A "Better" Program from Engineers' point of view

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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, 可以寫得很短, 或是很有效率...
  - 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)

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

```
01 #include <stdio.h>
02
03 void main()
04 {
05     int d[] = {12, 3, 37, 8, 24, 15, 5, 33};
06     int n = 8;
07     int *d1, *d2;
08     int *p;
09     int *e;
10
11     d1 = d;
12     d2 = d+n;
13     while (d1<d2)
14     {
15         p = d1;
16         e = d1 + 1;
17         while (e<d2)
18         {
19             if (*e<*p) p = e;
20             e++;
21         }
22         n = *p;
23         *p = *d1;
24         *d1 = n;
25         d1++;
26     }
27     printf("Sorted data:\n");
28     d1 = d;
29     while (d1<d2)
30         printf(" %d", *d1++);
31     printf("\n");
32 }
```

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.

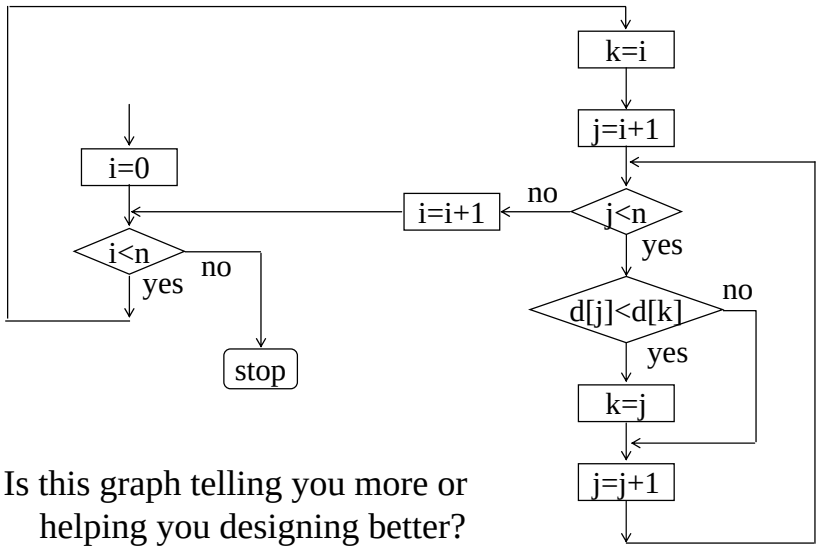
```
int array[100];
int *ptr=array;
int i, sum = 0;
…
for (i=0; i<100; i++)
   sum += *ptr++;
```

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


Version 2

```
01 #include <stdio.h>
02
03 void main()
04 {
05    int d[] = {12, 3, 37, 8, 24, 15, 5, 33};
06    int n = sizeof(d) / 4;
07    int i, j, k;
08
09    i = 0;
10    while (i<n)
11    {
12       k = i;
13       j = i + 1;
14       while (j<n)
15       {
16          if (d[j]<d[k]) k = j;
17          j = j + 1;
18       }
19       j = d[k];
20       d[k] = d[i];
21       d[i] = j;
22       i = i + 1;
23    }
24    printf("Sorted data:\n");
25    i = 0;
26    while (i<n)
27    {
28       printf(" %d", d[i]);
29       i = i + 1;
30    }
31    printf("\n");
32 }
```

Flowchart of the Program



Is this graph telling you more or helping you designing better?

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 J lk te st?

  or

  How does John like the steak?

Version 3

```
01 #include <stdio.h>
02
03 void main()
04 {
05     int data[] = {12, 3, 37, 8, 24, 15,
                     5, 33};
06     int ndata = sizeof(data) / sizeof(int);
07     int i, j;
08     int min;
09     int swapTmp;
10
11     i = 0;
12     while (i<ndata)
13     {
14         min = i;
15         j = i + 1;
16         while (j<ndata)
17         {
18             if (data[j]<data[min])
                   min = j;
19             j = j + 1;
20         }
21         swapTmp = data[min];
22         data[min] = data[i];
23         data[i] = swapTmp;
24         i = i + 1;
25     }
26
27     printf("Sorted data:\n");
28     i = 0;
29     while (i<ndata)
30     {
31         printf(" %d", data[i]);
32         i = i + 1;
33     }
34     printf("\n");
35 }
```


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
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

```
01 #include <stdio.h>
02
03 void main()
04 {
05     int data[] = {12,3,37,8,24,15,5,33};
06     int ndata = sizeof(data) / sizeof(int);
07     int i, j;
08     int min;
09     int swapTmp;
10
11     for (i=0; i<ndata; i++)
12     {
13         min = i;
14         for (j=i+1; j<ndata; j++)
15         {
16             if (data[j]<data[min]) min = j;
17         }
18         swapTmp = data[min];
19         data[min] = data[i];
20         data[i] = swapTmp;
21     }
22
23     printf("Sorted data:\n");
24     for (i=0; i<ndata; i++)
25         printf(" %d", data[i]);
26     printf("\n");
27 }
```


Code That Further Illustrates Itself

- **Function** is a powerful construct to **abstract** ideas, not just a utility for saving your typing time.

  --- 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

```
01 #include <stdio.h>
02
03 void swap(int *, int *);
04 void printArrayContents(int [], int);
05
06 void main()
07 {
08     int data[]={12,3,37,8, 24,15,5,33};
09     int ndata = sizeof(data)/sizeof(int);
10     int i, j;
11     int min;
12
13     for (i=0; i<ndata; i++)
14     {
15         min = i;
16         for (j=i+1; j<ndata; j++)
17         {
18             if (data[j]<data[min])
19                 min = j;
20         }
21         swap(&data[i], &data[min]);
22     }
23
24     printArrayContents(data, ndata)
25 }
26
27 void swap(int *x, int *y)
28 {
29     int tmp;
30     tmp = *x;
31     *x = *y;
32     *y = tmp;
33 }
```

Version 5 (cont'd)

```
34
35 void printArrayContents(int data[], int ndata)
36 {
37     int i;
38     printf("Sorted data:\n");
39     for (i=0; i<ndata; i++)
40         printf(" %d", data[i]);
41     printf("\n");
42 }
```


Version 6

```
01 #include <stdio.h>
02
03 void selectionSort(int[], int);
04 void findMinimumOfAnArray(int[], int);
05 void swap(int*, int*);
06 void printArrayContents(int[], int);
07
08 void main()
09 {
10     int data[] = {12, 3, 37, 8, 24, 15, 5, 33};
11     int ndata = sizeof(data) / sizeof(int);
12
13     selectionSort(data, ndata);
14     printArrayContents(data, ndata);
15 }
16
```


Version 6 (cont'd)

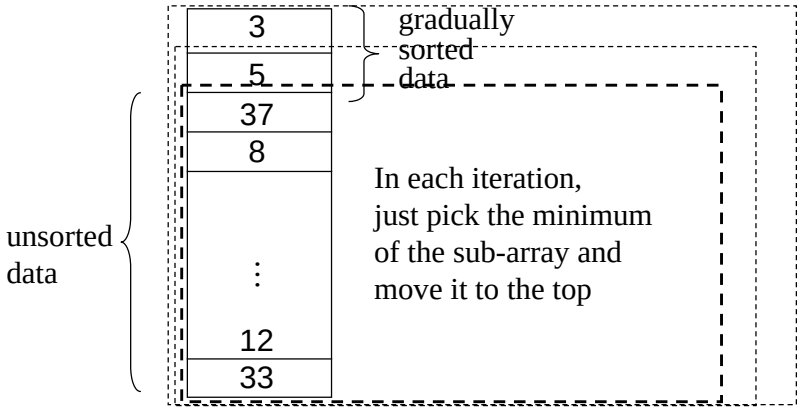
```
17 void selectionSort(int data[], int ndata)
18 {
19     int i;
20     for (i=0; i<ndata; i++)
21         findMinimumOfAnArray(&data[i], ndata-i);
22 }
23
24 void findMinimumOfAnArray(int data[], int ndata)
25 {
26     int i, min;
27
28     min = 0;
29     for (i=1; i<ndata; i++)
30     {
31         if (data[i]<data[min])
32             min = i;
33     }
34     swap(&data[0], &data[min]);
35 }
```

```
36 void swap(int *x, int *y)
37 {
38     int tmp;
39     tmp = *x;
40     *x = *y;
41     *y = tmp;
42 }
43
```

```
44 void printArrayContents(int data[], int ndata)
45 {
46     int i;
47     printf("Sorted data:\n");
48     for (i=0; i<ndata; i++)
49         printf(" %d", data[i]);
50     printf("\n");
51 }
```


Codes with a Conceptual Model

- Flowchart may not be needed here but definitely requires a conceptual model for the codes to work with.



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


Efficiency Issues

- Using expressive name for all identifiers make the program much longer, easy to have typo, 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 and to maintain
- 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.