What is a “Better” Program?

C++ Object Oriented Programming

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軟體的特性

- 軟體之所謂軟...因為沒有“硬性”不可變、不可挑戰的規則
  - 好處: 彈性很大, 山不轉路轉, 沒有標準答案, 正常運作就好...
  - 壞處: 很多小問題合在一起不斷放大, 到處藏污納垢, 沒有標準答案, 不知道到底對了沒有
- 解決方法
  - **Coding styles**
  - test-driven
  - 元件化
  - 模型化 (資料結構, 演算法, 物件化, 軟體模式)

Source Code is the Primary Document

- Jack Reeves, C++ Journal, 1992, "What is Software Design?"

  > "After reviewing the software development life cycle as I understood it, I concluded that the only software **documentation** that actually seems to satisfy the criteria of an engineering design is the **source code listings**."

- The **design** of a software project is an abstract concept:
  - It has to do with the overall shape and structure of the program as well as the detailed shape and structure of each module, class, and method.
  - It can be represented by many different diagrams and media, but its final embodiment is the source code.
- **Source code is the design**

Goals

- ✧ 透過一些基本的編碼規則，我們可以寫出一個“好”一點的 C 程式
- ✧ 除了正確性之外，程式短一點?? 執行快一點???
- ✧ “好” ?　　(in terms of test, debug, review, and extension)
  1. 容易了解，沒有邏輯上不緊密結合的資料變數或是敘述
  2. Self-explaining
  3. 和觀念上的運作模型一致
  4. 容易修改，不容易改錯
  5. 沒有容易錯誤的語法
- ✧ 正確性無關：以下給你一個很簡單的例子，共有七個版本，執行結果都是正確的

Version 1

```
#include <stdio.h>

void main()
{
    int d[] = {12, 3, 37, 8, 24, 15, 5, 33};
    int n = 8;
    int *d1, *d2;
    int *p;
    int *e;

    d1 = d;
    d2 = d+n;
    while (d1<d2)
    {
        p = d1;
        e = d1 + 1;
        while (e<d2)
        {
            if (*e<*p) p = e;
            e++;
        }
        n = *p;
        *p = *d1;
        *d1 = n;
        d1++;
    }
    printf("Sorted data:\n");
    d1 = d;
    while (d1<d2)
        printf(" %d", *d1++);
    printf("\n");
}
```

Execution Results

```
Sorted data:
    3  5  8  12  15  24  33  37
```

由小至大按順序排列

What is this program doing?

Initial view

- ✧ Input array initialized with unordered integers
- ✧ Two layers of while loops
- ✧ Some pointers to the elements of the array
- ✧ Another while loop for output the results

Don’t like it!!??

- ✧ Pointers
- ✧ Generic while loops
- ✧ Variable names (identifier means nothing)
- ✧ Deep control structures
- ✧ Looks like a snippet of low level assembly instructions

Remove Unnecessary Pointers

- Pointers are sophisticated and sometimes inevitable, but not always.
- In the case of accessing memory blocks, pointers are extraneous, use array whenever possible.
- Array has much better semantic meaning than the generic pointer dereferencing.

```
int array[100];
int *ptr=array;
int i, sum = 0;
…
for (i=0; i<100; i++)
   sum += *ptr++;
```

```
int array[100];
int i;
int sum = 0;
…
for (i=0; i<100; i++)
   sum += array[i];
```

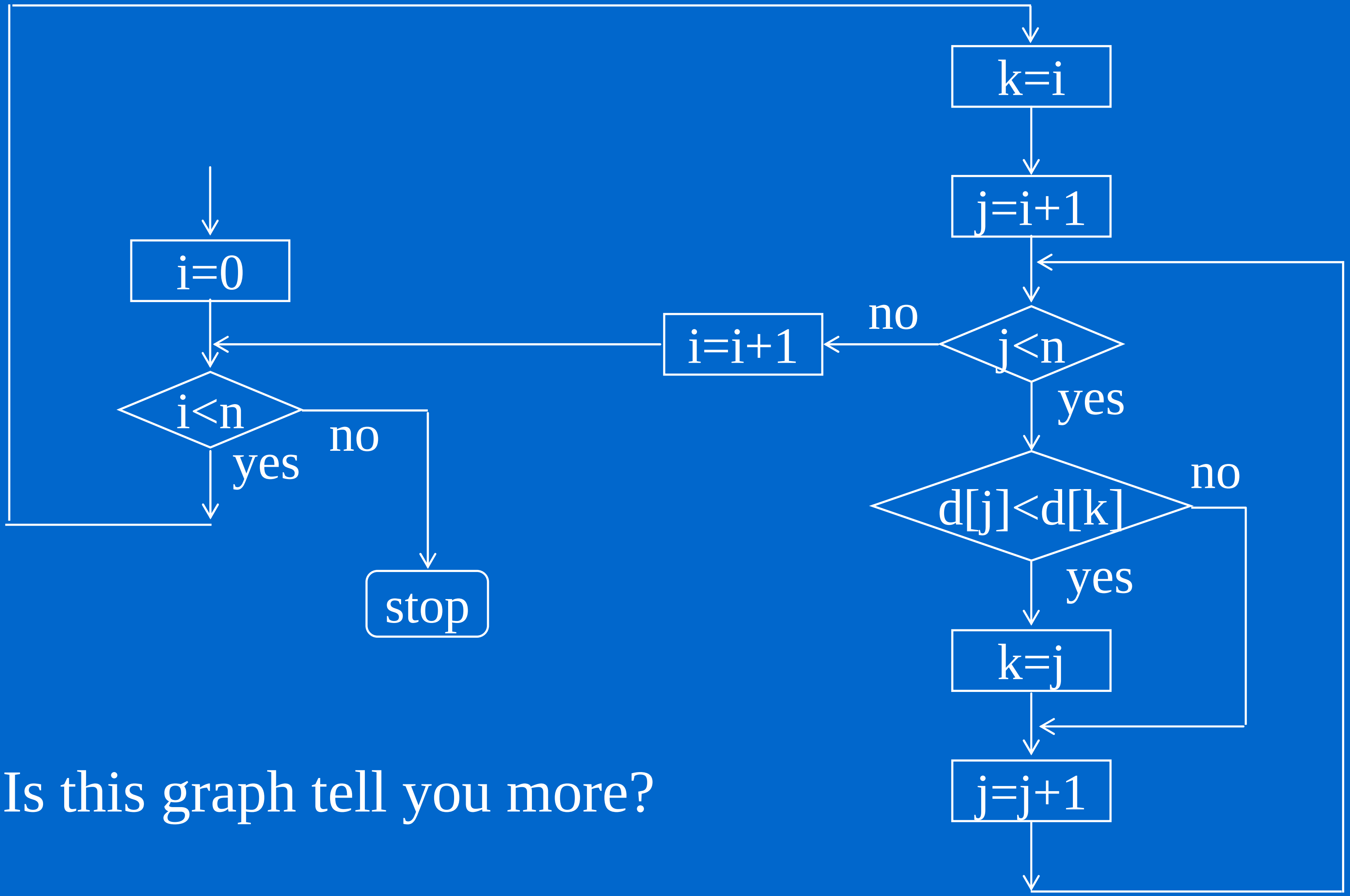
Version 2

```
#include <stdio.h>

void main()
{
    int d[] = {12, 3, 37, 8, 24, 15, 5, 33};
    int n = 8;
    int i, j, k;

    i = 0;
    while (i<n)
    {
        k = i;
        j = i + 1;
        while (j<n)
        {
            if (d[j]<d[k]) k = j;
            j = j + 1;
        }
        j = d[k];
        d[k] = d[i];
        d[i] = j;
        i = i + 1;
    }
    printf("Sorted data:\n");
    i = 0;
    while (i<n)
    {
        printf(" %d", d[i]);
        i = i + 1;
    }
    printf("\n");
}
```

Flowchart of the Program



Is this graph tell you more?

Meaningful Identifiers

- A program is composed with a language. Just like any language in your daily life, language itself should **tell good stories** when used properly.

- Why does the version 1 or version 2 program look like gibberish to a well trained programmer?

- Are the **identifiers** used meaningful??
  e.g.

  Hw ds Jhn lk th stk?

  or

  How does John like the steak?

Version 3

```
#include <stdio.h>

void main()
{
    int data[] = {12, 3, 37, 8, 24, 15, 5, 33};
    int ndata = sizeof(data) / sizeof(int);
    int i, j;
    int min;
    int swapTmp;

    i = 0;
    while (i<ndata)
    {
        min = i;
        j = i + 1;
        while (j<ndata)
        {
            if (data[j]<data[min]) min = j;
            j = j + 1;
        }
        swapTmp = data[min];
        data[min] = data[i];
        data[i] = swapTmp;
        i = i + 1;
    }

    printf("Sorted data:\n");
    i = 0;
    while (i<ndata)
    {
        printf(" %d", data[i]);
        i = i + 1;
    }
    printf("\n");
}
```

avoid magic constants

Advanced View of the Codes

Initial view

- Input array initialized with unordered integers
- Two layers of while loops
- Some pointers to the elements of the array
- Another while loop for output the results

Is it changing?

- Input array initialized with unordered integers
- Two layers of while loops, the outer one prepares ndata sub-arrays, the inner one goes through each sub-array to find something minimum
- A snippet of memory swapping code
- Another while loop for output the results

More Meaningful Language Construct

- While loop is the most generic repetition construct in C language

```
initialize the loop condition (let’s not even think of goto)
while (condition)
{
    …
}
```

  the condition might change inside the loop

- When you see this construct in a program, you expect some sort of job repetition, maybe an easy one or a complex one.
- For loop is a more semantically specific repetition construct in C language --- repeat for a predetermined number of times

```
for (i=0; i<count; i++)
{
    …
}
```

Version 4

```c
#include <stdio.h>

void main()
{
    int data[] = {12, 3, 37, 8, 24, 15, 5, 33};
    int ndata = sizeof(data) / sizeof(int);
    int i, j;
    int min;
    int swapTmp;

    for (i=0; i<ndata; i++)
    {
        min = i;
        for (j=i+1; j<ndata; j++)
        {
            if (data[j]<data[min]) min = j;
        }
        swapTmp = data[min];
        data[min] = data[i];
        data[i] = swapTmp;
    }

    printf("Sorted data:\n");
    for (i=0; i<ndata; i++)
        printf(" %d", data[i]);
    printf("\n");
}
```

Code That Further Illustrates Itself

- ✧ **Function** is a powerful construct to **abstract** ideas, not just a utility for saving your typing time or some sacred code-reuse purpose.

  --- Version 5

- ✧ Construct of **“loop inside a loop”** is somehow beyond the concrete control of human mind. A single layer of “loop” is better for most people to visualize in mind.

  --- Version 6

Version 5

```
#include <stdio.h>

void swap(int *, int *);
void printArrayContents(int [], int);

void main()
{
    int data[] = {12, 3, 37, 8, 24, 15, 5, 33};
    int ndata = sizeof(data) / sizeof(int);
    int i, j;
    int min;

    for (i=0; i<ndata; i++)
    {
        min = i;
        for (j=i+1; j<ndata; j++)
        {
            if (data[j]<data[min]) min = j;
        }
        swap(&data[i], &data[min]);
    }

    printArrayContents(data, ndata);
}

void swap(int *x, int *y)
{
    int tmp;
    tmp = *x;
    *x = *y;
    *y = tmp;
}
```

Version 5 (cont’d)

```

void printArrayContents(int data[], int ndata)
{
    int i;
    printf("Sorted data:\n");
    for (i=0; i<ndata; i++)
        printf(" %d", data[i]);
    printf("\n");
}
```

Version 6

```
#include <stdio.h>

void selectionSort(int[], int);
void findMinimumOfAnArray(int[], int);
void swap(int*, int*);
void printArrayContents(int[], int);

void main()
{
    int data[] = {12, 3, 37, 8, 24, 15, 5, 33};
    int ndata = sizeof(data) / sizeof(int);

    selectionSort(data, ndata);
    printArrayContents(data, ndata);
}

```

Version 6 (cont’d)

```
void selectionSort(int data[], int ndata)
{
    int i;
    for (i=0; i<ndata; i++)
        putMinimalElementInPlace(&data[i], ndata-i);
}

void putMinimalElementInPlace(int data[], int ndata)
{
    int i, min;

    min = 0;
    for (i=1; i<ndata; i++)
    {
        if (data[i]<data[min]) min = i;
    }
    swap(&data[0], &data[min]);
}

```

suitable level of details

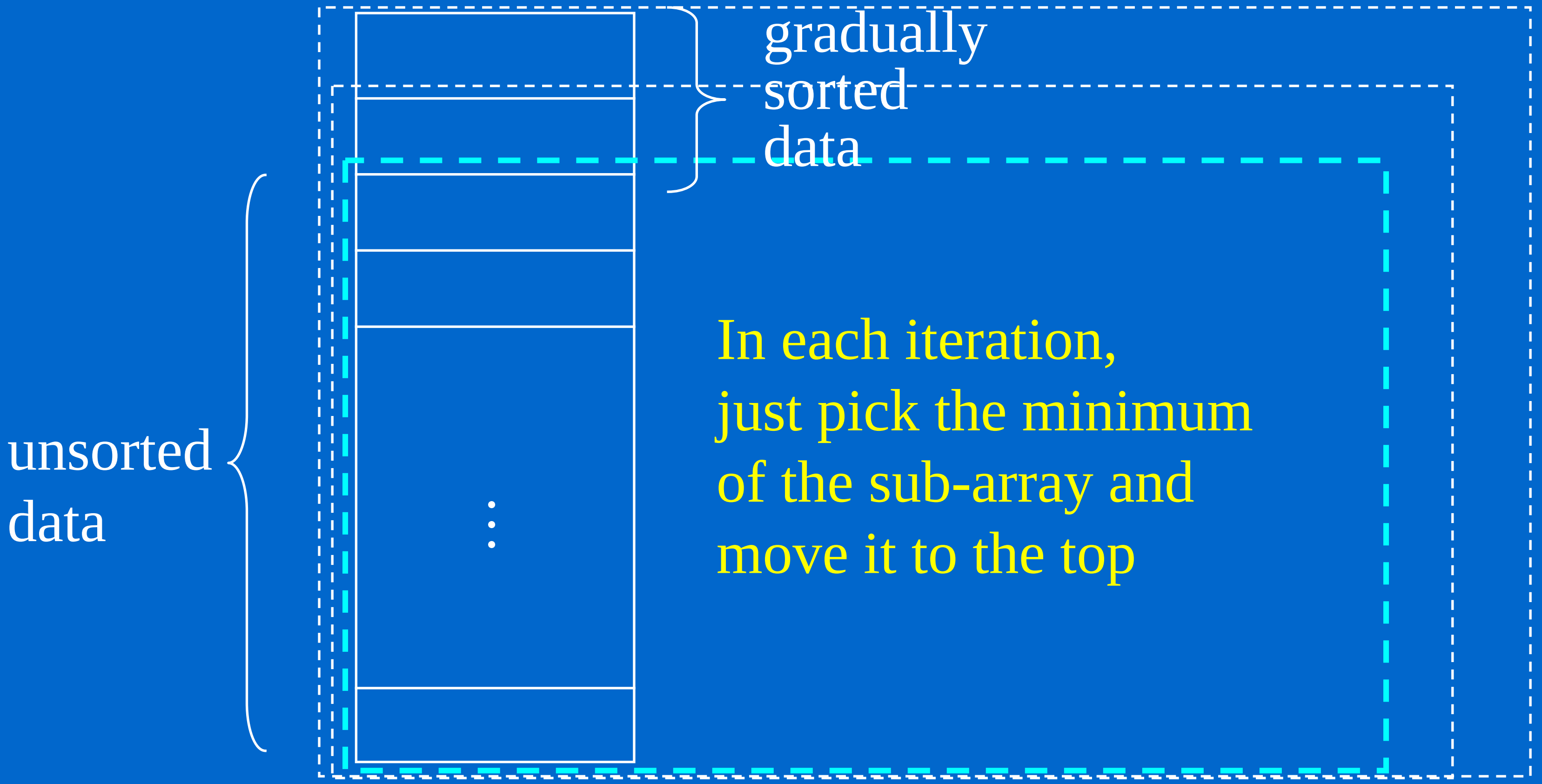
```
void swap(int *x, int *y)
{
    int tmp;
    tmp = *x;
    *x = *y;
    *y = tmp;
}

```

```
void printArrayContents(int data[], int ndata)
{
    int i;
    printf("Sorted data:\n");
    for (i=0; i<ndata; i++)
        printf(" %d", data[i]);
    printf("\n");
}
```

Codes with a Conceptual Model

- ✧ Flowchart is no longer needed but definitely requires a conceptual model for the codes to work with.



In each iteration, just pick the minimum of the sub-array and move it to the top

Who is responsible of this task?

- The programmer or the program reader?
- When we read the version 1 of this program, there were little clues in the codes that told us directly what the program is doing.
- Although we figure out that this is a piece of code that implements the selection sort algorithm at last, it should not take the original programmer too much effort to produce a code snippet like version 6 and its corresponding conceptual model which tell directly the story of what the program is doing.
- A piece of code is to implement some engineering design, **simplicity** is the best engineering principle. Try your best to think and express ideas in an intuitive way.

Recursive Version

- Recursive version is often the most expressive form of the underlying algorithm.

```
void selectionSort(int data[], int ndata)
{
    putMinimalElementInPlace(data, ndata);
    if (ndata>2)
        selectionSort(&data[1], ndata-1);
}
```

Efficiency Issues

- Using expressive name for all identifiers makes the program much lengthier, easier to have typos, slow in composing the program.
  - Harddisk is cheap. Not necessary to think of space.
  - It is easier for compiler to detect typo than using x, y, z.
  - Typing should not be the bottleneck.
  - Expressive programs are easier to compose, maintain, and extend.
- Excessive function calls take CPU time to transfer arguments and to branch the control.
  - Let the compiler worry about it --- use inline function.
- Using dedicated variables for independent tasks looks like abusing memories.
  - Let the compiler worry about it.
  - Lesser bugs is a far bigger concern.

Assignments

- ✧ Bubble Sort
- ✧ Quick Sort
- ✧ Minimum Spanning Tree
- ✧ Tree Traversal
- ✧ …