CM12002
Computer Systems Architectures

Data Representation

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Binary System

Convert the binary number 101101001 to decimal.

1	0	1	1	0	1	0	0	1
2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
256	128	64	32	16	8	4	2	1

256	0	64	32	0	8	0	0	1

256 + 64 + 32 + 8 + 1 = 361

$101101001_2 = 361_{10}$

Homework: convert 11101_2 to decimal

Binary System

Convert the decimal number 241 to binary.

Find the largest power of 2 that is lower than the number.

256	128	64	32	16	8	4	2	1

128

241-128 = 113 → 64

113-64 = 49 → 32

49-32 = 17 → 16

17-16 = 1 → 1

Result: 11110001

Homework: convert 165 to binary

$165_{10}=10100101_{2}$

Powers of 2

$2^1 = 2$
$2^2 = 4$
$2^3 = 8$
$2^4 = 16$
$2^5 = 32$
$2^6 = 64$
$2^7 = 128$
$2^8 = 256$
$2^9 = 512$
$2^{10} = 1024$
$2^{11} = 2048$
$2^{12} = 4096$
$2^{13} = 8192$
$2^{14} = 16384$
$2^{15} = 32768$
$2^{16} = 65536$

Binary System

Addition

```
  1 1 1 1
  1101101
+ 1010110
----------
 11000011
```

```
      1
  0101011
+ 1010001
----------
  1111100
```

The binary system

A binary digit (0 or 1) is called a bit

We can easily imagine that if we were operating with a system whose elements were built with two-state devices, we could use the two states of a collection of devices to encode a number in binary representation.

This is exactly what happens in computer systems!

More about numeration systems

The elements of the numeration system are that:

- as many digit symbols as the base are needed;
- the decimal system's *base* or *radix* of ten, the cardinal number of standards in the basic set, is denoted by '10';
- *place* values increase from right to left in successive powers of the base (a *positional* system);
- *addition* is used to make up a number consisting of combinations of digits and *multiplication* is used to make up the number represented by a digit in a specific place;
- there is an agreed starting point (the 'unit' place); and
- a *point* is used to denote this place.

More about numeration systems

Numeration for non-integer numbers

We can extend symmetrically to the right of the point:

E.g. the number 179.32 can be computed as:

$$(1 \times 10^{2}) + (7 \times 10^{1}) + (9 \times 10^{0}) + (3 \times 10^{-1}) + (2 \times 10^{-2})$$

More practice (check results with your classmates):

Convert 255 to binary.

Convert 10101010 to decimal.

Plus:

Homework: convert 11101_2 to decimal

Homework: convert 165 to binary

Next time:

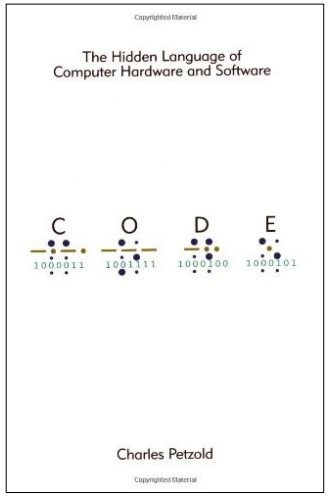
- How is data stored in memory
- representing and storing signed integers in binary.

Additional material

Videos

- http://www.youtube.com/watch?v=hacBFrgtQjQ
- http://www.youtube.com/watch?v=5sS7w-CMHkU

Book



Code: The Hidden Language of Computer Hardware and Software
Book by Charles Petzold