are “0” and “1”.
- So in this domain all information is represented in the form of binary patterns.
- Whether it is text, images, sound, video or simply numbers, binary coding is used.

2-Number system

2. Number system

- A number system is a set of rules and symbols for representing quantitative information. It is characterized by three important mathematical entities:
  - A base
  - A set of numbers
  - Rules for representing numbers

2. Number system

- Theoretically, there are an infinite number of numbering systems. In reality, the 4 most used numbering systems are: decimal, binary octal and hexadecimal.
- octal and hexadecimal system allow binary writing to be abbreviated for better understanding by humans.

2. Number system: example

Base	10	2	3	8	16
Set of numbers	0,1,2,3,4,5,6, 7,8,9	0, 1	0,1,2	0,1,2,3,4,5,6,7	0,1,2,3,4,5,6, 7,8,9, A,B,C,D,E,F
Number's example	198	1111001	1200111	76712	AB129

2.1 Decimal system

- Base 10 (decimal) is the most used by us human beings, this is due to the fact that we originally used our fingers to count (we have 10 fingers!).
- any number N expressed from the ten digits: 0, 1, 2, ..., 9. is written in the number base 10.

2.1 Decimal system

- **Example :**
- The number **1356.724** corresponds to:
  - $1356.724=1000+300+50+6+0.7+0.02+0.004$
  - $1356.724=1*10^{3}+3*10^{2}+5*10^{1}+6*10^{0}+7*10^{-1}+2*10^{-1}+4*10^{-3}$
  - $(1356.724)_{10}=1*B^{3}+3*B^{2}+5*B^{1}+6*B^{0}+7*B^{-1}+2*B^{-1}+4*B^{-3}$

with B=10.

2.1 Decimal system: Converting from Decimal to any base

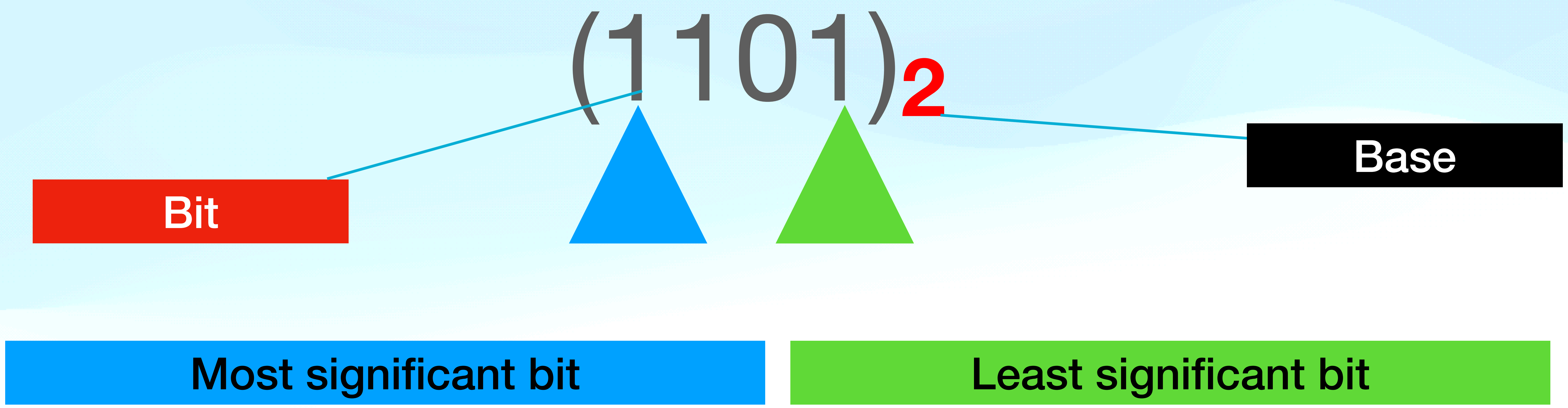
- To convert a number from base 10 to any base B, you must make successive divisions by B and retain the remainder each time until you obtain a quotient lower than base B, in this case the number s 'written from left to right starting with the last quotient going to the first remainder.

2.2 Binary system

- Base 2 (binary) has been widely used since the invention of the computer. This is due to the fact that the latter uses the binary system to represent information.

- In the binary system, to express any value we only use 2 symbols: { 0 , 1}

2.2 Binary system



2.2 Binary system : Binary Decimal Conversion

- To convert a binary number to decimal, simply write it in its polynomial form in base 2 (B=2)

- $(N)10=a_n*B^n + a_{n-1}*B^{n-1}+ ... + a_1*B^1+ a_0*B^0 + a_{-1}*B^{-1} + ... a_{-m}*B^{-m}$

2.2 Binary system : Binary Decimal Conversion

- **Example :** Convert binary number to decimal $(11010)_2$
- $(11010)_2 = 1*2^4+1*2^3+0*2^2+1*2^1+0*2^0$

  $(11010)_2 = 16+8+2$

  $(11010)_2 = (26)_{10}$

- $(110001,001)_2 = 1*2^5+1*2^4+0*2^3+0*2^2+0*2^1+1*2^0+0*2^{-1}+0*2^{-2}+1*2^{-3}$

  $(110001,001)_2 = 32+16+1+0.125$

  $(110001,001)_2 = (49,125)_{10}$

2.2 Binary system : Decimal Binary conversion

- **Converting the integer part of a number**
  - **Method of successive divisions**
    - The successive division method consists of successively dividing by 2, the decimal number to be converted, until the result of the division is a zero. the corresponding binary number will be the succession of the remainders obtained. the most significant bit of this number, being the remainder of the last division.

2.2 Binary system : Decimal Binary conversion

- **Converting the integer part of a number**
  - **Example :**
    - $(27)_2=(11011)_2$

27 :	2	=	13 :	2	=	6 :	2	=	3 :	2	=	1 :	2	= 0
	1			1			0			1			1	

Reading Text

2.2 Binary system : Decimal Binary conversion

- **Converting the integer part of a number**
  - **Converting the fractional part of a number**
    - We successively multiply the fractional part by 2 until we obtain a whole number, we stop the calculations. At each multiplication, we only take into account the integer part obtained.

2.2 Binary system: Decimal Binary conversion

- **Example**
  - $(462,625)_{10} = (?)_2$
    - $(462)_{10}=(111001110)_2$
    - 0.625*2=1.25
    - 0.25*2=0.5
    - 0.5*2=1.0
  - The result is therefore: $(462, 625)_{10} =(111001110,101)_2$

2.2 Binary system : Decimal Binary conversion

- **Example**

  - $(12,15)_{10}= (?)_2$
    - $(12)_{10}=(1100)_2$
    - 0.15*2= 0.3
    - 0.3*2=0.6
    - 0.6*2=1.2
    - 0.2*2=0.4
    - 0.4*2=0.8
    - 0.8*2=1.6
    - 0.6*2=1.2
  - The result is therefore: $(12, 15)_{10} = (1100, 001001...)_2$

2.3 Octal system

- The octal or base 8 system includes eight digits which are: 0, 1, 2, 3, 4, 5, 6, 7. The digits 8 and 9 do not exist in this base (B=8).

2.3 Octal system

- **Example**
- $(4527)_8 = 4*8^3 + 5*8^2 + 2*8^1 + 7*8^0$
- $(1274.632)_8 = 1*8^3 + 2*8^2 + 7*8^1 + 4*8^0 + 6*8^{-1} + 3*8^{-2} + 2*8^{-3}$

2.4 Hexadecimal system

- The use of the base B =16 results from the development of microcomputers. The symbols used in this database are the ten digits from 0 to 9 completed by the letters A (for 10), B (for 11), C (for 12), D (for 13), E (for 14) and F (for 15).

2.4 Hexadecimal system

- **Example**
  - $(4210)_{16} = 4*16^3 + 2*16^2 + 1*16^1 + 0*16^0$
  - $(2A4E)_{16} = 2*16^3 + 10*16^2 + 4*16^1 + 14*16^0$
  - $(C1B.D5)_{16} = 12*16^2 + 1*16^1 + 11*16^0 + 13*16^{-1} + 5*16^{-2}$

2.5 Other conversions

- To convert a number from any base B1 to another base B2 you have to go through the base 10. But if the base B1 and B2 are written respectively in the form of a power of 2 we can go by base 2 (binary):
- Octal base (base 8): $8=2^3$ each octal digit converts itself to 3 bits.
- Hexadecimal base (base 16): $16=2^4$ each hexadecimal digit converts itself to 4 bits.

2.5 Other conversions

- **Example**
  - $(1\ 1001\ 1101,1101\ 0011)_2=(19D,D3)1_{16}$
  - $(1231)_4=(01\ 10\ 11\ 01)_2$
  - $(1231)_8=(001\ 010\ 011\ 001)_2$

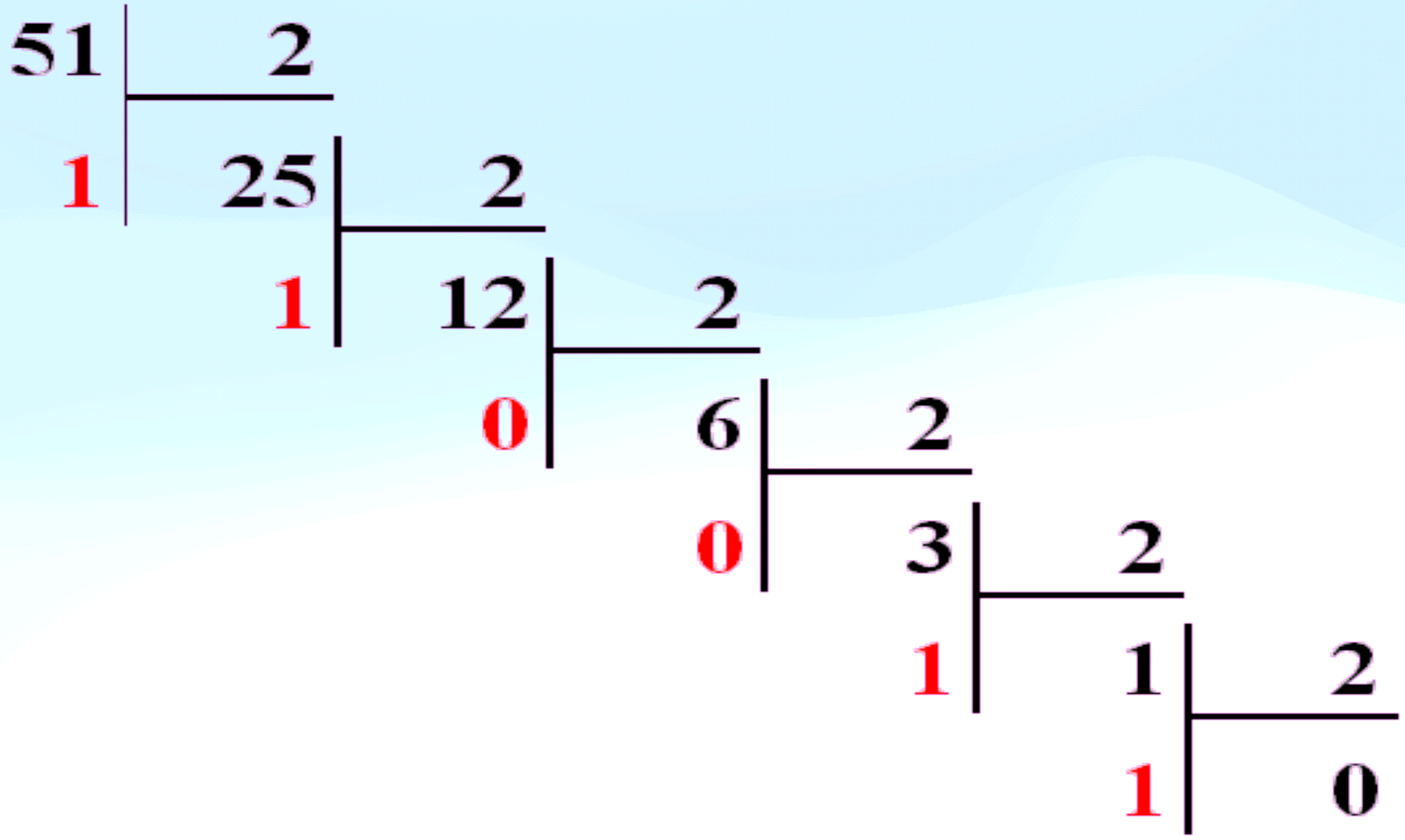
2.6 Abstract

- In a base X, we use X distinct symbols to represent numbers.
- The value of each symbol must be strictly less than the base X.
- Every number in a base X can be written in its polynomial form

2.6 Exercise

- $(51)_{10} = (??????)_2$

2.6 Exercise



- $(51)_{10} = (110011)_2$

3-Binary Arithmetic

3.1 Binary addition:

- To add two binary numbers, we proceed exactly as in decimal, but taking into account the following elementary addition table:
  - 0+0 = **0 retained 0**
  - 0+1 = 1 + 0 = **1 retained 0**
  - 1 + 1 = **0 retained 1**
  - 1 + 1 + 1 = **1 retained 1**

3.1 Binary addition:

		Binary								Decimal		
Retained →		*1*	*1*	*1*	*1*	*1*	*1*	*1*			*1*	
			1	1	1	0	0	1	1	1	1	5
	+				1	1	1	0	1		2	9
Result →	=	1	0	0	1	0	0	0	0	1	4	4

3.2 Binary subtraction:

- In binary subtraction, we proceed as in decimal. When the quantity to be subtracted is greater than the quantity from which we are subtracting, we borrow 1 from the neighbor on the left. In binary, this 1 adds 2 to the quantity from which we subtract, while in decimal it adds 10.

3.2 Binary subtraction:

- **Binary subtraction table:**
  - 0 - 0 = **0** **retained 0**
  - 1 - 0 = **1** **retained 0**
  - 0 - 1 = **1** **deduction 1 to subtract from the neighboring number on the left**
  - 0 - 1 - 1 = **0** **retained 1 to subtract from the neighboring digit on the left**

3.2 Binary subtraction:

		Binary						Decimal	
		1	1	0	0	0		2	4
	-	0	0	1	1	1	-		7
Retained →	-		1	1	1				
Result →	=	1	0	0	0	1	=	1	7

3.3 Binary multiplication

- Binary multiplication is performed like decimal multiplication. Here are the calculation rules to use:
  - 0x0 = **0**
  - 0x1 = **0**
  - 1 x 0 = **0**
  - 1 x 1 = **1**

3.3 Binary multiplication

- It consists of making a series of additions with the multiplicand shifted to the left. This operation is repeated as many times as there are binary elements (to 1) in the multiplier.),

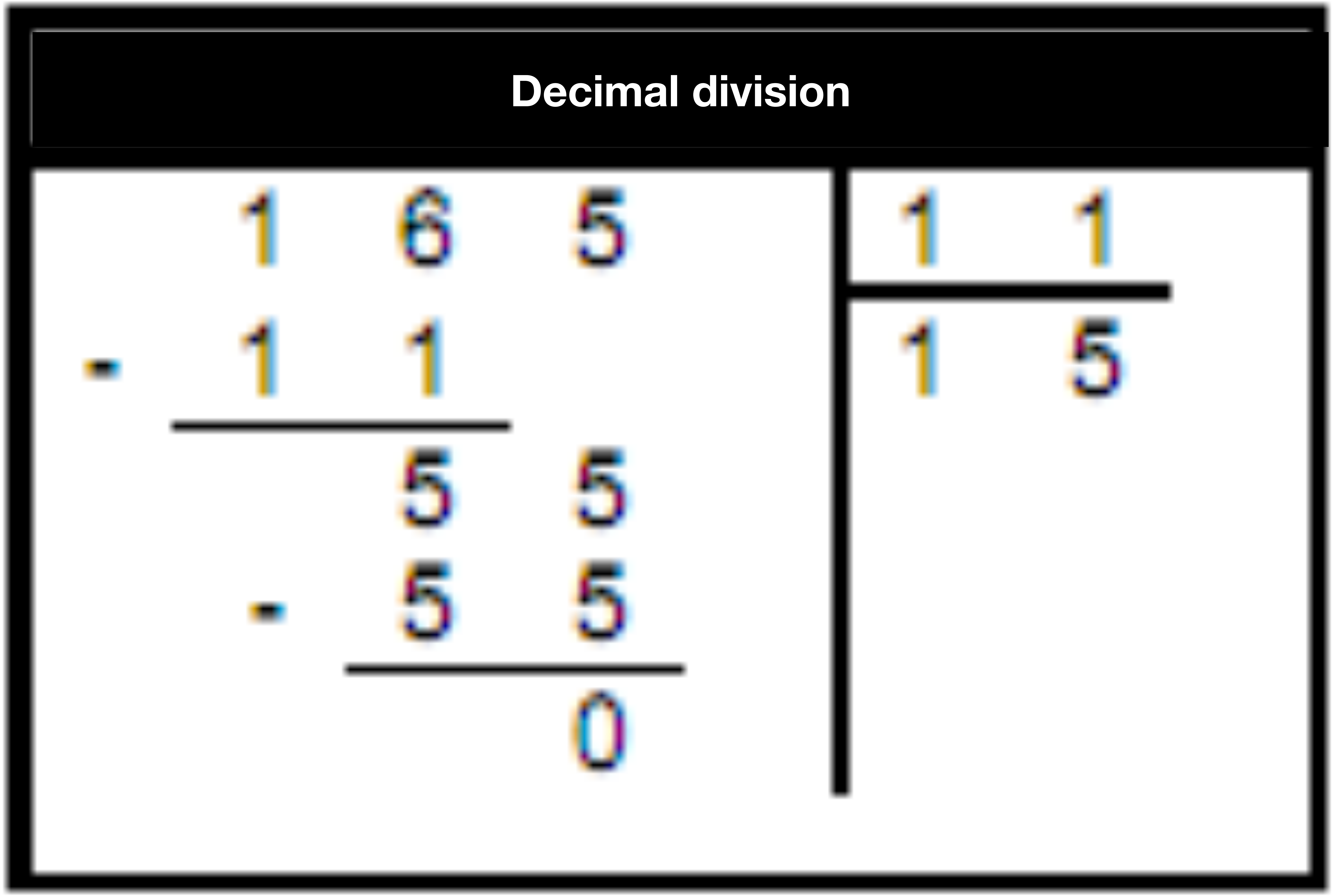
3.3 Binary multiplication

```
     1101
   x 1011
 --------
  0001101
+ 001101
+ 1101
 --------
 10001111
```

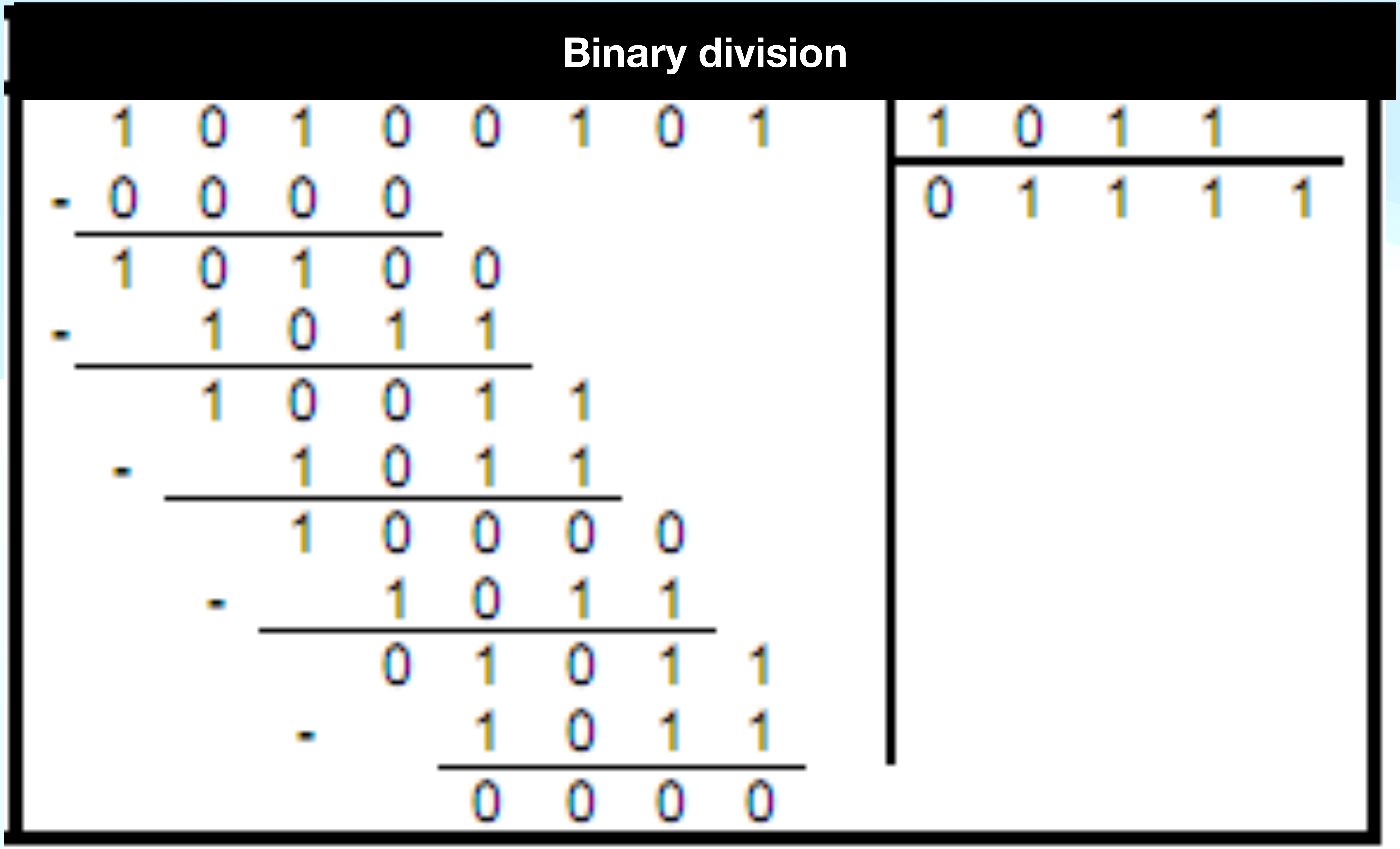
3.4 Binary division

- Binary division is performed using subtractions and shifts, like decimal division, except that the digits of the quotient can only be 1 or 0. The quotient bit is 1 if the divisor can be subtracted, otherwise it is 0.

3.4 Binary division



3.4 Binary division



4-Amount of information

4. Amount of information

- The information processed by a computer can be of different types (text, numbers, images, sound, videos, etc.) but it is always represented and manipulated by the computer in digital form.
- All information will be treated as a sequence of 0 and 1. The unit of information is therefore the binary digits (0 and 1) which we call **bit** (for binary digit).

4. Amount of information

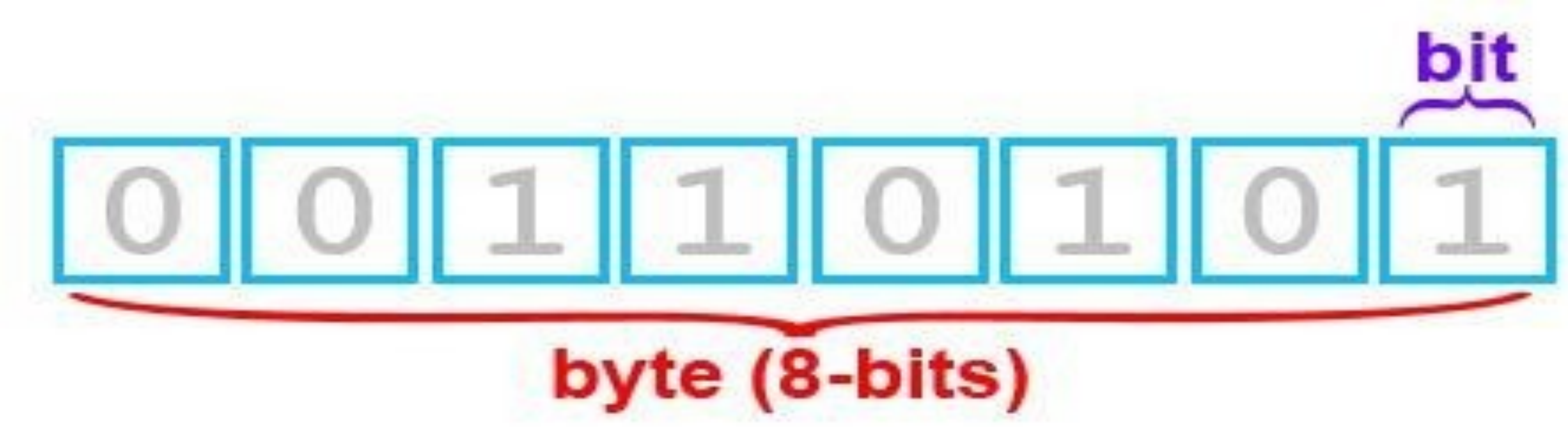
- Coding information consists of establishing a correspondence between the (usual) external representation of the information (text, image, etc.) and its internal representation in the machine which is always a series of bits.

4. Amount of information : measurement unit

- Bit: basic unit of measurement, its symbol is b or bit. The bit (binary digit) represents the smallest unit of memory usable on a computer. This memory can only take two values, most of the time interpreted as 0 or 1.

4. Amount of information: measurement unit

- Each 8 bits constitute 1 Byte (Octet in French)



4. Amount of information : measurement unit

- 1 Byte is generally the smallest unit of memory addressable to represent characters such as a letter. A kilobyte, the second largest unit of bytes, consists of 1,024 bytes and can already represent 103 different states.
- Most computer files are expressed in KB (Kilo bytes), MB (Mega bytes), GB (Giga bytes) or TB (Tera bytes).

4. Amount of information : measurement unit

Name	Value
KiloOctet/ kiloByte	2^{10}
MegaOctet/ MegaByte	2^{20}
GigaOctet/ GigaByte	2^{30}
TéraOctet/ TeraByte	2^{40}
PétaOctet/ PetaByte	2^{50}
ExaOctet/ ExaByte	2^{60}
ZettaOctet/ ZettaByte	2^{70}
YottaOctet/ YotaByte	2^{80}

4. Amount of information : measurement unit

octets/ Bytes	character
kiloOctet/ KiloBytes	Text / Picture
MegaOctet/ MegaByte	File
700 MegaOctets/MegaByte	CDROM
4.7 GigaOctets/GigaByte	DVD
Tera octets/ TeraByte	Hard Disk

Exercise

- The capacity of a DVD is 4.7 GB
    - **Give the size in Mega bytes???**

Exercise

- 1GB= 2^{10}MB= 1024MB
- 4,7GB= 4.7*1024 MB = 4812,8 MB

5-Transmission of information

5. Transmission of information

- **Throughput or bandwidth (Debit ou bande passante en Français)**:
  - speed at which data is transmitted. It can also be defined as the amount of data successfully moved from one location to another in a given period. Throughput is measured in bits per second (BPS).

5. Transmission of information: example

Telephone modem connection	56 kbps
ADSL	256 kbps - 1 Mbps
GPRS	171,2 kbps
EDGE (2G)	384 kbps
3G	1,9 Mbps
3G+ (3.5G)	14,4 Mbps / 3,6 Mbps
4G	300 Mbps / 40 Mbps
5G	Jusqu'à 1 Gbps
Wifi Network	11-54 Mbps
Local Network	100 Mbps

5. Transmission of information: example

Name	Symbol	Multiple
bit per second	bit/s	1 b/s
kilobit per second	kbit/s	10^3 b/s
megabit per second	Mbit/s	10^6 b/s
gigabit per second	Gbit/s	10^9 b/s
terabit per second	Tbit/s	10^{12} b/S

Exercise

- What is the maximum size to download in one second, with a 1Mbps connection????

Exercise

- 1M BpS = 10^6BpS
- 1 Byte = 8 bits
- Size to download in one second $10^6/8$ Byte

6-Frequency

6. Frequency

- Frequency corresponds to the number of operations performed in a given time.
- It’s the number of events per second used to measure:
  - the frequency of the processor bus,
  - the screen refresh rate,
  - RAM bus frequency

6. Frequency

- 1 kilo hertz KHz = 1000 Hz

- 1 Méga Hertz MHz = 1000 KHz
  = 10^6 Hz

- 1 Giga Hertz GHz = 1000 MHz
  = 10^9 Hz