Lecture 2: Data representation, addresses

September 4, 2019

601.229 Computer System Fundamentals

Welcome!

- Today:
  - Data representation
  - Addresses

Data representation

Motto


There are only 10 kinds of people.
Those who understand binary
and those who don't.

Roman Numerals

- Basic units

I	V	X	L	C	D	M
1	5	10	50	100	500	1000

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- Additive combination of units

II III VI XVI XXXIII MDCLXVI MMXVI

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2	3	6	16	33	1666	2016

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- Subtractive combination of units

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4	9	40	90	400	900	1971

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Arabic Numerals

- Developed in India and Arabic world during the European Dark Age
- Decisive step: invention of zero by Brahmagupta in AD 628
- Basic units

  0 1 2 3 4 5 6 7 8 9

- Positional system

  1 10 100 1000 10000 100000 1000000

Why Base 10?

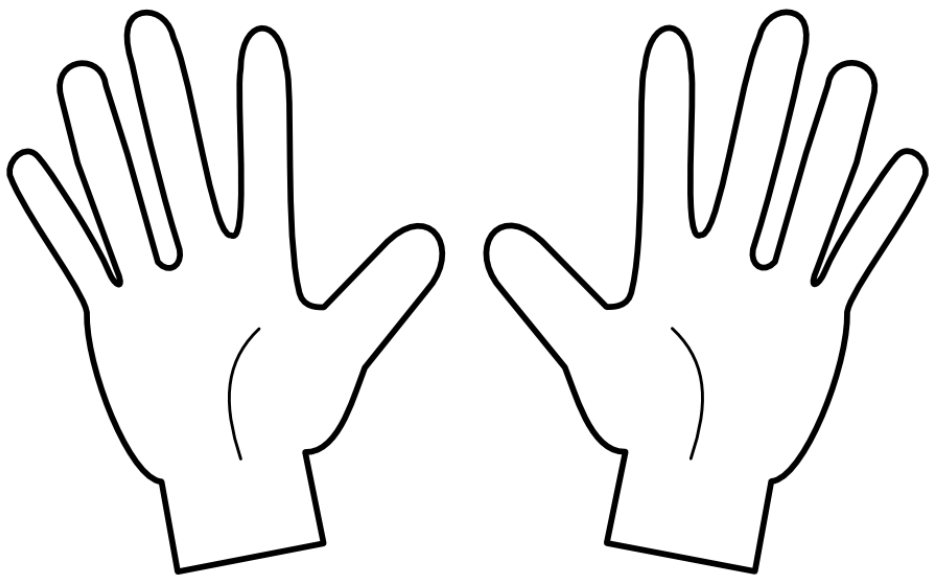
dig·it

/ˈdijit/

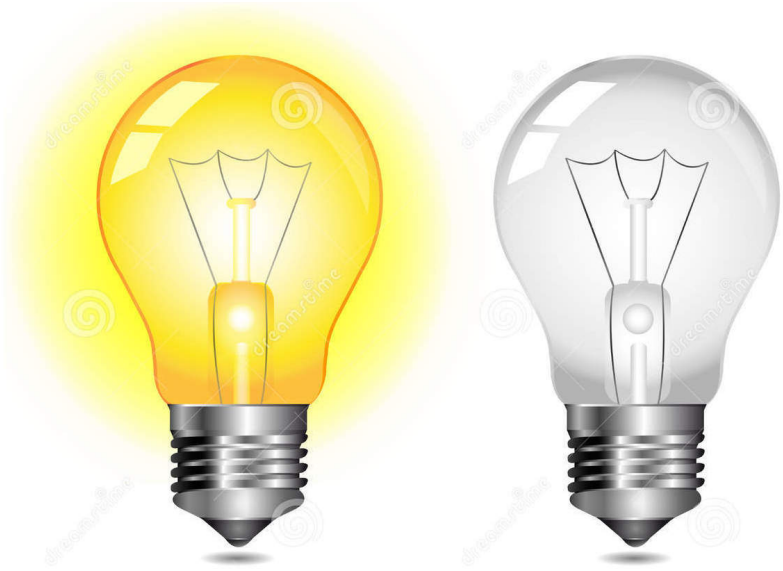
noun

1. any of the numerals from 0 to 9, especially when forming part of a number.
   synonyms: numeral, number, figure, integer
   "the door code has ten digits"

2. a finger (including the thumb) or toe.
   synonyms: finger, thumb, toe; extremity
   "we wanted to warm our frozen digits"



Base 2



Base 2

- Decoding binary numbers

Binary number	1	1	0	1	0	1	0	1

Base 2

- Decoding binary numbers

Binary number	1		1	0	1	0	1	0	1
Position	7		6	5	4	3	2	1	0

Base 2

- Decoding binary numbers

Binary number	1		1	0	1	0	1	0	1
Position	7		6	5	4	3	2	1	0
Value	2^7		2^6	0	2^4	0	2^2	0	2^0

Base 2

- Decoding binary numbers

Binary number	1	1	0	1	0	1	0	1	
Position	7	6	5	4	3	2	1	0	
Value	2^7	2^6	0	2^4	0	2^2	0	2^0	
	128	64	0	16	0	4	0	1	$= 213$

Clicker quiz 1

Clicker quiz omitted from public slides

Base 8

- Numbers like 11010101 are very hard to read

$\Rightarrow$ Octal numbers

Binary number	1	1	0	1	0	1	0	1
Octal number		3			2			5

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Binary number	1 1	0 1 0	1 0 1
Octal number	3	2	5
Position	2	1	0

Base 8

- Numbers like 11010101 are very hard to read

$\Rightarrow$ Octal numbers

Binary number	1 1	0 1 0	1 0 1
Octal number	3	2	5
Position	2	1	0
Value	3×8^2	2×8^1	5×8^0

Base 8

- Numbers like 11010101 are very hard to read

$\Rightarrow$ Octal numbers

Binary number	1 1	0 1 0	1 0 1	
Octal number	3	2	5	
Position	2	1	0	
Value	3×8^2	2×8^1	5×8^0	
	192	16	5	$= 213$

- ... but grouping **three** binary digits is a bit odd

Base 16

- Grouping 4 binary digits $\rightarrow$ base $2^4 = 16$
- "Hexadecimal" (hex = Greek for six, decimus = Latin for tenth)

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Binary number	1	1	0	1	0	1	0	1
Hexadecimal number		d				5		

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- "Hexadecimal" (hex = Greek for six, decimus = Latin for tenth)
- Need characters for 10-15: use letters a-f

Binary number	1 1 0 1	0 1 0 1
Hexadecimal number	d	5
Position	1	0

Base 16

- Grouping 4 binary digits $\rightarrow$ base $2^4 = 16$
- "Hexadecimal" (hex = Greek for six, decimus = Latin for tenth)
- Need characters for 10-15: use letters a-f

Binary number	1	1	0	1	0	1	0	1	
Hexadecimal number		d				5			
Position		1				0			
Value		13×16^1				5×16^0			
		208				5			$= 213$

Clicker quiz 2

Clicker quiz omitted from public slides

Examples

Decimal	Binary	Octal	Hexademical
0			
1			
2			
3			
8			
15			
16			
20			
23			
24			
30			
50			
100			
255			
256			

Examples

Decimal	Binary	Octal	Hexademical
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
8	1000	10	8
15	1111	17	f
16	10000	20	10
20	10100	24	14
23	10111	27	17
24	11000	30	18
30	11110	36	1e
50	110010	62	32
100	1100100	144	64
255	11111111	377	ff
256	100000000	400	100

Placeholder 1

Placeholder slide

Addresses

Placeholder 2

Another placeholder slide