CS 101: Computer Programming and Utilization

Shivaram Kalyanakrishnan
(Abhiram Ranade's slides, borrowed and edited)
Lecture 6

This Lecture

- How to express real life problems as numerical problems.
  - Picture processing
  - Predicting the weather
  - Processing text/language

- How a computer does the required operations
  - How numbers are represented
  - Parts of a computer

“What is in this picture?”

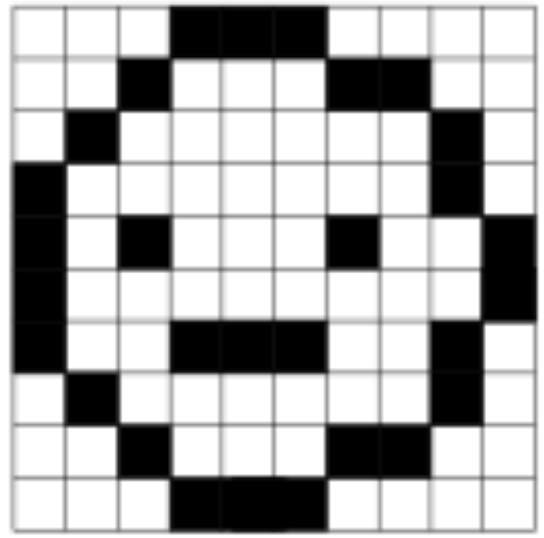
https://en.wikipedia.org/wiki/File:Jackson%27s_Chameleon_2_edit1.jpg

Picture, Representation, Reconstruction

(a)

```
0 0 0 1 1 1 0 0 0 0
0 0 1 0 0 0 1 1 0 0
0 1 0 0 0 0 0 0 1 0
1 0 0 0 0 0 0 0 1 0
1 0 1 0 0 0 1 0 0 1
1 0 0 0 0 0 0 0 0 1
1 0 0 1 1 1 0 0 1 0
0 1 0 0 0 0 0 0 1 0
0 0 1 0 0 0 1 1 0 0
0 0 0 1 1 1 0 0 0 0
```

(b)



(c)

Remarks

- Better representation if picture divided into more cells.
- Pictures with different “gray levels”: use numbers 0, 0.1, …, 1.0 to represent level of darkness rather than just 0, 1.
- Pictures with colours: picture = 3 sequences
  - sequence for red component,
  - sequence for blue component,
  - sequence for green component
- Add up the colours to get the actual colour.

Weather prediction

- Divide the surface of the earth into small regions (like pixels).
- Let p_i, t_i, h_i = pressure, temperature, humidity in region i
- Laws of physics tell us how to the values will change with time.
- We can measure current pressure, humidity, temperature values, and calculate what will happen tomorrow!
- Smaller the regions, better will be the accuracy. (Smaller the pixels, better will be the picture representation).

Language/text using numbers

- Define a code for representing letters.
- Commonly used code: ASCII
  - (American Standard Code for Information Interchange)
- Letter ‘a’ = 97 in ASCII, ‘b’ = 98, …
- Uppercase letters, symbols, digits also have codes. Code also for space character.
- Words = sequences of ASCII codes of letters in the word.
- ‘computer’ = 99, 111,109,112,117,116,101,114.
- Sentences/paragraphs = larger sequences.
- Does the word “computer” occur in a paragraph?
  - Does a certain sequence of numbers occur inside another sequence of numbers?

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Bits, bytes, half-words, words

- Bit = 1 binary “digit”, (one number = 0 or 1)
- byte = 8 bits
- half-word = 16 bits
- word = 32 bits
- double word = 64 bits

“one byte of memory” = memory capable of storing 8 bits = 8 capacitors.

Binary representation revision

- Binary number $a_{n-1}a_{n-2}\ldots a_1a_0 \,.\, a_{-1}a_{-2}\ldots a_{-k}$
  - Example: 101.11
- Decimal value $v = \sum_i a_i 2^i$
  - $1*2^2 + 0*2^1 + 1*2^0 + 1*2^{-1} + 1*2^{-2} = 5.75$
- Converting a decimal integer v to binary
  - Divide v by 2, remainder gives a_0
  - Repeat previous step with the quotient to get a_1, a_2, …
- Converting fraction f to binary
  - If $f > 0.5$, $a_{-1} = 1$
  - Similarly other bits…

Representing integers that can be positive or negative

- One of the bits is used to indicate sign
- Sign bit = 0 (low charge/voltage) means positive number, = 1 means negative number.
- To store -25 use

10000000000000000000000011001

- Leftmost bit = sign bit
- Max positive number: $2^{31} - 1$

01111111111111111111111111111111

- Range stored: $-2^{31} – 1$ to $2^{31} – 1$.
- Actual representation used:
  - more complex. “Two’s complement”.

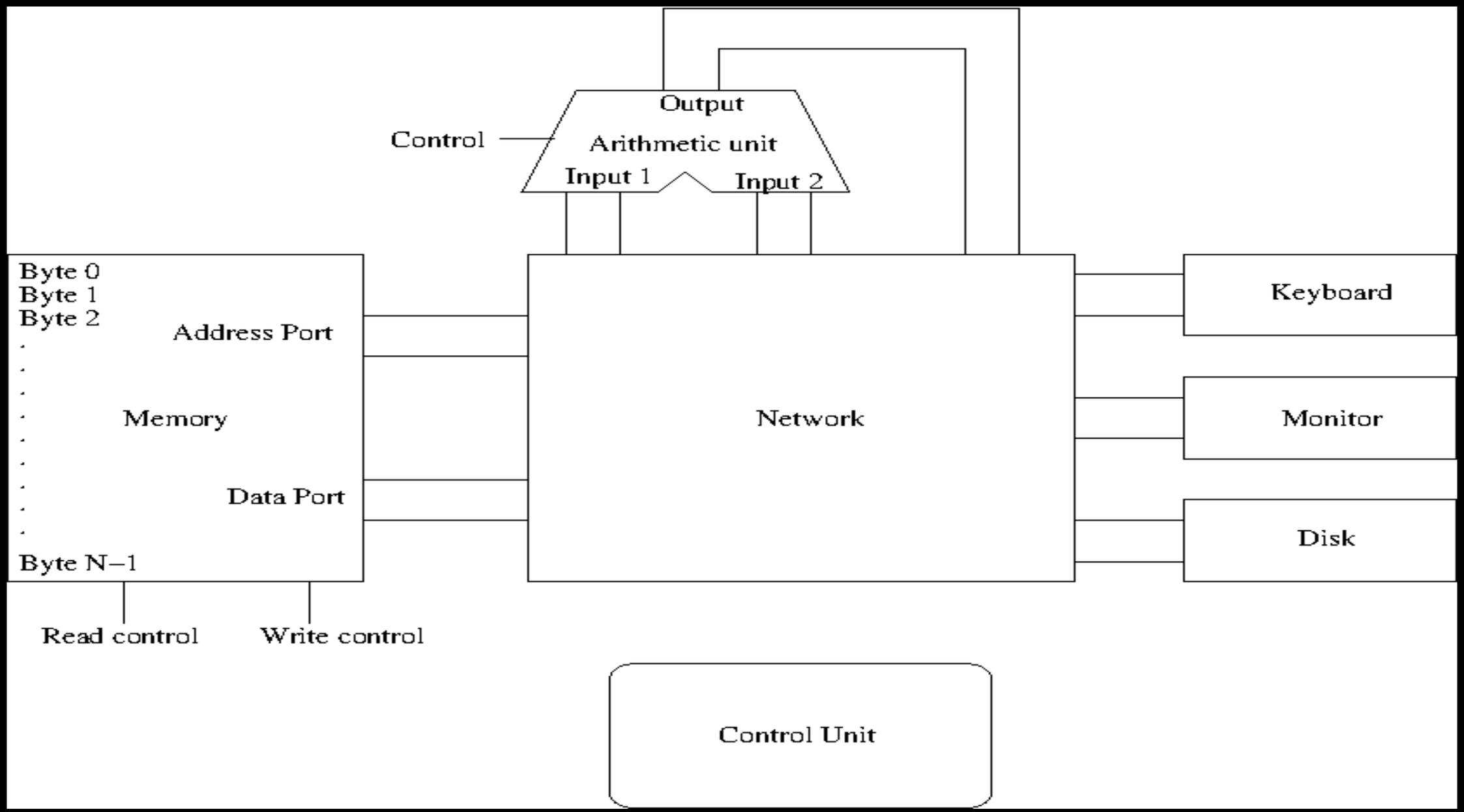
Representing Real numbers

- Use analogue of “scientific notation”:significand * 10^{exponent}
  e.g. 6.022 * 10^{23}
- Same idea, but significand, exponent are in binary, thus number is:

significand * 2^{exponent}

- “Single precision”: store significand in 24 bits, exponent in 8 bits.
  - Fits in one word!
  - 24 bits of significand = 7-8 decimal digits
- “Double precision”: store significand in 53 bits, exponent in 11 bits.
  - Fits in a double word!
  - 53 bits of significand = 16-17 decimal digits
- Actual representation: more complex. “IEEE Floating Point Standard”.

Organization of a computer



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