



COMP2012H Honors Object-Oriented Programming and Data Structures

Topic 1: Introduction

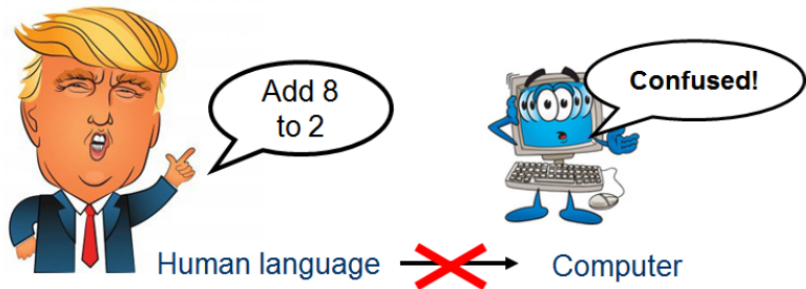
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Computer Programming

- Learning computer programming is just like learning a natural language such as English, Japanese, Korean, etc.
- Although they are similar, it doesn't mean they are exactly the same.



- Don't worry. Actually this is good. Since **computer programming** is **more systematic and should be much easier to learn**, in my opinion. ;) (Good news!)

Programming Languages

- Computer programs are written in programming languages.
- Different to those human languages, a programming language defines A SET OF INSTRUCTIONS in SPECIFIC FORMAT that can be given to a computer.
- Two important issues on writing programs:
 1. Program syntax – Is the grammar of the instructions correct?
 2. Program logic – Is the program able to solve the problem?

C/C++ Apache
C# SQL Server
Visual Basic
Java
ASP
IIS
Java Servlets



Machine Code: Can You Understand This?

```
0000100100101110011001100110100101101100011001010000100100100010011011000110010101100011011101000111
0101011100100110010100110001001011100110001100100010000010100110011101100011011000110011001001011111
011000110110111011011010111000001101001011011000110010101100100001011100011101000001010001011100111
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01101110000010100000100100101110011101000111001011100000110010100001001001000000110110101000010110
1001011011100010110000100011011001100111010101101110011000110111010001101110110111000001010
0000100100101110011100000110010011011101100110000100100110000001101000000101001101101011000010110
1001011011100011101000001010000010010010000100100011010100000101001001001111010011000100111101000111
0101010101000101001000110010000000110000000010100000100101110011011000010111011001100101001000000010
010101110011011100000001010000101100101100010011000001100000101100001001011100110111000000001010
0000101000001001001000010010001101010000010010010011101001100010011101000111010101101010010001010010
0011001000000011000100001010000010010110110101101110110110001000000011000100101100001001010110111
00110000000010100000100101110011011101000010000000100101011011100110000001011000100101010110
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0111010000100000001001010110111001100000010100010110110010010101100110011100000010110100110010011
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000010100000100101100010001000000010111001001100010011000011000100001010000010010110111001101110111
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00001001011100100110010101110011011101000101110111001001100101000010100010111001001100010011000110
0110011001010011000100111010000010100000100100101110011100110110100101111010011001010000100100100000
011011010110000101100101101110001011000010111001001100001001100110010010001100011001001010110110
110101100000101101001011011100000101000001001001011100110100101100100011001001011101100110000001001
00100010010001110100001101000011001110100010000000101000010001110100111001010100101001001000000011
0010001011100011100000101110001100010010001000001010
```

Assembly Language: How About This?

main:

!#PROLOGUE# 0

save %sp,-128,%sp

!#PROLOGUE# 1

mov 1,%o0

st %o0,[%fp-20]

mov 2,%o0

st %o0,[%fp-24]

ld [%fp-20],%o0

ld [%fp-24],%o1

add %o0,%o1,%o0

st %o0,[%fp-28]

mov 0,%i0

nop



High-Level Language: Is This Better Now?

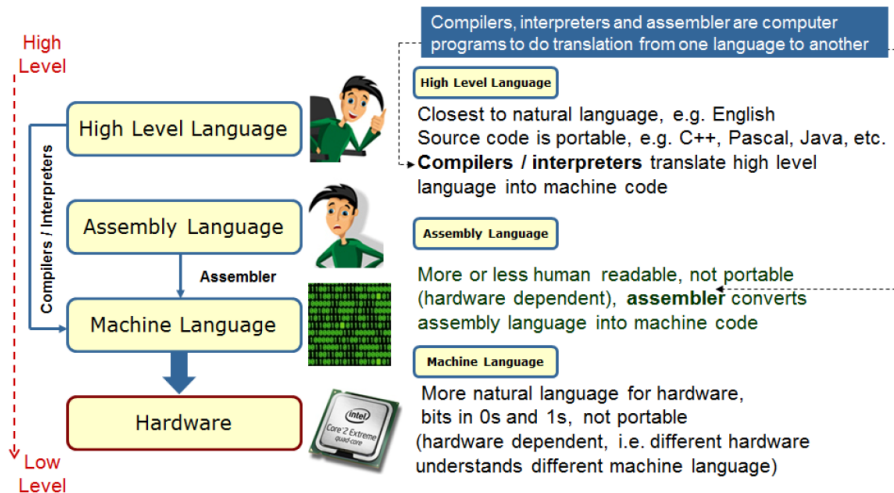
```
int main( )  
{  
    int x, y, z;  
  
    x = 1;  
    y = 2;  
    z = x+y;  
  
    return 0;  
}
```



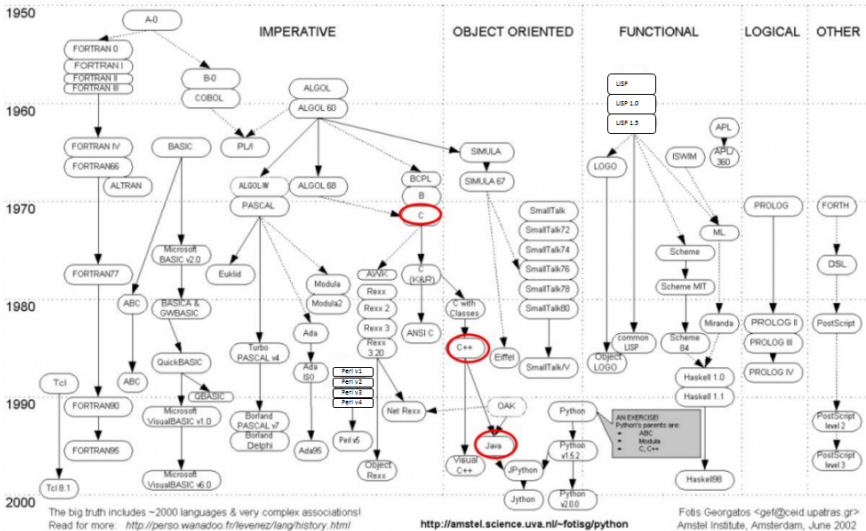
Write a Program to Sum 2 Numbers

- There are 3 integer-value-holding objects: x, y, and z.
- x and y have the value of 1 and 2 respectively.
- z's value is the sum of x's and y's.

Levels of Programming Languages



Chronology of Some High Level Programming Languages



Which Programming Language Are We Going to Use?

We are going to use C++ in this course!

- Why C++?

Read the FAQ from the designer of C++, Bjarne Stroustrup.

- Which C++?

- ▶ The language has been **evolving**:

C++ 1983 \Rightarrow C++ 1998 \Rightarrow C++ 2003 \Rightarrow C++ 2011 \Rightarrow ...

- ▶ We will learn C++11 (but not all the new features).

- Which compiler?

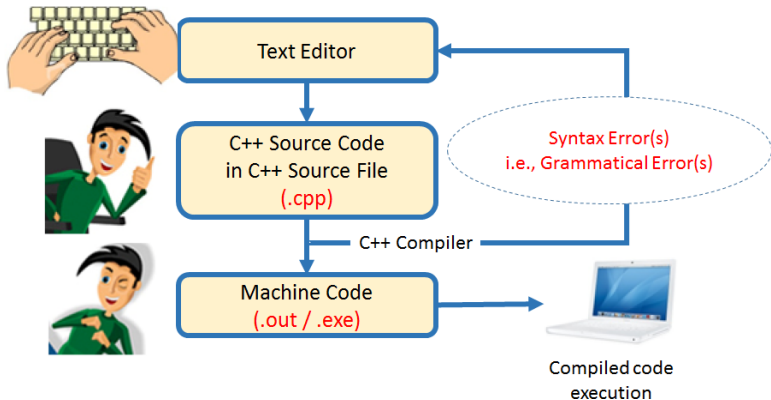
GNU gcc/g++. It is free.

(The compiler you will use is C++11-compliant.)

- Which IDE (integrated development environment) for writing programs?

VSCode. It is free and supported by many operating systems such as Windows, Mac OS, and Linux.

Development Cycle of a C++ Program



- A **compiler** translates **source programs** into **machine codes** that run directly on the target computer.
- For example, `a.cpp` \rightarrow `a.out` (or `a.exe`).
- Some C++ compilers: `gcc/g++`, `VC++`.

Example: Hello World!

```
/*  
 * File: hello-world.cpp  
 * A common program used to demo a new language  
 */  
  
#include <iostream>           // Load info of a Standard C++ library  
using namespace std;         // Standard C++ namespace  
  
int main()                    // Program's entry point  
{  
    /* Major program codes */  
    cout << "Hello World!" << endl;  
  
    return 0;                 // A nice ending  
}
```



Write, Compile, and Run a Program in a Terminal

STEP 1 : Write the program using an **editor**.

e.g., **VSCode**, **vi** (Unix/Linux), **MS Word** (Windows)

STEP 2 : Save the program into a file called **hello-world.cpp**.

STEP 3 : Compile the program using **g++** compiler.

```
g++ -o hello-world hello-world.cpp
```

If you don't specify the output filename using the “**-o**” option, the default is **a.out**.

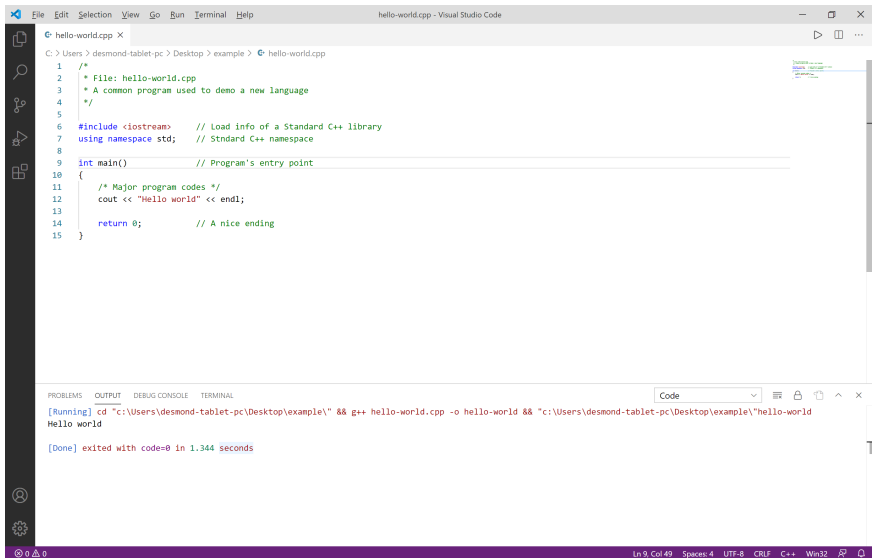
```
g++ hello-world.cpp
```

STEP 4 : Run the program in a terminal (command window):

```
linux:: hello-world  
Hello World!
```

VSCode IDE for C/C++

In the lab, you will use VSCode (similar to MS Visual Studio).



The screenshot displays the Visual Studio Code interface. The top menu bar includes File, Edit, Selection, View, Go, Run, Terminal, and Help. The title bar indicates the active file is 'hello-world.cpp - Visual Studio Code'. The left sidebar contains icons for Explorer, Search, Source Control, Run and Debug, and Extensions. The main editor area shows the following C++ code:

```
1  /*  
2  * File: hello-world.cpp  
3  * A common program used to demo a new language  
4  */  
5  
6  #include <iostream>    // Load info of a Standard C++ library  
7  using namespace std;  // Standard C++ namespace  
8  
9  int main()             // Program's entry point  
10 {  
11     /* Major program codes */  
12     cout << "Hello world" << endl;  
13  
14     return 0;          // A nice ending  
15 }
```

Below the editor, the 'TERMINAL' tab is active, showing the execution of the program:

```
[Running] cd "c:\Users\desmond-tablet-pc\Desktop\example\" && g++ hello-world.cpp -o hello-world && "c:\Users\desmond-tablet-pc\Desktop\example\hello-world  
Hello world  
  
[Done] exited with code=0 in 1.344 seconds
```

The status bar at the bottom indicates the current cursor position: Ln 9, Col 49, with 4 spaces, UTF-8 encoding, CRLF line endings, C++ language, Win32 architecture, and a 100% zoom level.

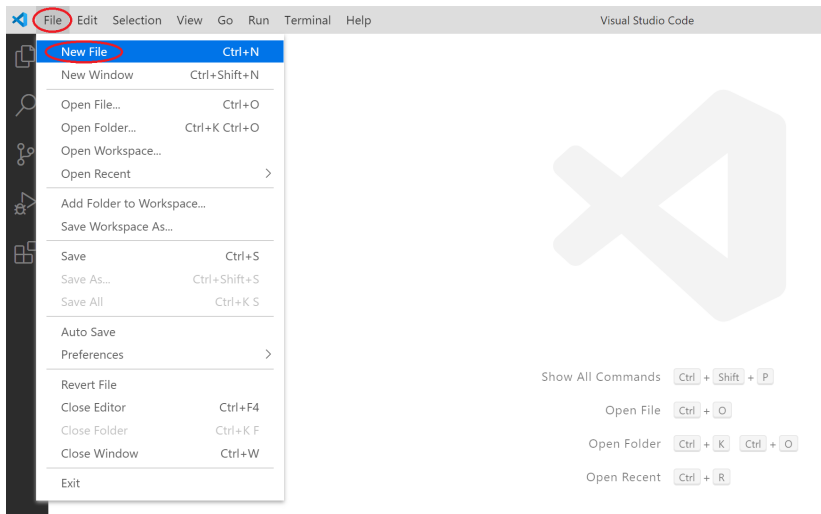
Program Development using VSCode



Step 1	Create a new file	Ctrl-N (or Click File → New File)
Step 2	Write program	VSCode built-in editor
Step 3	Save program	Ctrl-S (or Click File → Save)
Step 4	Compile and run program	F1 → “Run code”

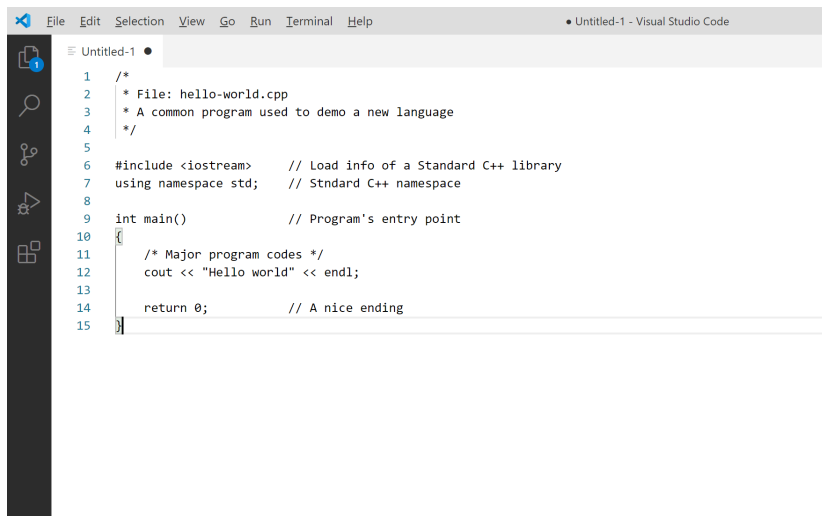
Step 1a: Create a new file

- Ctrl-N (or Click “File” → “New File”)



Step 2: Write program

- Write your program

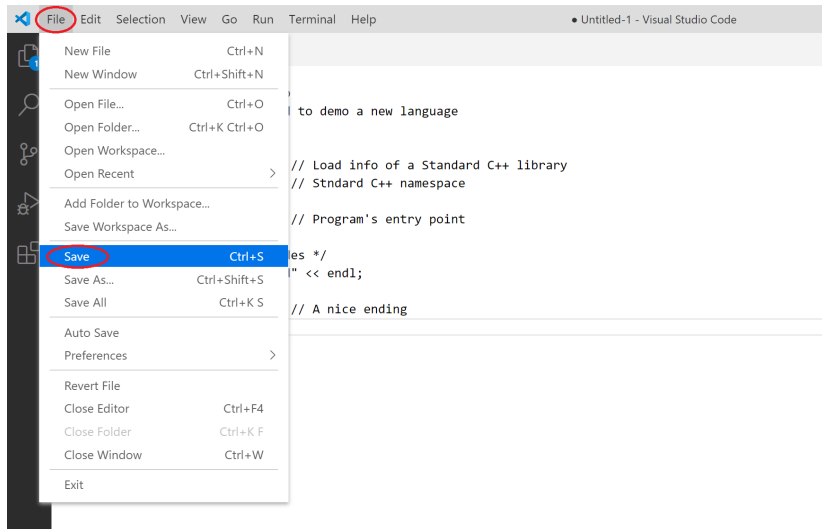


The screenshot shows the Visual Studio Code interface. The top menu bar includes File, Edit, Selection, View, Go, Run, Terminal, and Help. The title bar indicates the file is 'Untitled-1 - Visual Studio Code'. The left sidebar contains icons for Explorer, Search, Source Control, Run and Debug, and Extensions. The main editor area displays a C++ program in a file named 'Untitled-1'. The code is as follows:

```
1  /*
2  * File: hello-world.cpp
3  * A common program used to demo a new language
4  */
5
6  #include <iostream>    // Load info of a Standard C++ library
7  using namespace std;  // Standard C++ namespace
8
9  int main()            // Program's entry point
10 {
11     /* Major program codes */
12     cout << "Hello world" << endl;
13
14     return 0;          // A nice ending
15 }
```

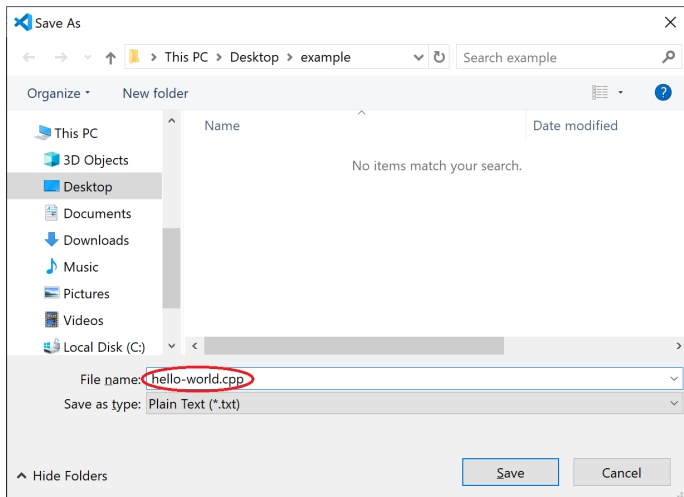

Step 3a: Save program

- Ctrl-S (or File → Save)



Step 3b: Save program

- Choose a location, give it a proper name, and click “Save”.
Note: make sure the name is something which ends with `.cpp` to indicate that is a C++ source file (e.g., `hello-world.cpp`).



Step 4: Compile and run program

- F1 → click “Run code”

The screenshot shows the Visual Studio Code interface with the file `hello-world.cpp` open. The code is a simple C++ program that prints "Hello world". A context menu is open over the code, with the `Run Code` option highlighted. The menu also lists other commands like `Add Browser Breakpoint`, `Add Cursor Above`, etc. Below the code editor, the `OUTPUT` panel is visible, showing the command `cd "c:\Users\desmond-tablet-pc\Desktop\example\" && g++ hello-world.cpp -o hello-world` and the output `Hello world`, which is circled in red. The terminal also shows `[Done] exited with code=0 in 1.072 seconds`.

```
File Edit Selection View Go Run Terminal Help
hello-world.cpp - Visual Studio Code

hello-world.cpp x
C: > Users > desmond-tablet-pc > Desktop > example
1 /*
2  * File: hello-world.cpp
3  * A common program used to demo a
4  */
5
6 #include <iostream>    // Load in
7 using namespace std;  // Standard
8
9 int main()            // Program
10 {
11     /* Major program codes */
12     cout << "Hello world" << endl;
13
14     return 0;         // A nice e
15 }
```

Run Code (Ctrl + Alt + N) recently used
other commands
Ctrl + Alt + UpArrow
Ctrl + Alt + DownArrow
Shift + Alt + I
Ctrl + K Ctrl + C
Ctrl + D

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

[Running] cd "c:\Users\desmond-tablet-pc\Desktop\example\" && g++ hello-world.cpp -o hello-world
Hello world
[Done] exited with code=0 in 1.072 seconds

Main: the Entry Point

- Every program must have exactly one and only one `main()` function.

Simple Form of the `main` Function

```
int main () { ... }
```

General Form of the `main` Function

```
int main (int argc, char** argv) { ... }
```

(We'll talk about `argc` and `argv` later.)

- Between the braces “{” and “}” are the program codes consisting of zero or more program **statements**.
- Each simple C++ statement ends in a semicolon “;”.

C++ Comments

- Use `/* ... */` for **multiple-line comments**.

```
/*  
 * A common program used to demo a new language  
 */
```

- **Single-line comments** start with `//`.

```
// Program's entry point
```

- Comments are just for human to read.
- They will **not** be translated by the compiler into machine codes.

#include and Standard C++ Libraries

- `#include` will include information of a **library** — a collection of sub-programs. e.g. `#include <iostream>` gets the information of the **standard C++ library** called **iostream** that deals with I/O:
 - ▶ **cin**: an object to read, e.g., from the keyboard or file
 - ▶ **cout**: an object to print out, e.g., to the screen or file
 - ▶ **cerr**: an object to print error message, e.g., to the screen or file

Examples

```
// endl means "end of a line"
cout << "Einstein: God does not play dice." << endl;

// You may also break down the message in several lines
cerr << "Error: "
     << "There is no stress and tension in HKUST!"
     << endl;
```

- These library information files are called **header files**.

#include and User-defined Libraries

- You may also define your *own* library.
- Again you need to use `#include` to include its information into your sub-programs.
- Example: `#include "drawing.h"` gets the information of a *user-defined C++ library* about drawing.
- By convention, the *header file* of a *user-defined library* ends in `".h"` or `".hpp"`, while *Standard C++ library* header files have *no* file suffix.
- Also by convention, the *header file* of a *user-defined library* is delimited using double-quotes `"..."`, while *Standard C++ library* header files use `< ... >`.

C++ is a Free Format Language

- Extra blanks, tabs, lines are ignored.
- Thus, codes may be indented in any way to enhance readability.
- More than one statement can be on one line.
- Here is the same Hello World program:

```
#include <iostream> /* File: hello-world-too.cpp */  
using namespace std; int main (int argc,  
    char** argv) { cout<<"Hello World!"<<endl;return 0;}
```

- On the other hand, a single statement may be spread over several lines.

```
cout << "Hello World!"  
    << endl;
```


Good Programming Style

- Place **each** statement on a line by itself.
- For **long** statements
 - ▶ if possible, break it down into several shorter statements.
 - ▶ wrap it around with proper indentation (since extra space doesn't matter!)
- Use blank lines to **separate** sections of related codes that together perform some action.
- **Indent consistently**. Use the same indentation for the same block of codes.



Programming as Problem Solving



- **Understand** and **define** the problem clearly.
 - ▶ What are the input(s) and output(s)?
 - ▶ Any constraints?
 - ▶ Which information is essential?
- **Develop** a solution.
 - ▶ Construct an algorithm.
- **Translate** the algorithm into a C++ program.
- **Compile** the program.
- **Test** the program.
- **Debug** the program.
- **Document** the program as you write the program.
- **Maintain** the program
 - ▶ modify the codes when conditions change.
 - ▶ enhance the codes to improve the solution.

What Makes a Good Program?

- Correctness
 - ▶ Meets the problem requirements
 - ▶ Produces correct results
- Easy to read and understand
- Easy to modify
- Easy to debug
- Efficient
 - ▶ Fast
 - ▶ Requires less memory



That's all!

Any questions?

