Chapter 8: Algorithms

Algorithms + Data Structures = Programs

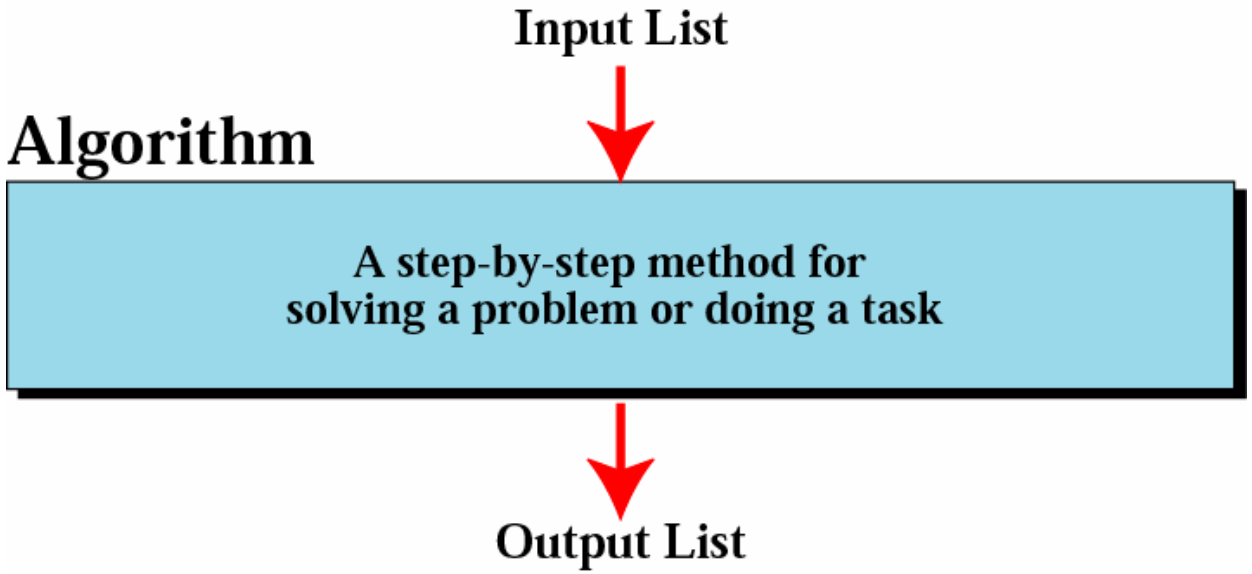
- Niklaus Wirth, 1975.

8.1

CONCEPT

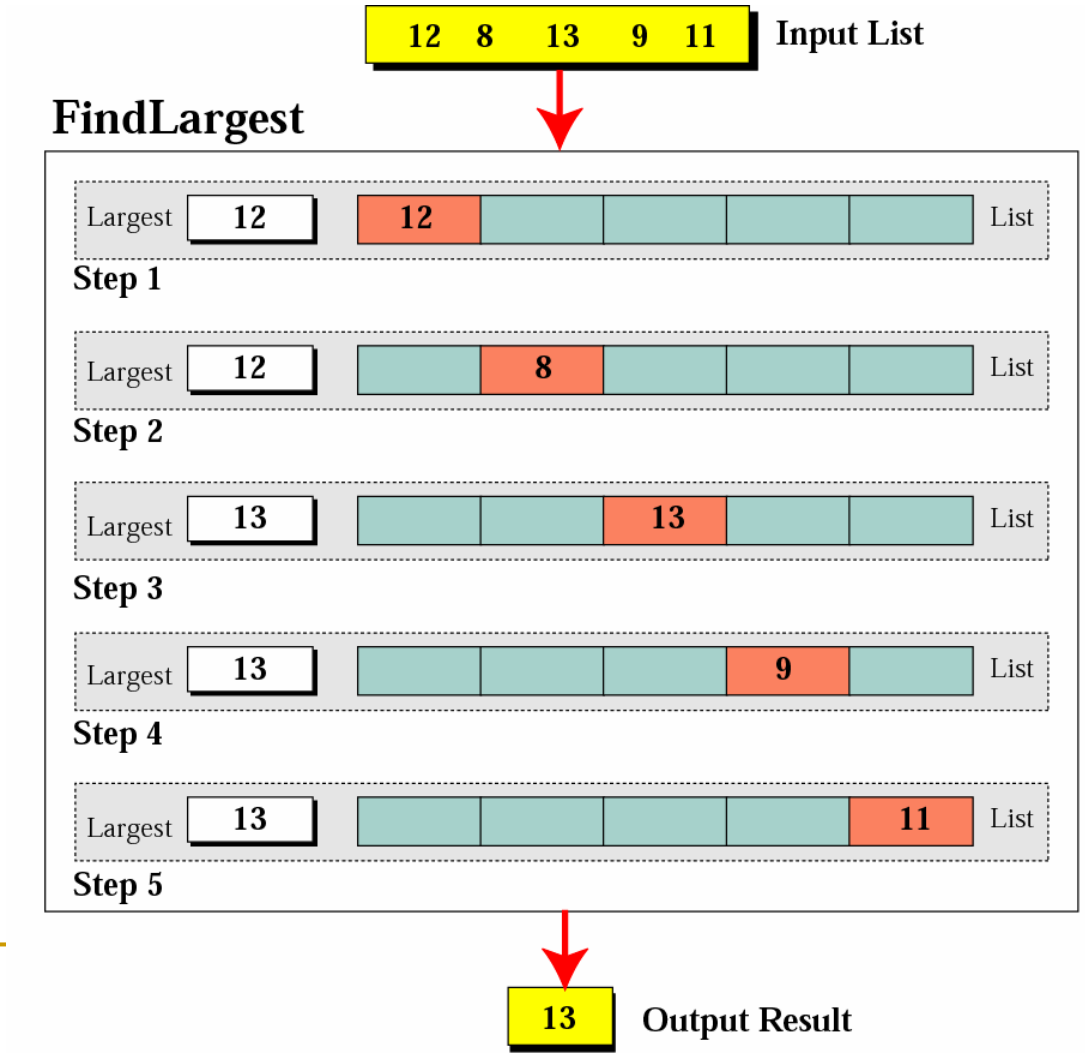
Informal definition

- Informally, an algorithm is a step-by-step method for solving a problem or doing a task.
- An algorithm accepts an input list of data and creates an output list of data.

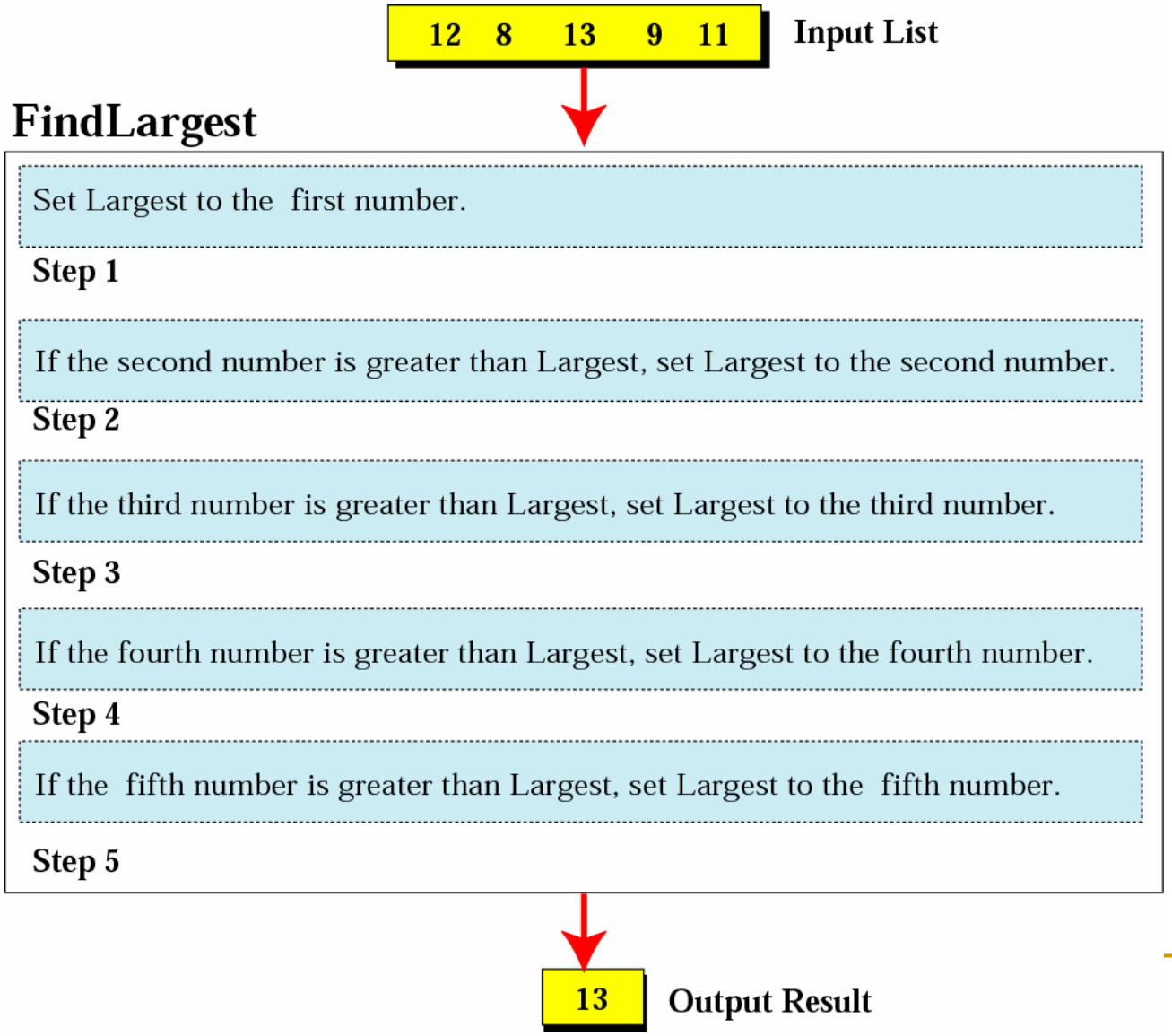


Example

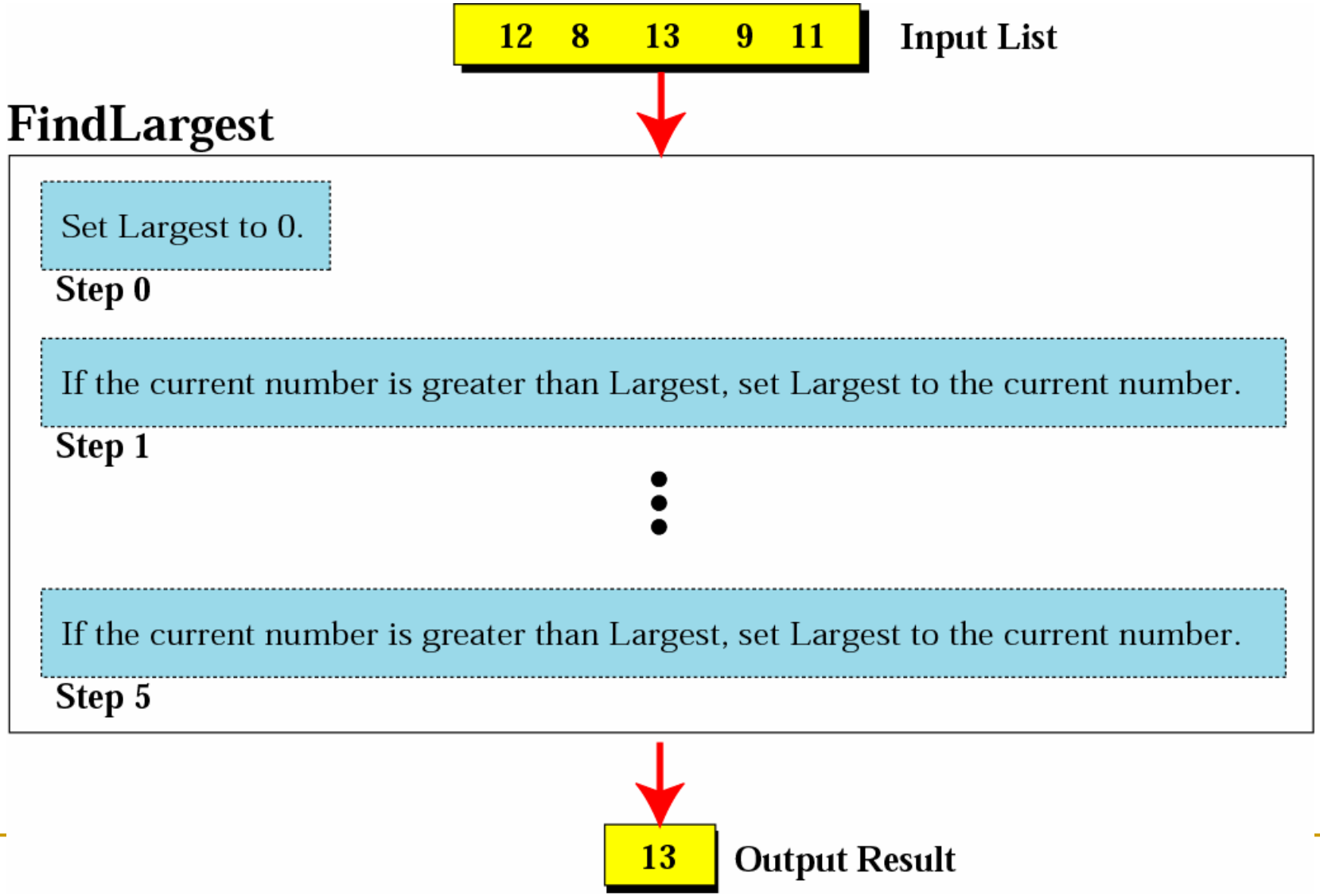
The algorithm uses the following five steps to find the largest integer.



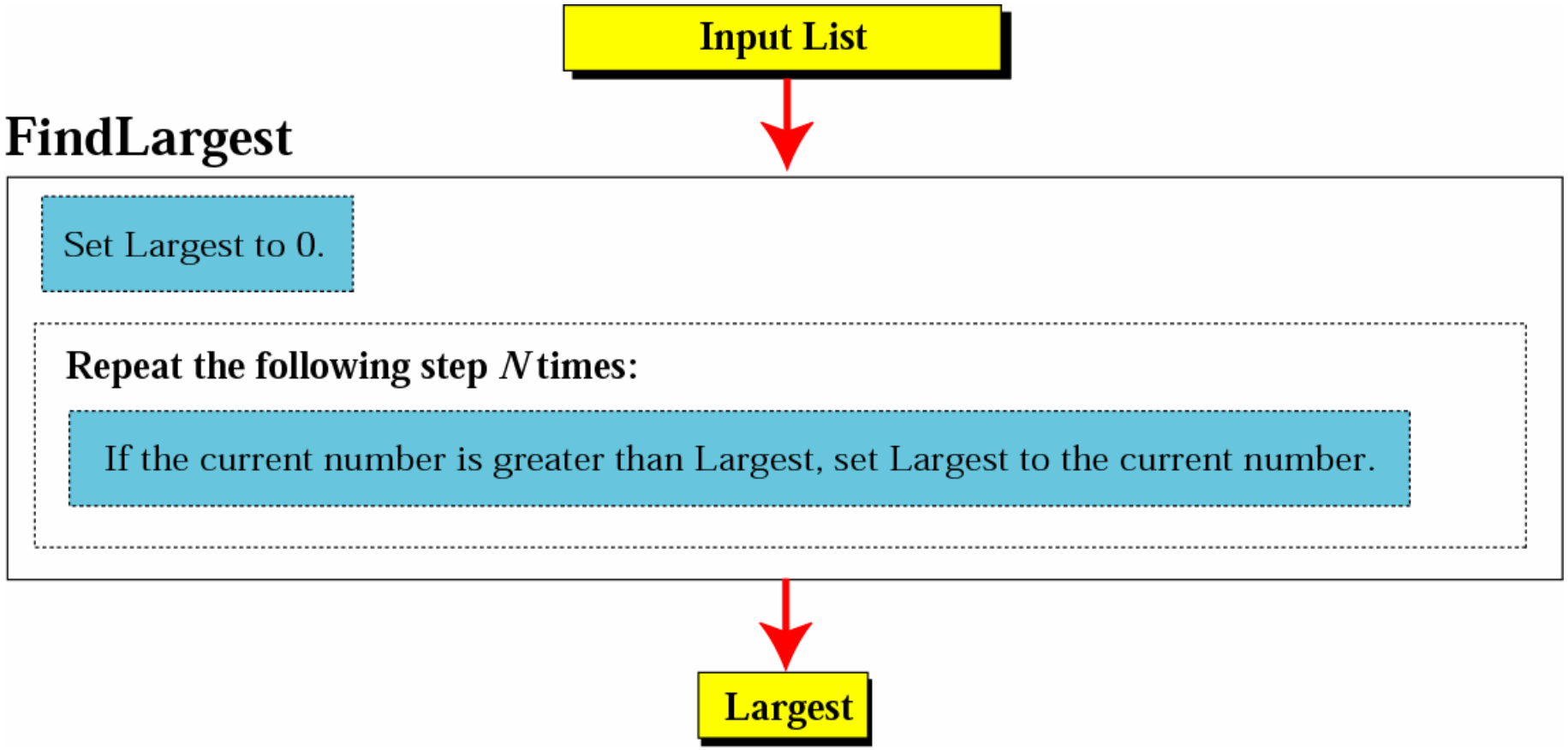
Defining actions in FindLargest algorithm



Refinement


12 8 13 9 11
Input List
FindLargest
Set Largest to 0.
Step 0
If the current number is greater than Largest, set Largest to the current number.
Step 1
If the current number is greater than Largest, set Largest to the current number.
Step 5
13
Output Result

Generalization

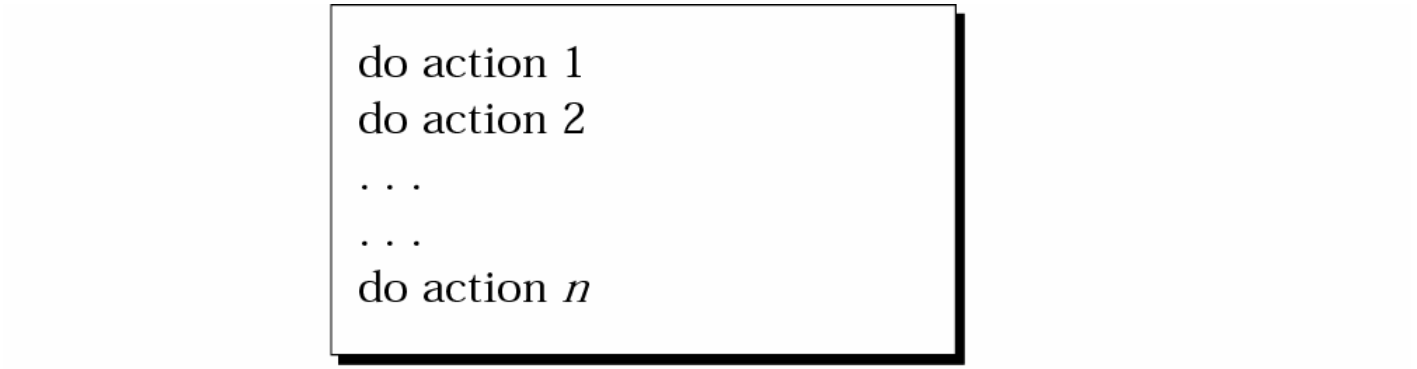


8.2

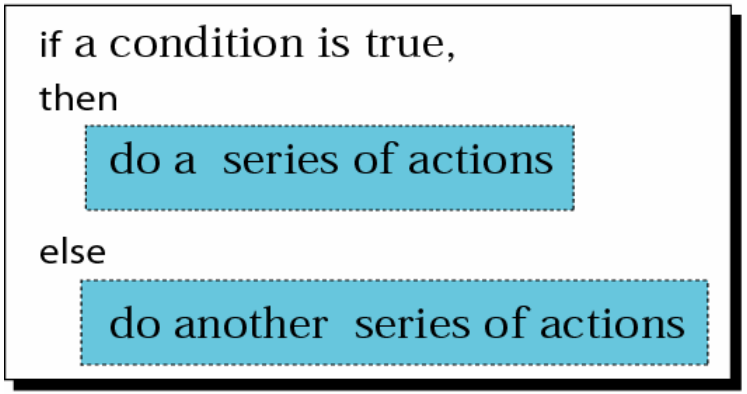
THREE CONSTRUCTS

Three constructs

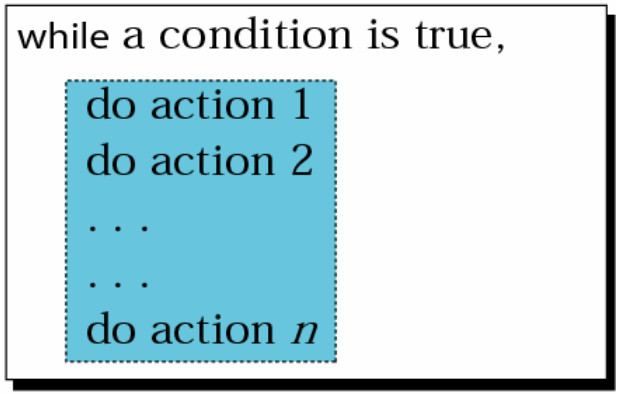
- A program is a combination of sequence constructs, decision constructs, and repetition constructs.



a. Sequence



b. Decision



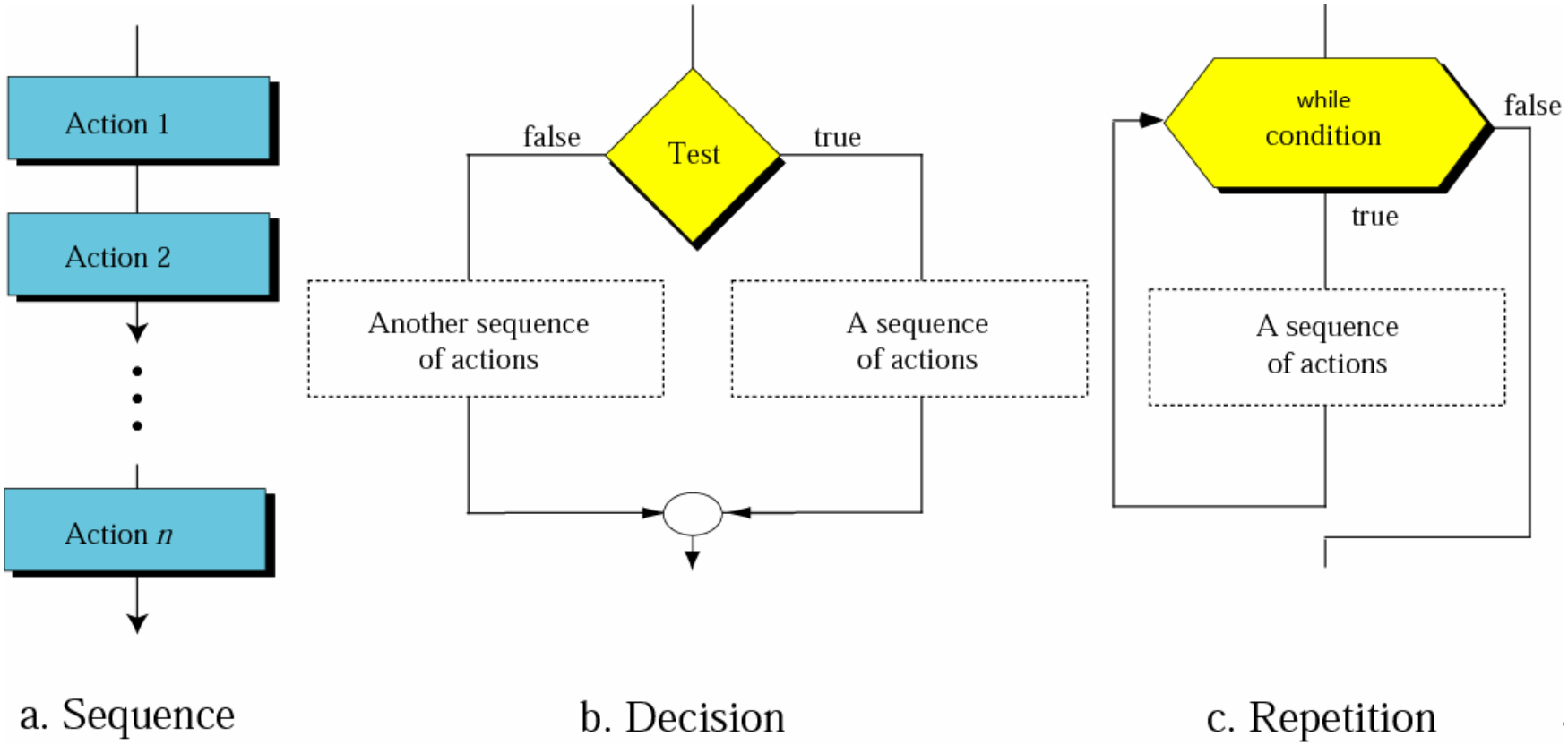
c. Repetition

8.3

ALGORITHM REPRESENTATION

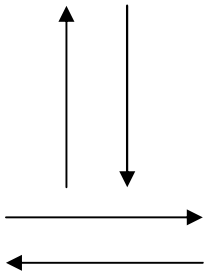
Flowcharts for three constructs

- A flowchart is a pictorial representation of an algorithm.

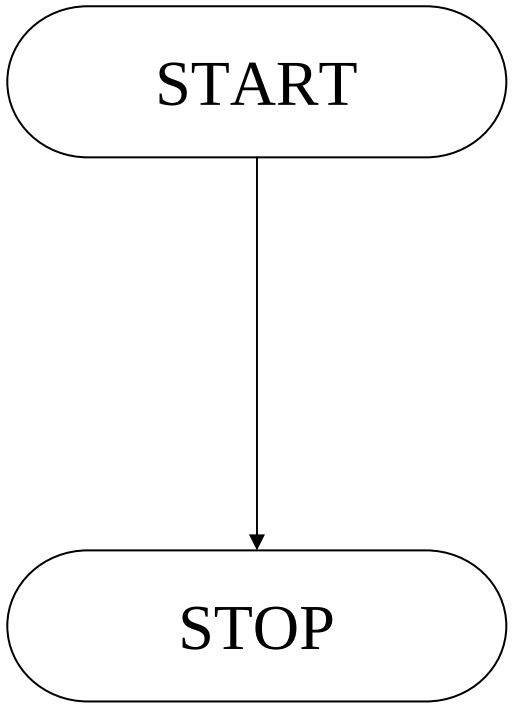


a. Sequence b. Decision c. Repetition

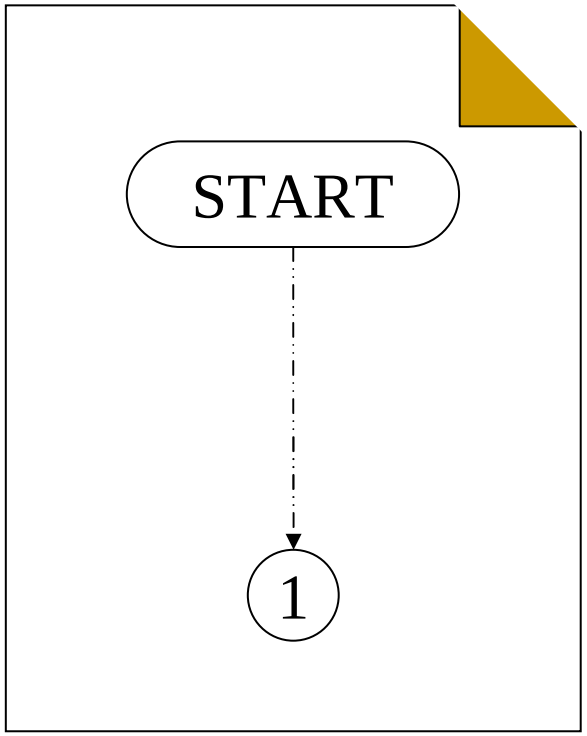
Appendix C: Flowcharts

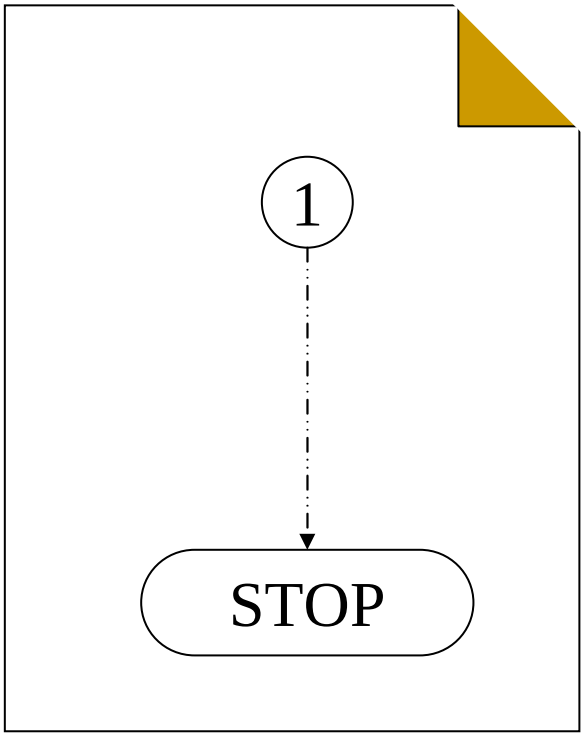
SYMBOL	NAME	APPLICATION
	Terminal	Shows the beginning or end of an algorithm
	Flow Lines	Show the action order in an algorithm
	Connector	Shows the continuity of the algorithm on the next page

START and STOP



Connectors





Sequence Symbols

Assignment statement

Input/output statement

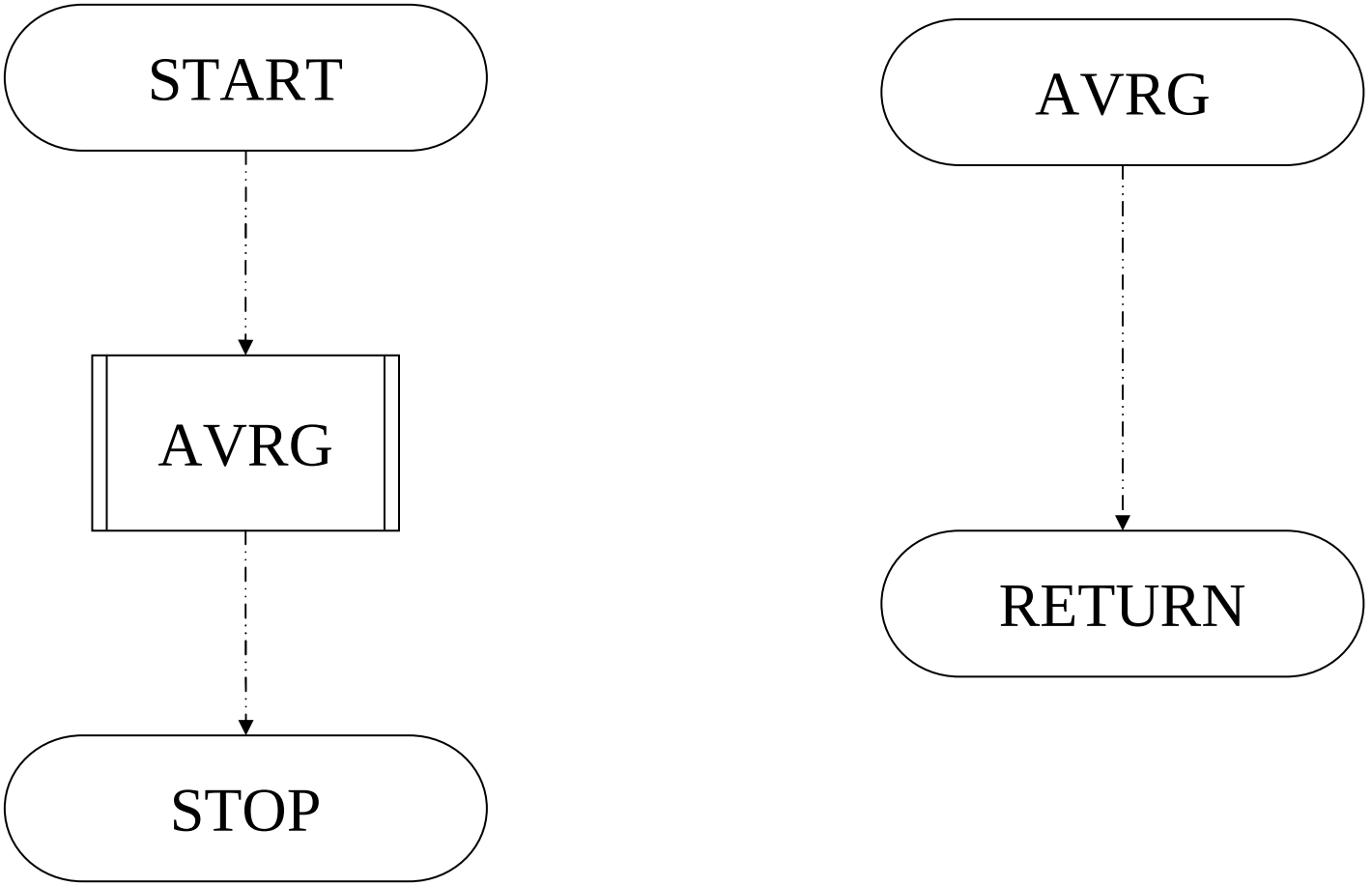
Module call

Compound statement

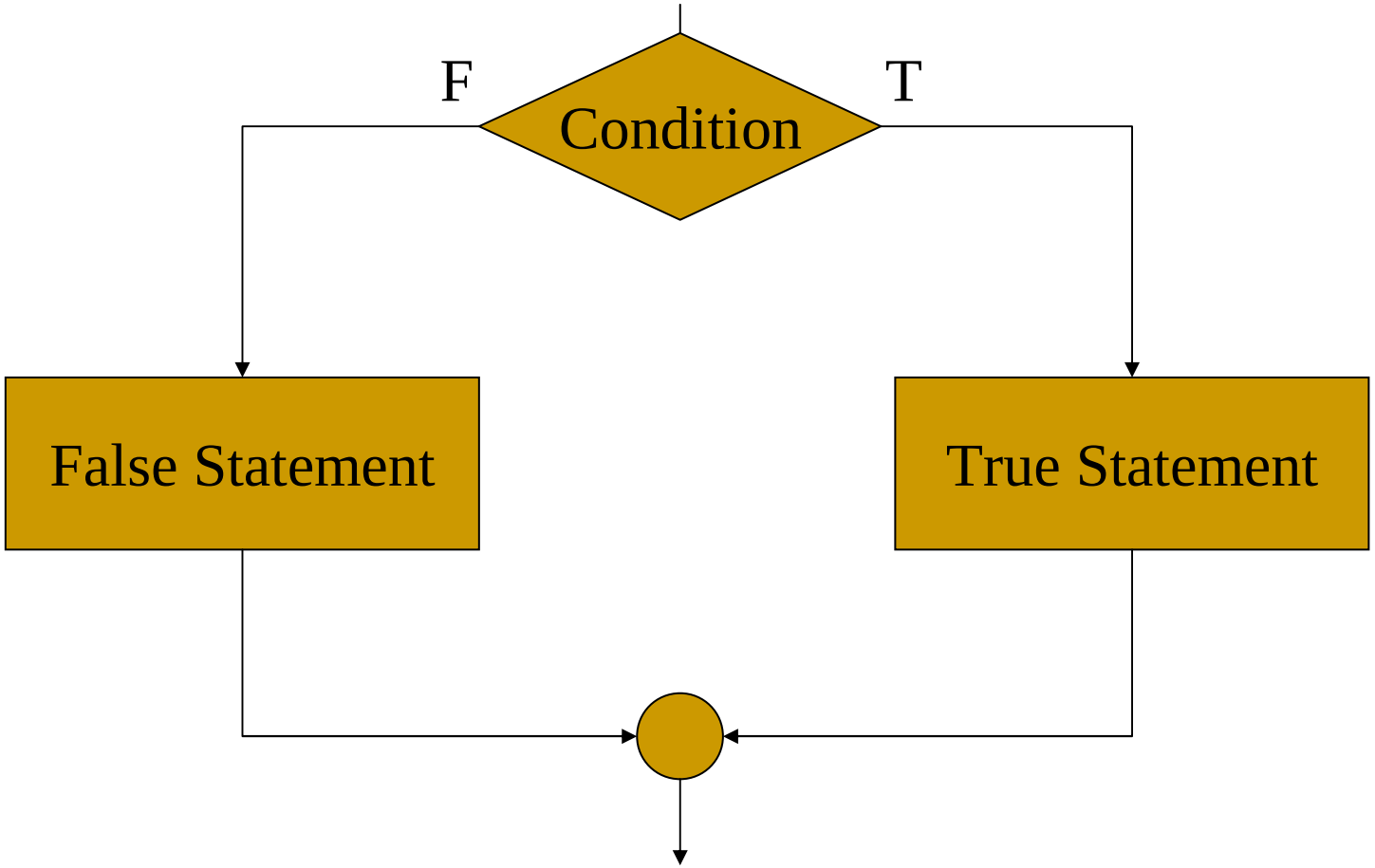
Assignment statement

variable ← expression

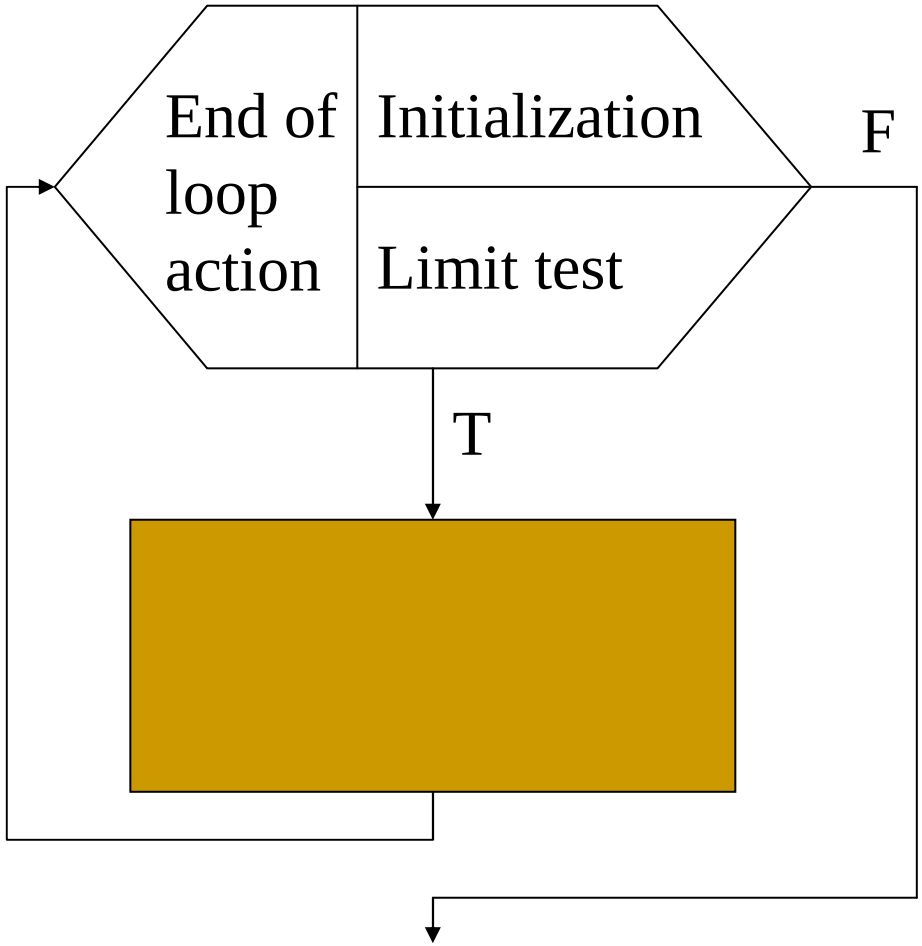
Module-Call Statement



Two-Way Selection

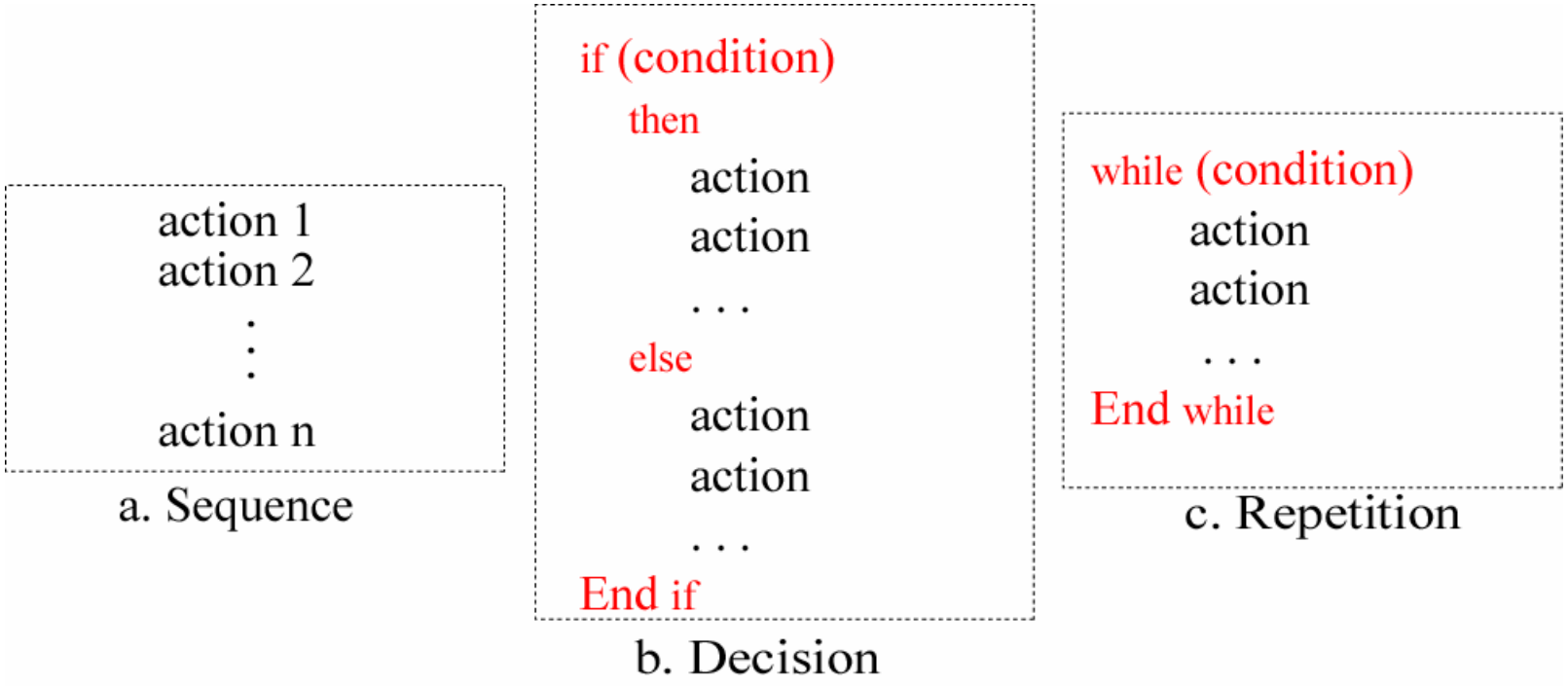


for Loop



Pseudocode for three constructs

- Pseudocode is an Englishlike representation of an algorithm.



Example 1

Write an algorithm in pseudocode that finds the average of two numbers

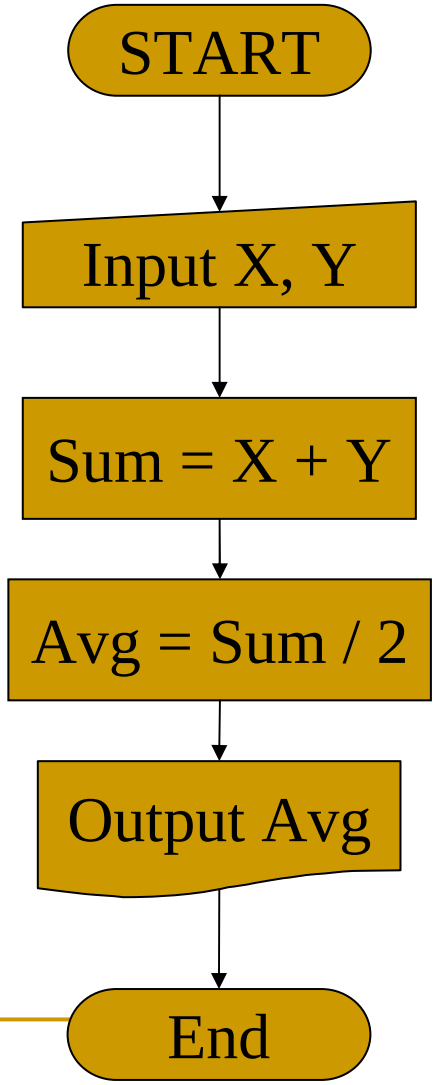
Solution

See Algorithm 8.1 on the next slide.

Algorithm 8.1: Average of two

AverageOfTwo
Input: Two numbers
1. **Add the two numbers**
2. **Divide the result by 2**
3. **Return the result of Step 2**

End



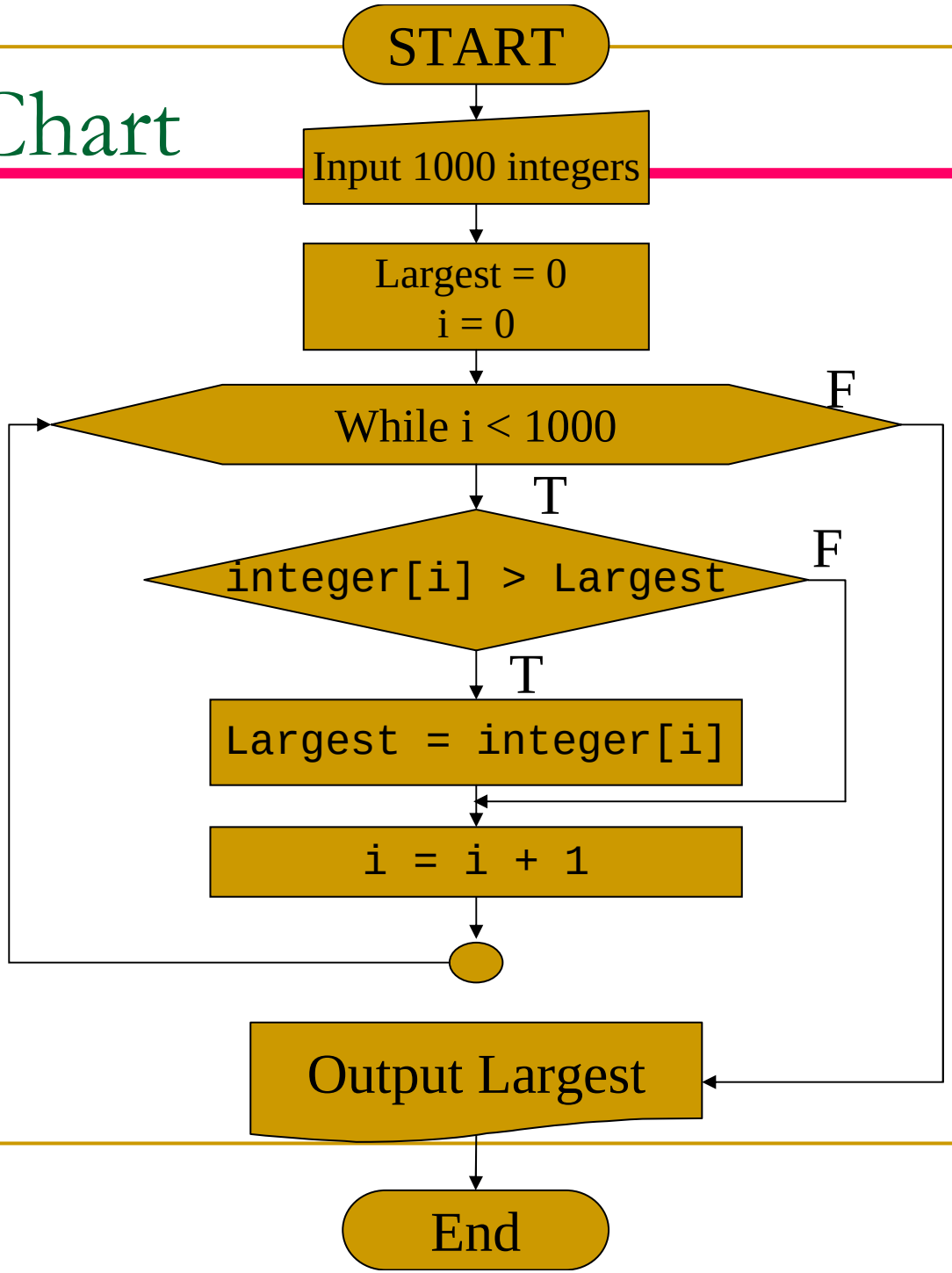
Example 5

Write an algorithm to find the largest of 1000 numbers.

Solution

See Algorithm 8.5 on the next slides.

Flow Chart


START
Input 1000 integers
Largest = 0
i = 0
While i < 1000
F
T
integer[i] > Largest
F
T
Largest = integer[i]
i = i + 1
Output Largest
End

Algorithm 8.5: *Find largest of 1000 numbers*

```
FindLargest
Input: 1000 positive integers
1. Set Largest to 0
2. Set Counter to 0
3. while (Counter less than 1000)
    3.1  if (the integer is greater than Largest)
              then
                 3.1.1  Set Largest to the value of the integer
            End if
     3.2  Increment Counter
   End while
4. Return Largest
   End
```

8.4 MORE FORMAL DEFINITION

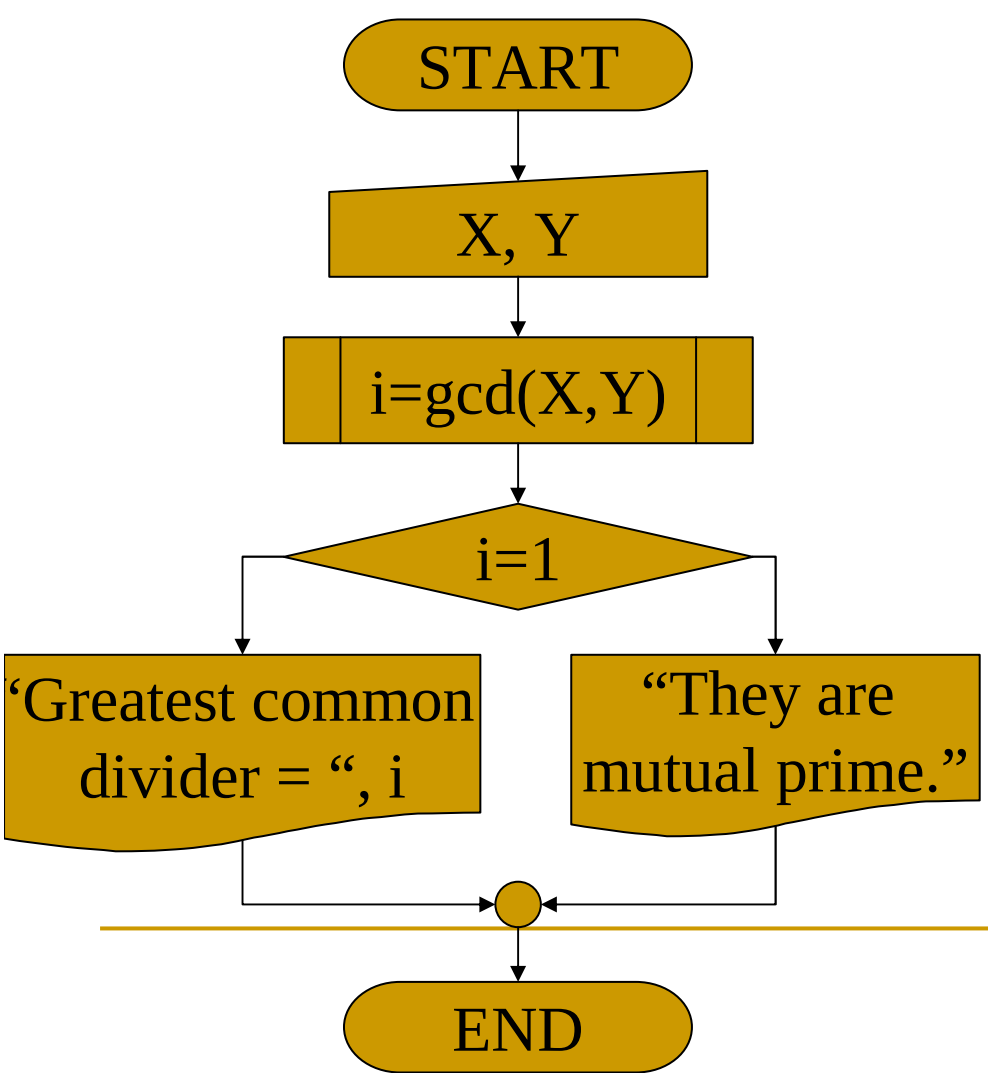
Formally, an algorithm is an ordered set of unambiguous steps that produces a result and terminates in a finite time.

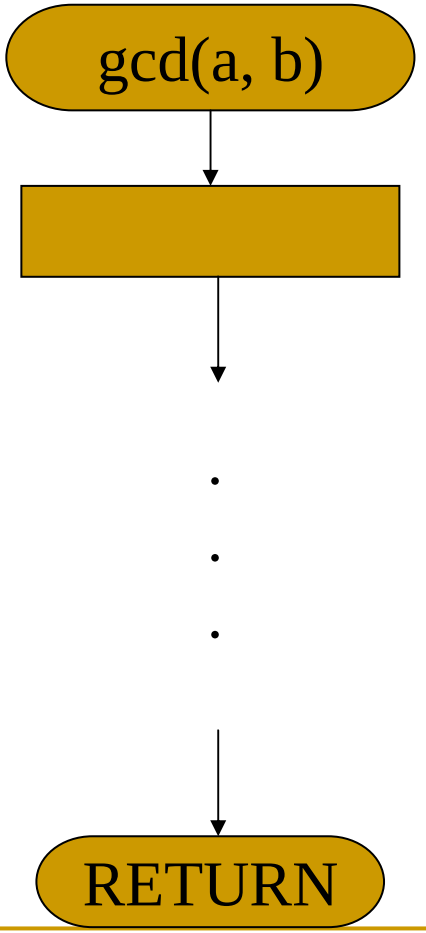
8.5

SUBALGORITHMS

Concept of a subalgorithm

- An algorithm can be broken into smaller units called subalgorithms.

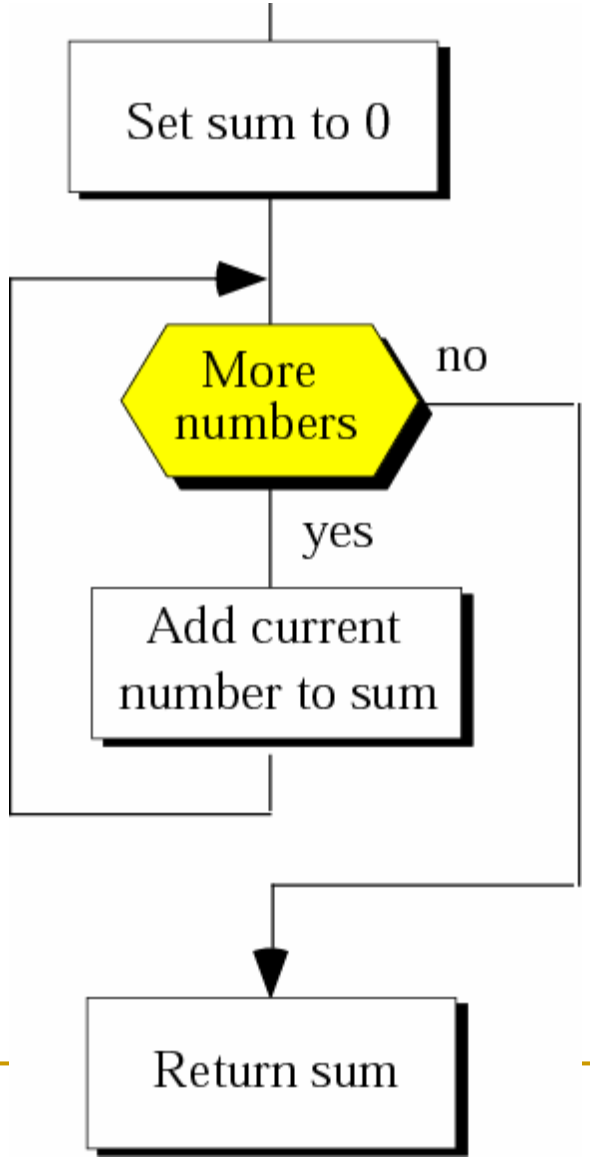




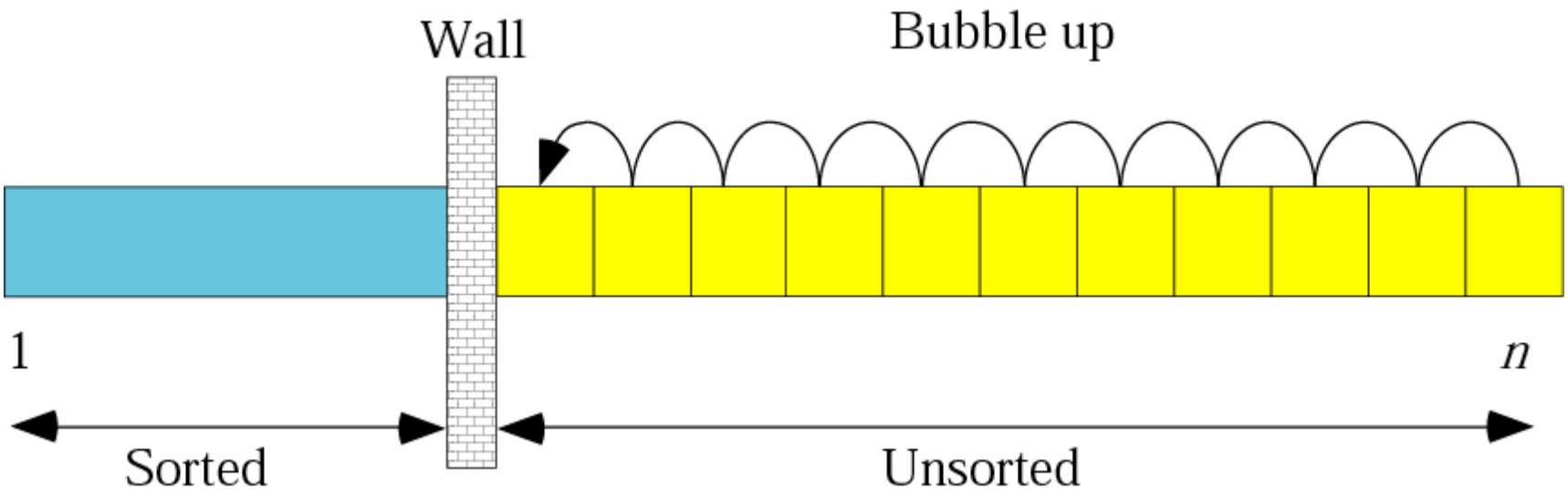
8.6

BASIC ALGORITHMS

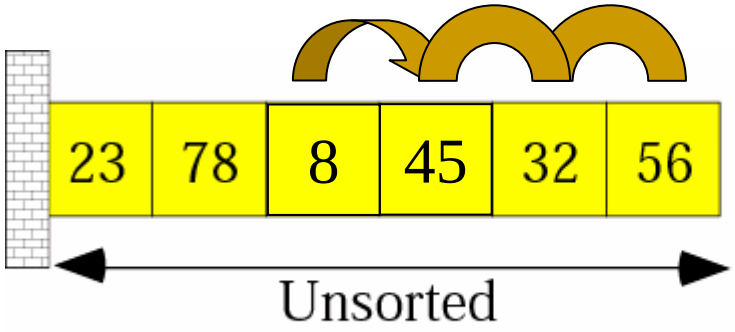
Summation


Set sum to 0
More numbers
no
yes
Add current number to sum
Return sum

Bubble sort

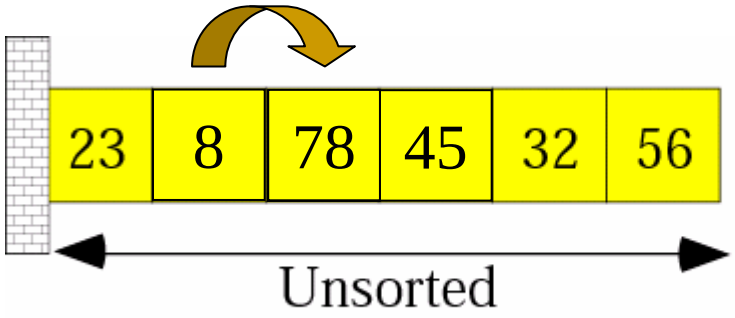


Example of bubble sort



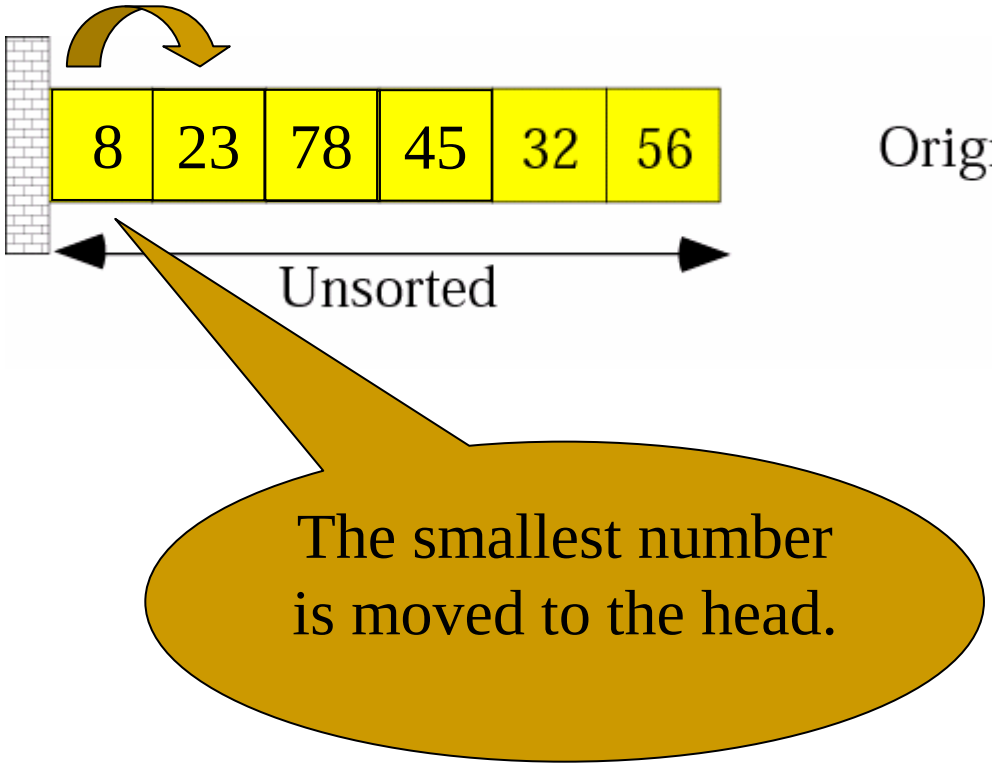
Original list

Example of bubble sort

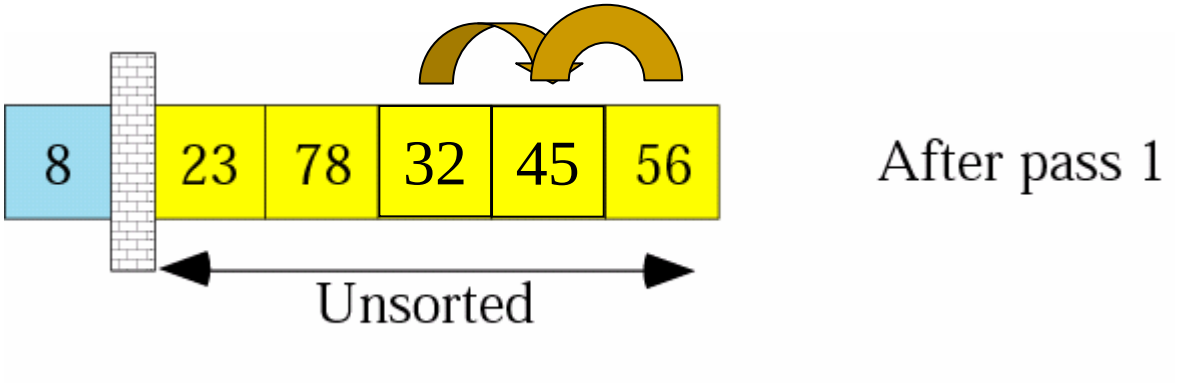


Original list

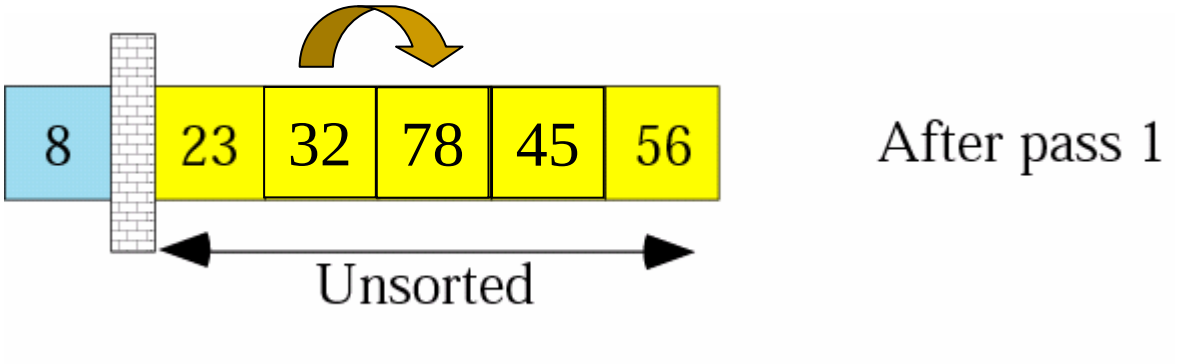
Example of bubble sort



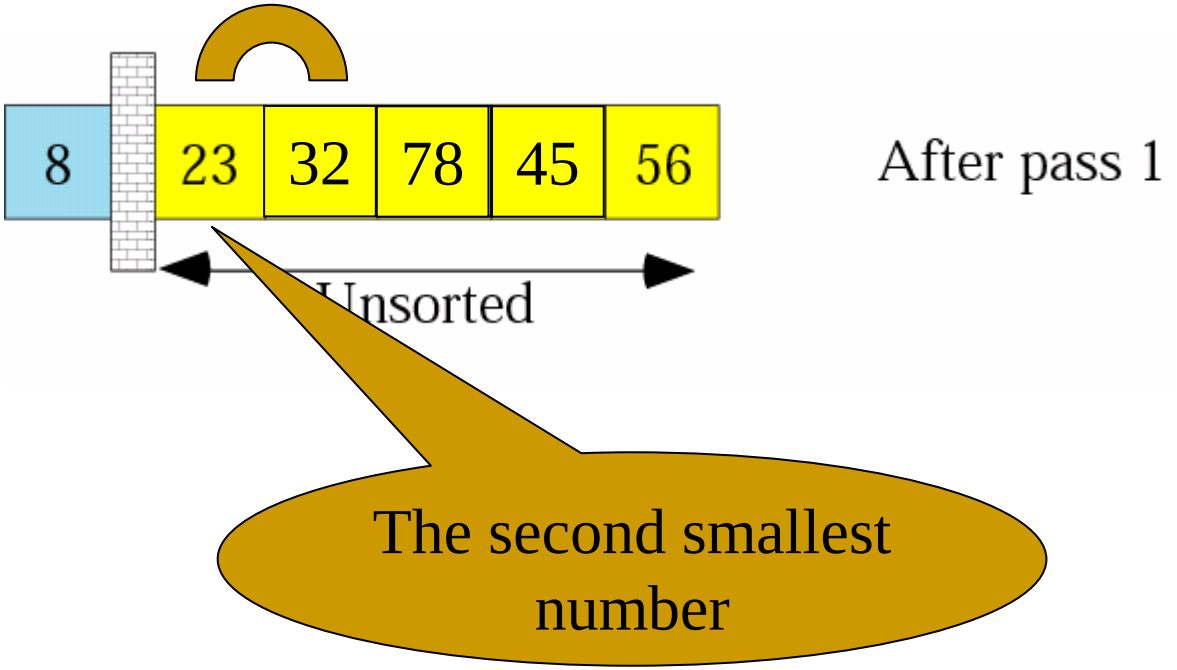
Example of bubble sort



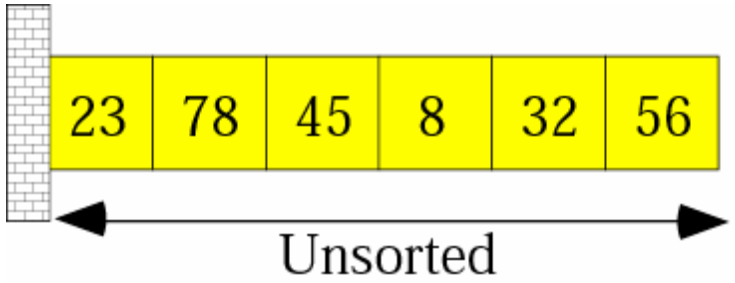
Example of bubble sort



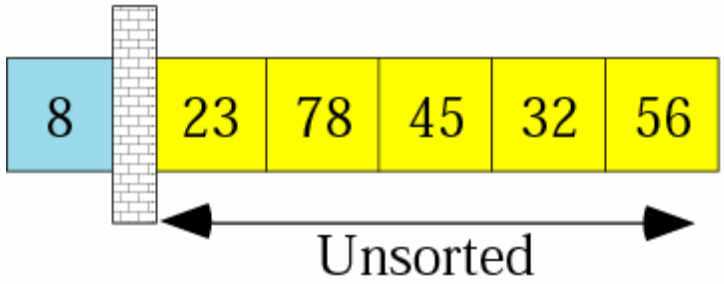
Example of bubble sort



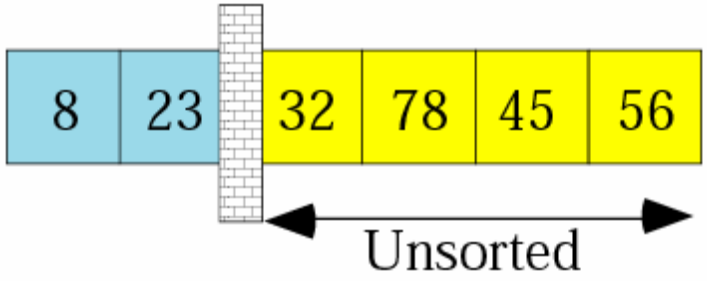
Example of bubble sort



Original list

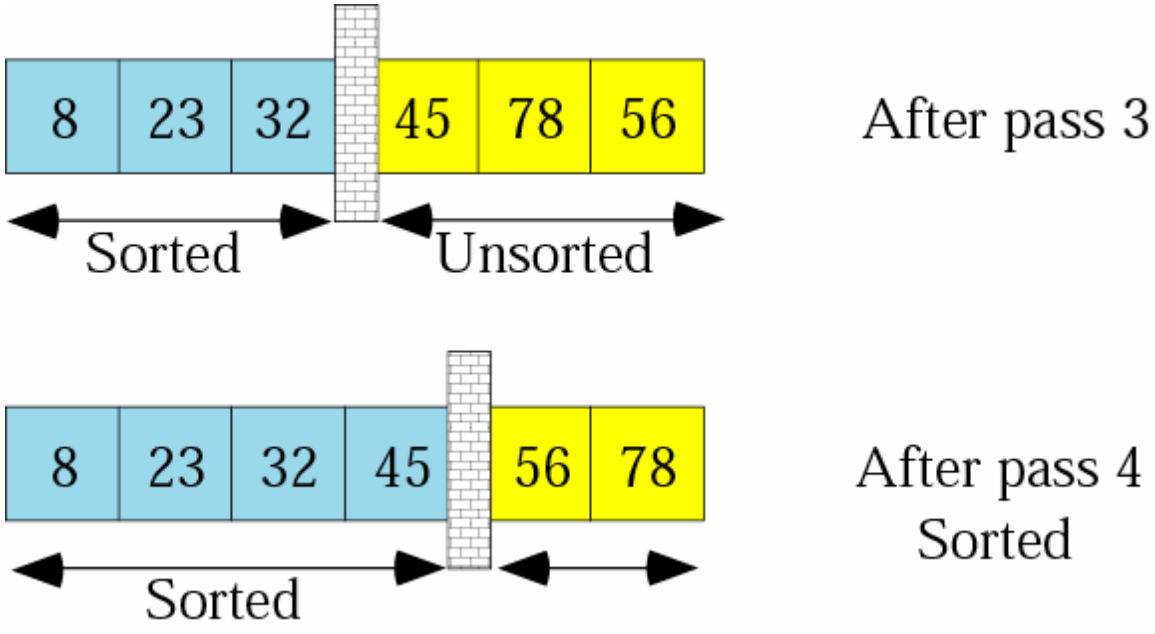


After pass 1



After pass 2

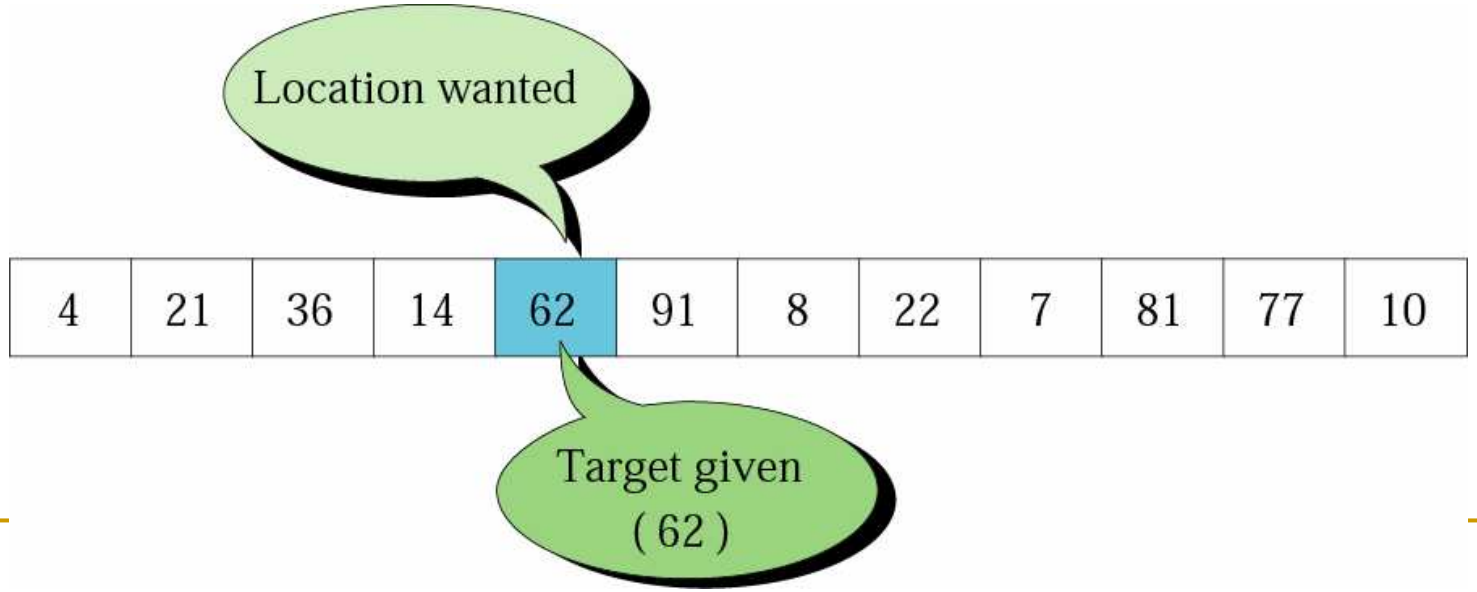
Example of bubble sort



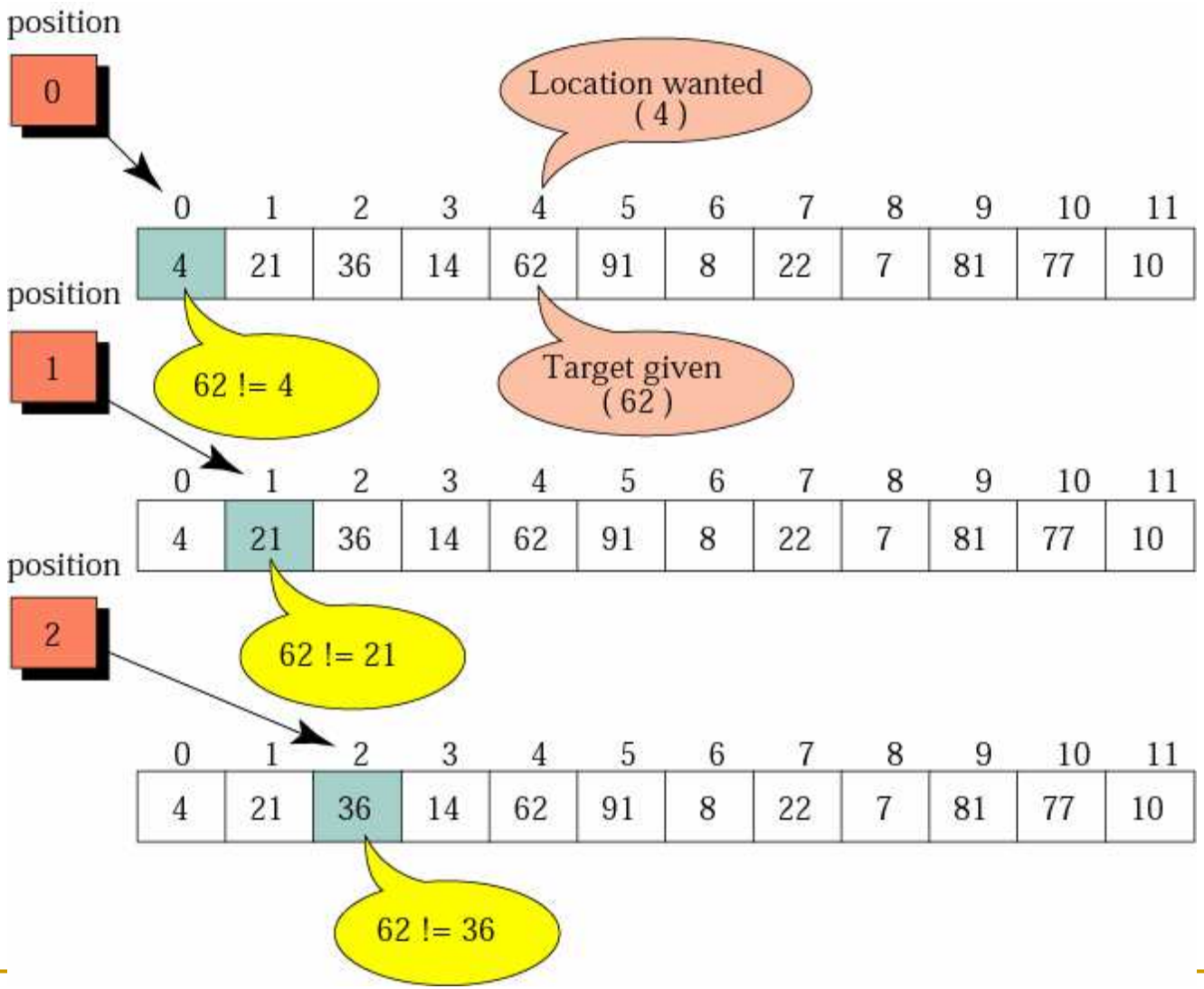
And so on …

Search concept

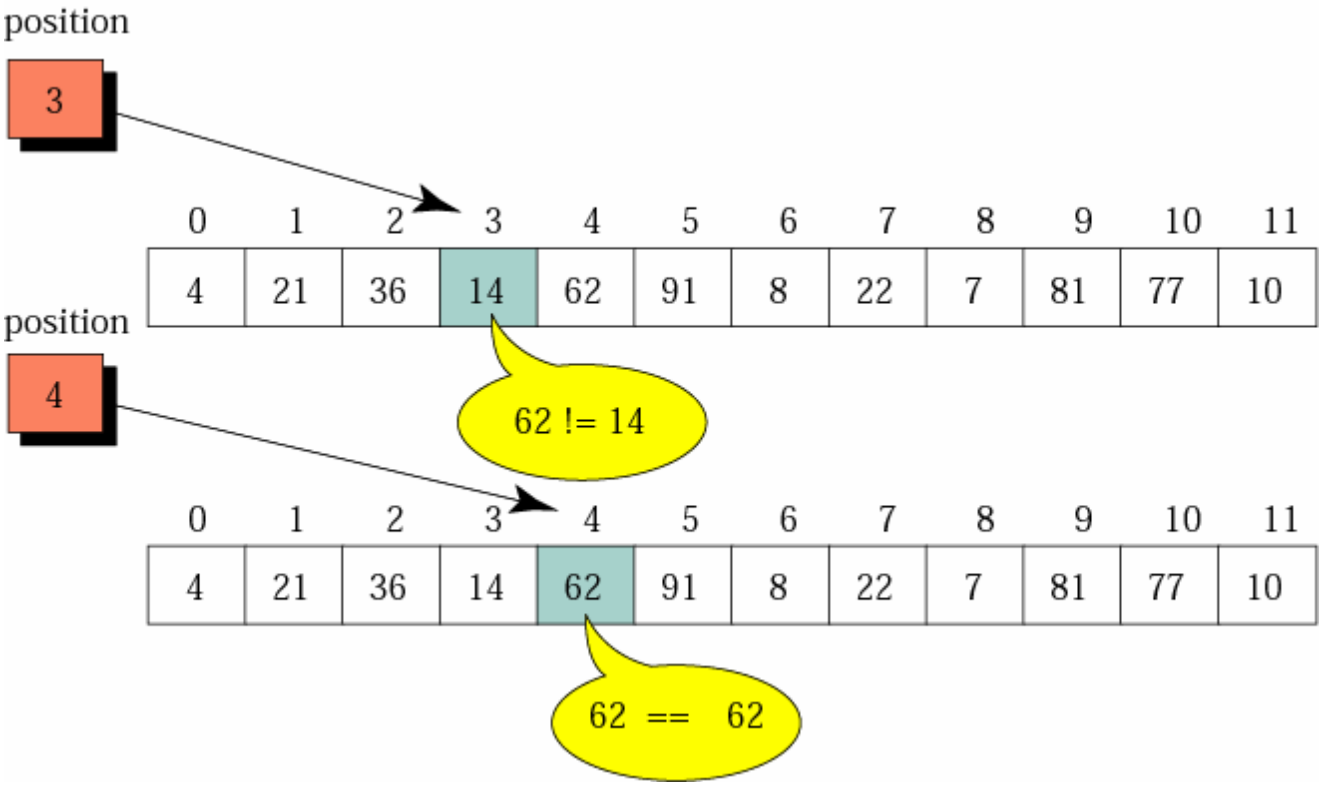
- Searching, a process to locate a target in a list of data, is a basic algorithm.
- Sequential search is used for unordered lists.
- Binary search is used for ordered lists.



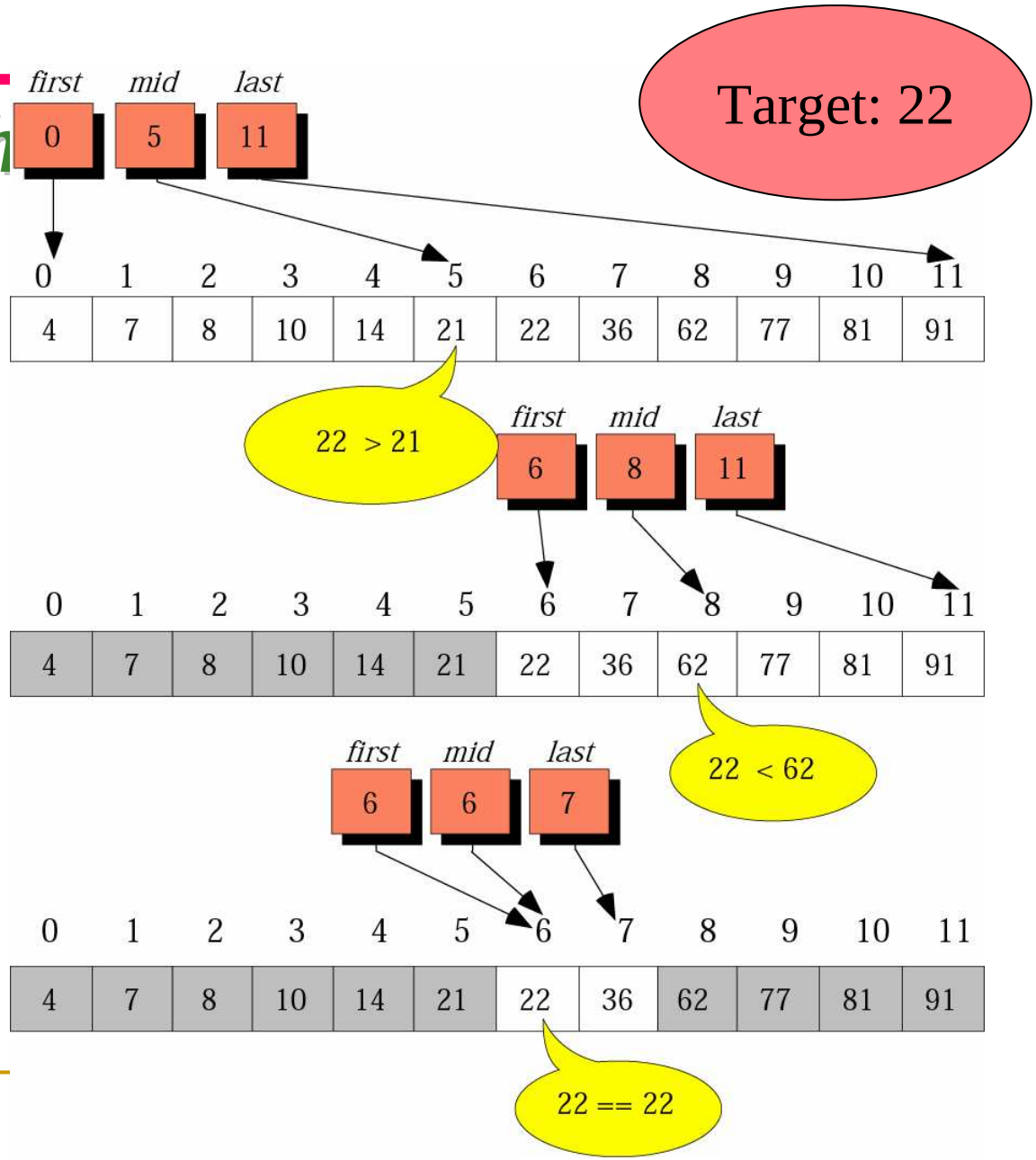
Example of a sequential search



Example of a sequential search



Example of a binary search

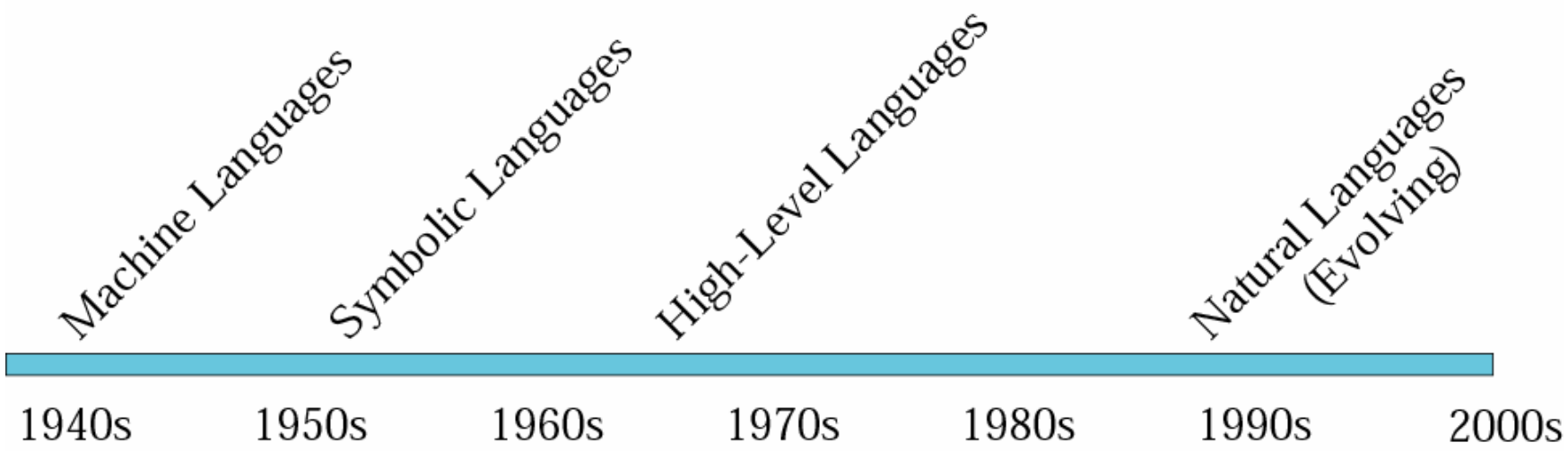


Chapter 9: Programming Languages

9.1

EVOLUTION

Evolution of computer languages



Program 9.1 Program in machine language

1	00000000	00000100	0000000000000000	
2	01011110	00001100	11000010	0000000000000010
3		11101111	00010110	0000000000000101
4		11101111	10011110	0000000000001011
5	11111000	10101101	11011111	0000000000010010
6		01100010	11011111	0000000000010101
7	11101111	00000010	11111011	0000000000010111
8	11110100	10101101	11011111	0000000000011110
9	00000011	10100010	11011111	0000000000100001
10	11101111	00000010	11111011	0000000000100100
11	01111110	11110100	10101101	
12	11111000	10101110	11000101	0000000000101011
13	00000110	10100010	11111011	0000000000110001
14	11101111	00000010	11111011	0000000000110100
15			00000100	0000000000111101
16			00000100	0000000000111101

The only language understood by a computer is machine language.

Evolution of computer languages

- A symbolic language uses symbols to represent various machine language instructions. Symbolic languages are also called assembly languages.
- A high-level language is portable from one computer type to another and free the programmer from one computer type to another and frees the programmer from hardware concerns. BASIC, Pascal, Ada, C, C++, and Java are high-level languages.
- Natural language

Program 9.2 Program in symbolic language

```
1    Entry     main,     ^m<r2>
2    subl2     #12,sp
3    jsb       C$MAIN_ARGS
4    movab     $CHAR_STRING_CON
5
6    pushal    -8(fp)
7    pushal     (r2)
8    calls     #2,read
9    pushal    -12(fp)
10   pushal    3(r2)
11   calls     #2,read
12   mull3     -8(fp),-12(fp),-
13   pushal     6(r2)
14   calls      #2,print
15   clrl       r0
16   ret
```

Program 9.3 Program in C++ language

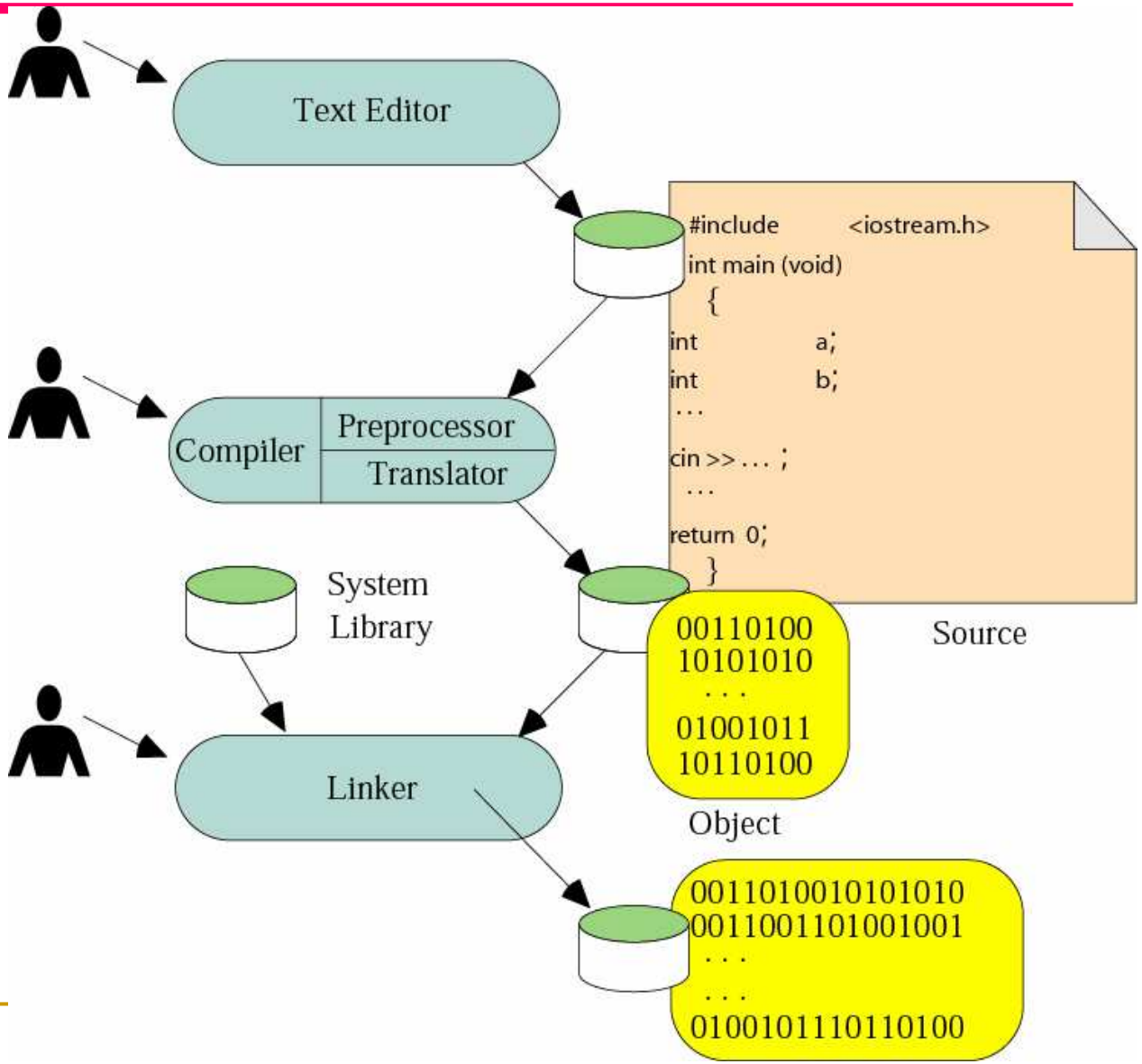
```
1   /*     This program reads two integer numbers from the
2          keyboard and prints their product.
3   */
4   #include <iostream.h>
5
6   int main (void)
7   {
8   //     Local Declarations
9          int number1;
10         int number2;
11         int result;
12  //     Statements
13         cin >> number1;
14         cin >> number2;
15         result = number1 * number2;
16         cout << result;
17         return 0;
18  }      // main
```

9.2

BUILDING A PROGRAM

Building a program

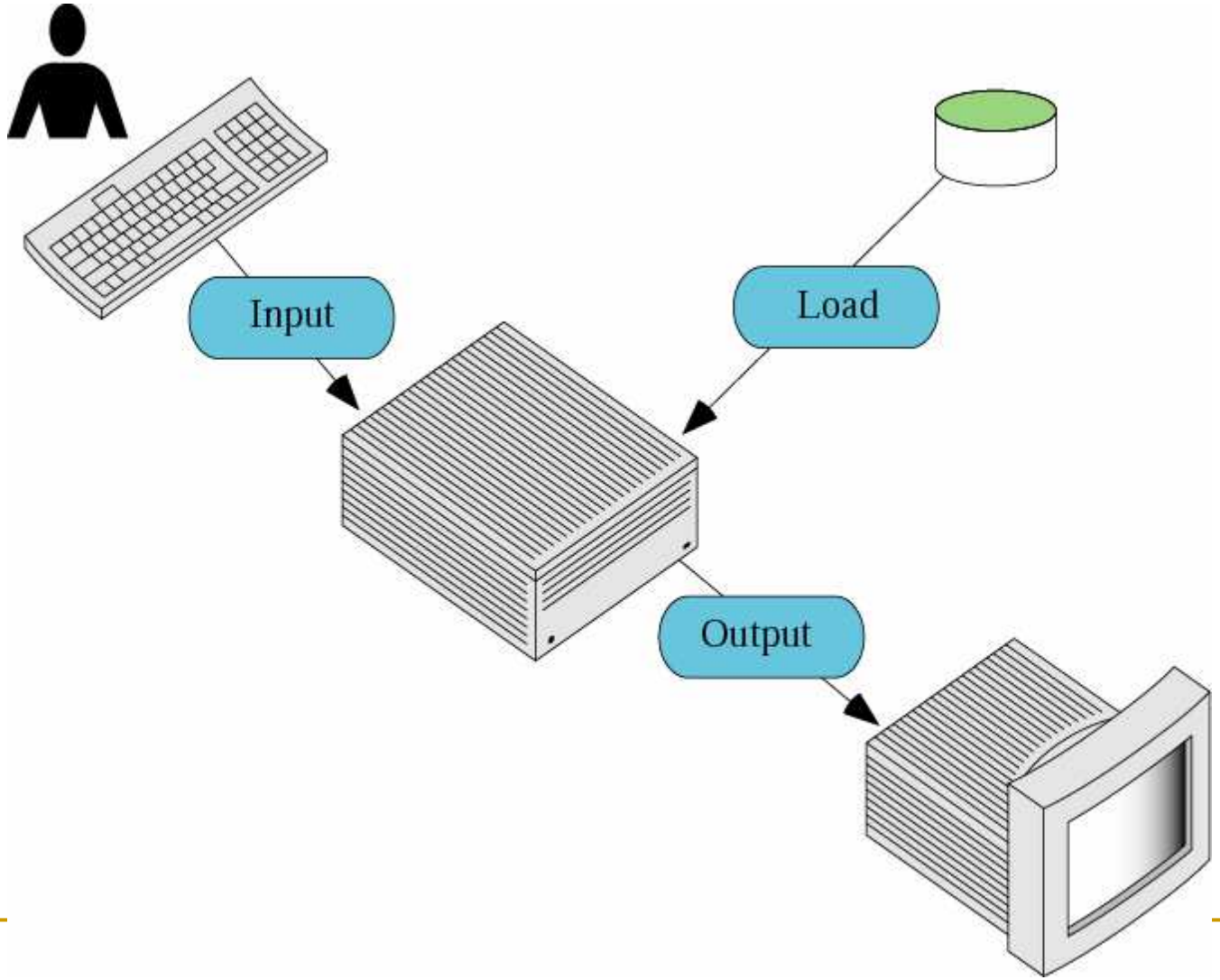
- The steps to building a program include writing, editing, compiling, and linking code.



9.3

PROGRAM EXECUTION

Program execution



Mid-Term Exam

- Date: 10/29 (Wednesday)
- Time: 14:10-17:00
- Scope: Chapter 1,2,3,4,5,8,9
- Close Book
  - You have seen all the English vocabularies in the textbook or the homework, so do not ask the TA to explain the questions.