Data Representation and Problem Solving

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Bits, Bytes, Words…

1 *bit* is a storage unit that must contain either a 0 or a 1.

1 *byte* is a unit consisting of 8 bits.

A *word* is a group of one or more bytes.

(Pentium 4 is a 32-bit machine, 4 bytes per word.)

Data Representation

Analog (continuous) vs. Digital (discrete)

Signed-Magnitude Representation of Negative Numbers

Add an extra bit on the left to represent the sign.

Use 0 for the '+' sign, 1 for the '-' sign.

Example (3 bits allocated for the magnitude, 1 bit for the sign):

$0101=5_{10}$, $1101=-5_{10}$.

Problems with the *signed-magnitude* representation:

- Two representations of 0: 0000 and 1000;
- Special logic is required to perform addition, subtraction, multiplication and division.

Ten's Complement Representation of Negative Numbers

- Limit the maximum number of decimal digits by *k*.
- Interpret the first half of numbers (0,1,…,(10^k/2)-1) as natural numbers. Interpret the other numbers as

$$\text{Negative}(m) = 10^k - m$$

- Example, *k*=3: 123+(-455)=123+(1000-455)=668_{10c}=-332_{10}

Two's Complement Representation of Negative Numbers

- Representing

$$\text{Negative}(m) = 2^k - m,$$

where *k* is the number of bits used.

Example: *k*=8,

-125	10000011	(256-125=131=1+2+128)
+ 3	+ 00000011	
-122	10000110	"134"=Negative(122))

Overflow will occur if the result of addition exceeds 127: "128" (10000000) now serves as (-128)!

Representing Real Numbers

- *Scientific notation*:

  .00508259 = $5.08259*10^{-3} \rightarrow$ 5.08259E-3

  The *decimal point* is kept to the right of the most significant (non-zero) digit.
- *Floating point*: A real value in Base 10

  r = sign*mantissa*$10^{exponent}$

  The # of digits is fixed, but the point “floats”.
- In other bases, the analog of the decimal point is called a *radix point*.

Representing Real Numbers in Binary

r = sign*mantissa*$2^{exponent}$

How to convert the fractional part from decimal to binary? Keep multiplying by the base and reading off the digits. Example:

$17.875_{10} = 10001.111_2$

17/2=8.5, 0.5*2=1; 8/2=4; 4/2=2;2/2=1;

.875*2=1.75; 0.75*2=1.5; 0.5*2=1.

Representing Text

- Encoding characters vs. *formatting* (fonts, margins, tables, color, etc.)
- A *character set* is a list of characters and the codes used to represent them. How many characters do we need?..
- *ASCII* (American Standard Code for Information Interchange): Originally allowed 128 unique characters. The eighth bit was a *check bit*. *Latin-1 Extended ASCII character set*: 256 characters.

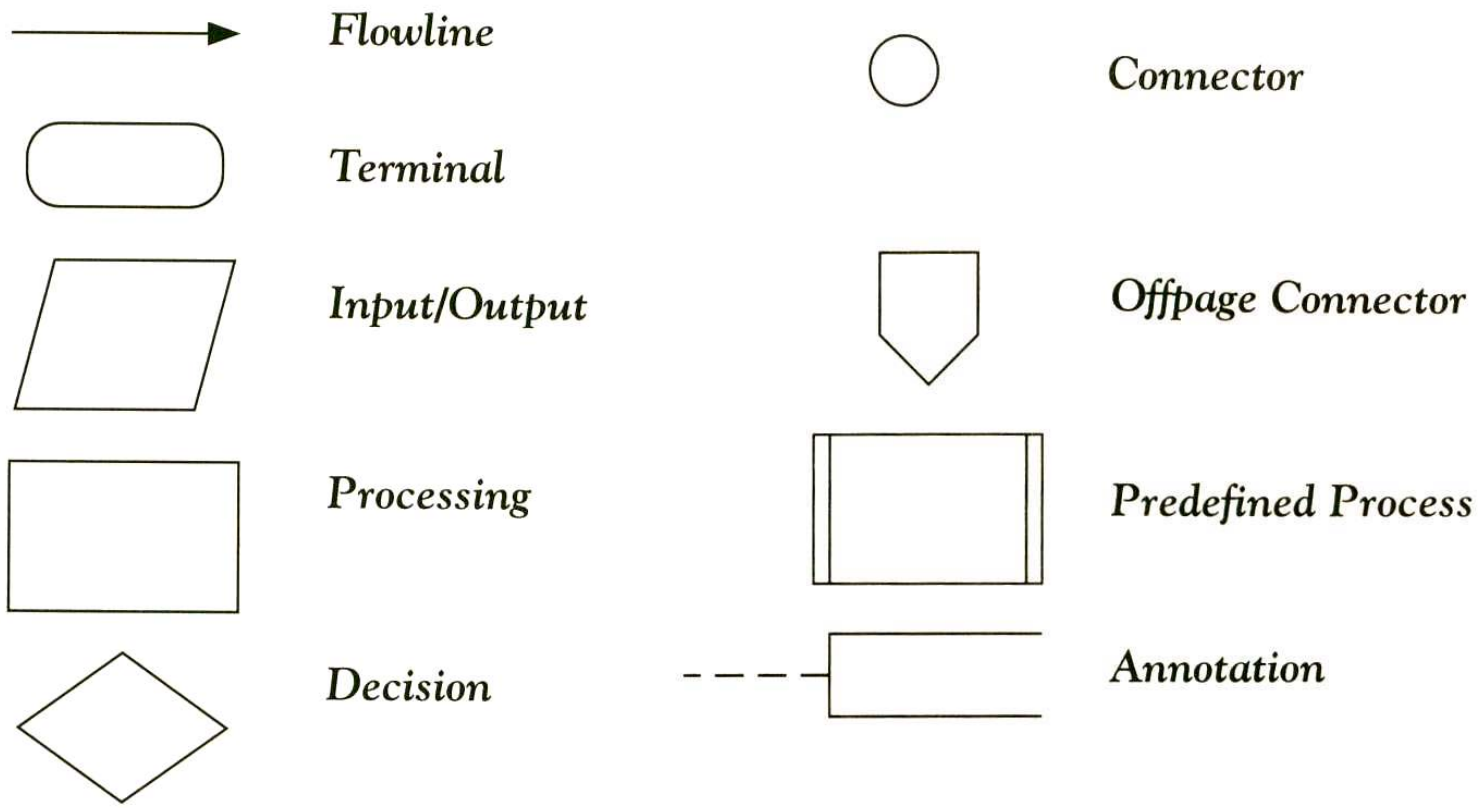
The Unicode Character Set

- 16 bits per character. 2^{16}=65536 unique characters can be represented.
- The first 256 characters in the Unicode set correspond to those of the extended ASCII character set. ("*Backward compatibility*".)

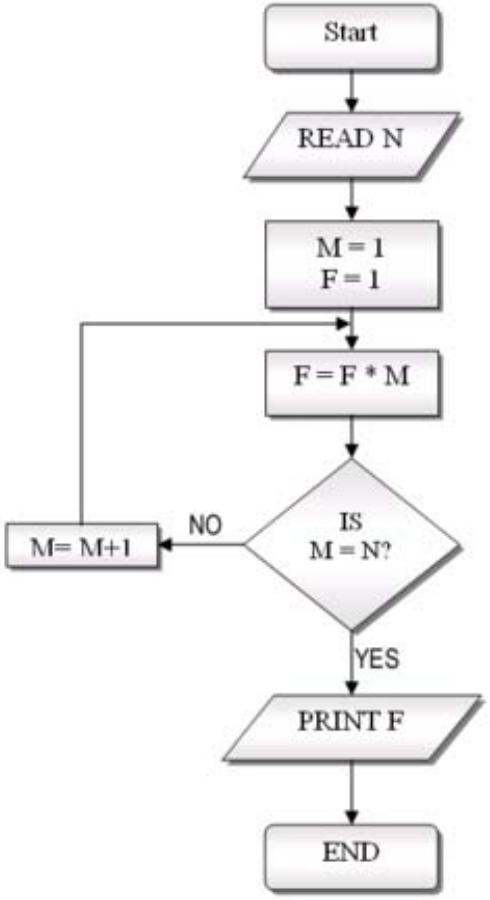
Program Development Cycle

1. **Analyze**: What should the output be? What data/input is necessary to obtain the output?
2. **Design**: Develop an algorithm – a logical sequence of precise steps that solve the problem
3. **Choose the interface**: Create command buttons and menus to allow the user to control the program
4. **Code**: Translate the algorithm into a programming language
5. **Test and debug**: Locate and remove any errors ("bugs") in the program
6. **Complete the documentation**: For commercial programs, develop an instruction manual and on-line help

Flowchart Symbols



Sample Flowchart: Factorial



Pseudocode

Pseudocode is a compact and informal high-level description of a computer programming algorithm that uses the structural conventions of programming languages, but omits detailed subroutines, variable declarations or language-specific syntax. The programming language is augmented with natural language descriptions of the details, where convenient. Pseudocode generally does not actually obey the syntax rules of any particular language; there is no systematic standard form, although any particular writer will generally borrow the appearance of a particular language.