What is a “Better” Program?

C++ Object Oriented Programming

Pei-yih Ting

NTOU CS

軟體的特性

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    模型化 (資料結構, 演算法, 物件化, 設計樣版)

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正確性無關：接下來是一個很簡單的例子，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

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- ✧ Another while loop for output the results

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Don’t like it!!??

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- Generic while loops

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- ✧ Mysterious variable names (identifier means nothing)

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- Pointers
- Generic while loops
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- Deep control structures

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Don’t like it!!??

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Looks like a snippet of low level assembly instructions

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  Array syntax has much better semantic meaning than the generic **pointer dereferencing and arithmetics**.

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

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- In the case of **accessing memory blocks**, pointers are error prone, use array whenever possible.

  Array syntax has much better semantic meaning than the generic **pointer dereferencing and arithmetics**.

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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];
```

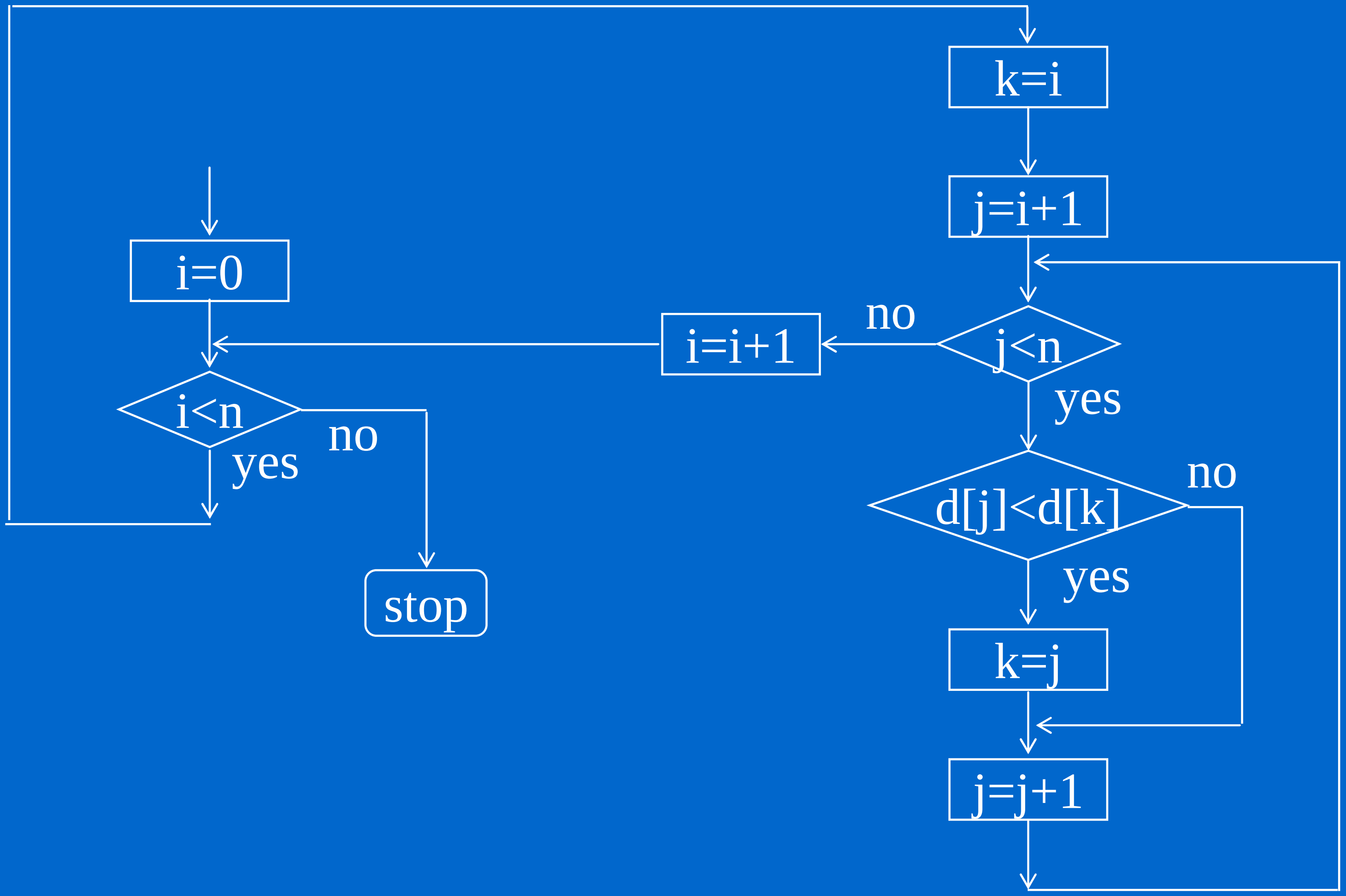
Version 2

```
#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



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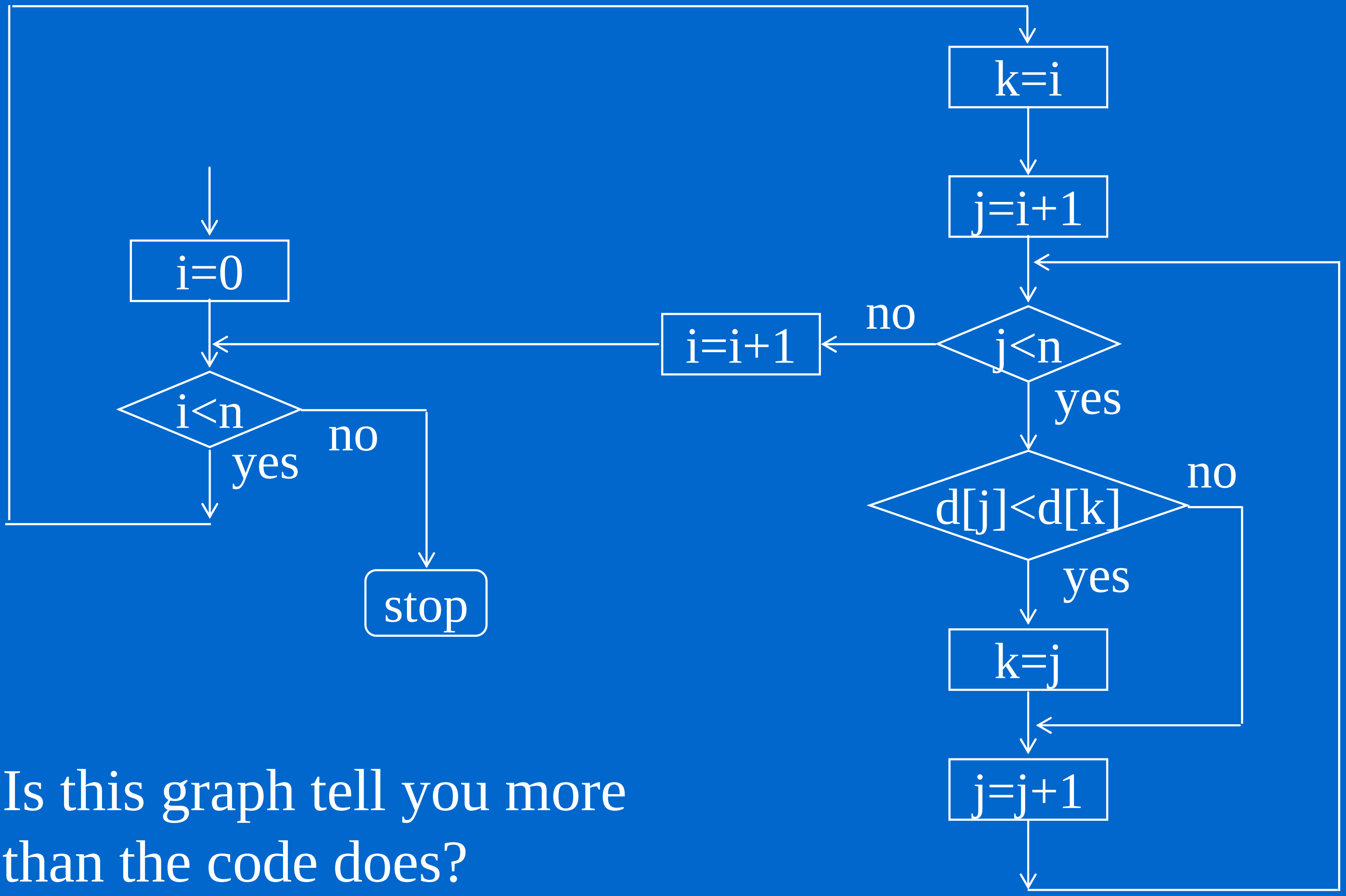

Is this graph tell you more than the code does?

Meaningful Identifiers

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

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

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");
}
```

Version 3

```c
#include <stdio.h>

void main()
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    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];
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    }

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

avoid magic constants

Advanced View of the Codes

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- 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 minimal.
- Another while loop for output the results

Advanced View of the Codes

Initial view

- Input array initialized with unordered integers
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- Some pointers to the elements of the array
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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 minimal.
- 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

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Forget about ***goto*** please!!!

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initialize the loop condition
while (condition)
{
   …
}
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  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

```
#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, to **hide** distracting details, not just a utility for saving your typing time and removing redundancy.

  --- Version 5

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- ✧ A construct like **“loop inside a loop”** is somehow beyond the concrete control of common 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)

suitable level of details

```
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]);
}

```

```
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");
}
```

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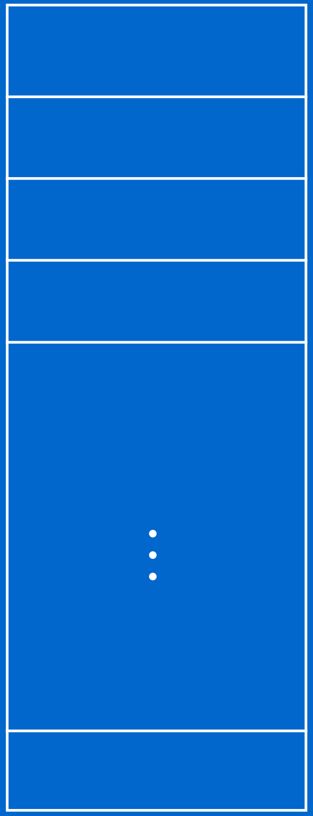

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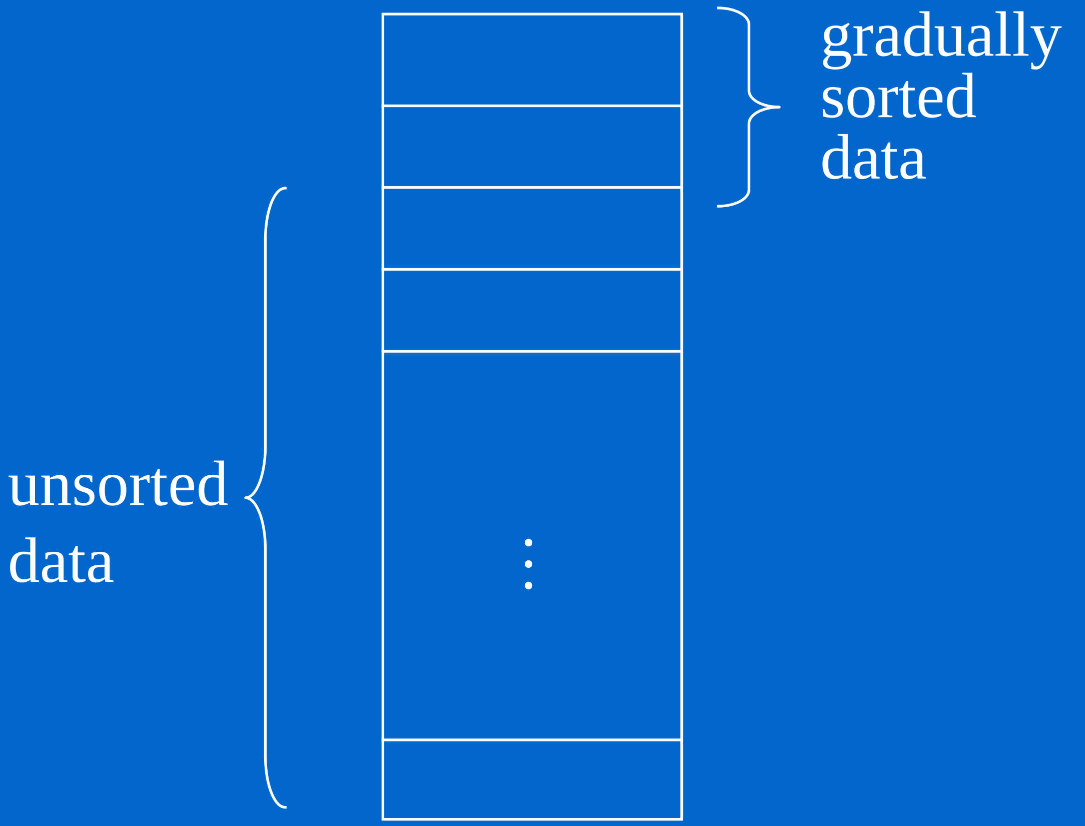

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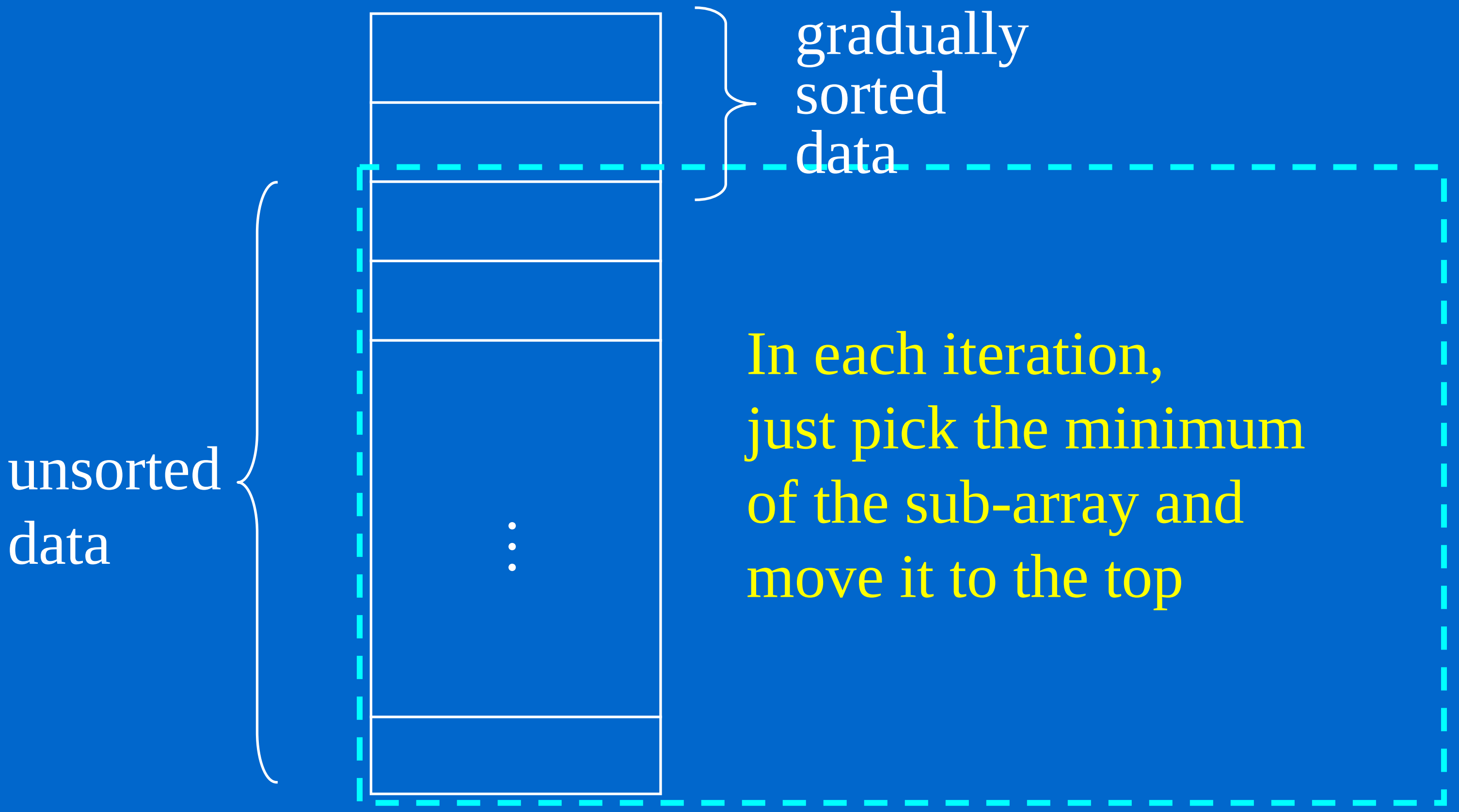

In each iteration, just pick the minimum of the sub-array and move it to the top

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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.

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

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Assignments

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