(T26)討論 Thread(執行緒)
CourseGUID: 29f1196a-1950-41a4-b9c1-dd13a9e92d92
==

==

0. Summary

1.
Thread
1.1.
In computing, a process is an instance of
a computer program that is being executed.
Windows Task Manager provide limit functions
to control the process in Windows operation system.
A process has one main thread and
might have some other threads.
Each tread executes the different piece of code.
For a single core machine,
Asynchronous Programming might reduce performance
because of context-switching.
However, Most machine nowadays normally have multiple cores CPU
which allows Asynchronous Programming provide a way
to run thread/Tasks simultaneously.
1.2.
Thread member.
1.2.1.
ThreadObject.Join()
ThreadObject.Join(int millisecondsTimeout)
ThreadObject.Join(TimeSpan timeout)
Reference:
https://msdn.microsoft.com/en-us/library/system.threading.thread.join(v=vs.110).aspx
Blocks the calling thread until ThreadObject terminates or until timeout.
Return true if the thread has been terminated;
Return false if the thread has not been terminated and time out.
1.2.2.
Thread.IsAlive
Reference:

https://msdn.microsoft.com/en-us/library/system.threading.thread.isalive(v=vs.110).aspx
Return true if this thread has been started
and has not terminated normally or aborted;
otherwise, false.
2.
//Stopwatch stopwatch = Stopwatch.StartNew();
//stopwatch.Stop();
//stopwatch.ElapsedMilliseconds
will return the timespan by milliseconds
3.
Get the number of CPU cores.
3.1.
See the Task Manager.
3.2.
In .Net,
Environment.ProcessorCount
3.3.
In command line,
echo %NUMBER_OF_PROCESSORS%

==

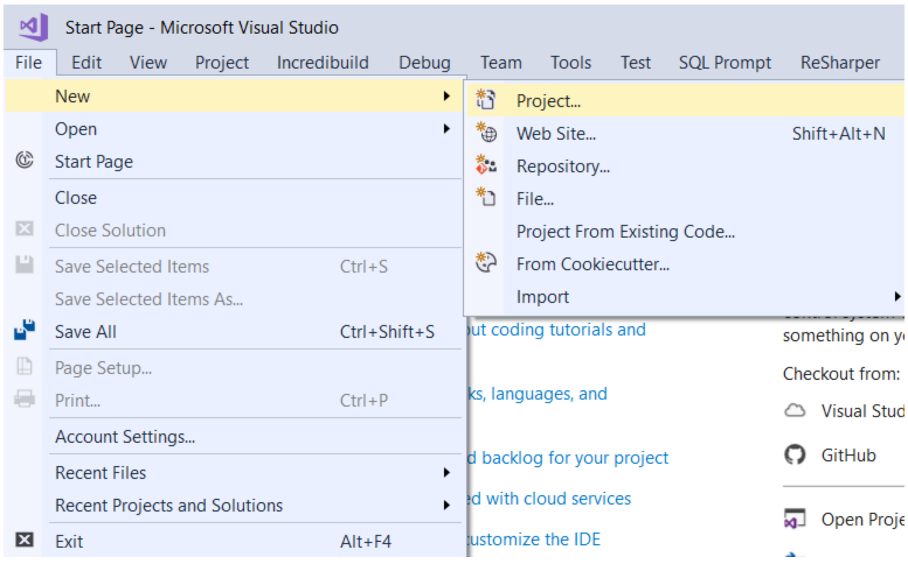
1. New Project

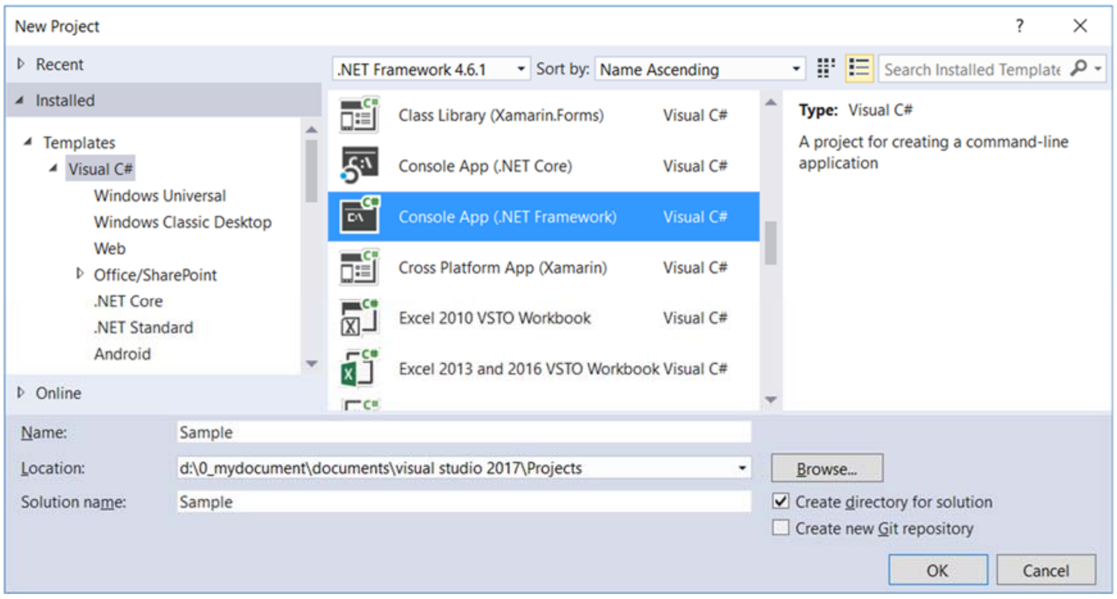
1.1. Create New Project : Sample

File --> New --> Project... -->

Visual C# --> **Console App (.Net Framework)** -->

Name: **Sample**





.NET Framework 4.6.1 Sort by: Name Ascending

Class Library (Xamarin.Forms)	Visual C#
Console App (.NET Core)	Visual C#
Console App (.NET Framework)	Visual C#
Cross Platform App (Xamarin)	Visual C#
Excel 2010 VSTO Workbook	Visual C#
Excel 2013 and 2016 VSTO Workbook	Visual C#

Type: Visual C#

A project for creating a command-line application

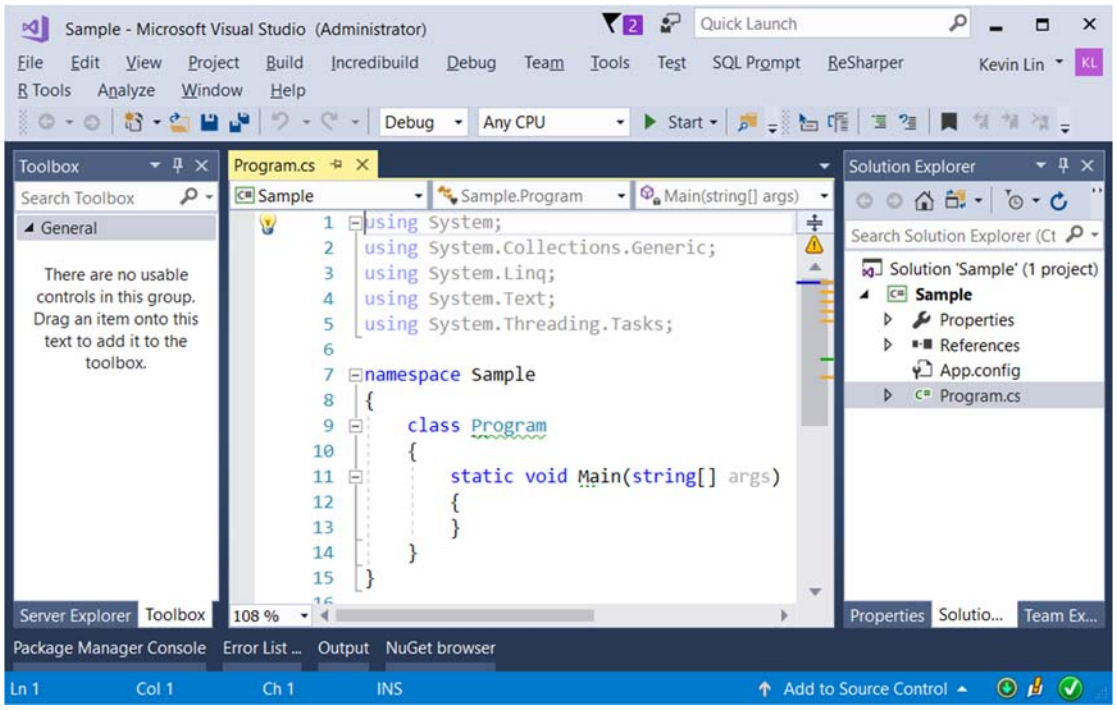
Name: Sample

Location: d:\0_mydocument\documents\visual studio 2017\Projects

Solution name: Sample

[✓] Create directory for solution

[ ] Create new Git repository



There are no usable controls in this group. Drag an item onto this text to add it to the toolbox.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace Sample
{
    class Program
    {
        static void Main(string[] args)
        {
        }
    }
}
```

==

2. Sample : Program.cs

```
using System;
using System.Diagnostics;
using System.Threading;
using OnlineGame;



namespace Sample
{
    class Program
    {
        static void Main(string[] args)
        {
            ////1. ==========================================================
            ////No Task, No Thread
            //Console.WriteLine("1. RunSlow() ; No Task, No Thread =================");
            //RunSlow();
            ////2. ==========================================================
            ////Thread
            //Console.WriteLine("2. RunSlow2(); Thread =================");
            //RunSlow2();
            ////3. ==========================================================
            ////Parameterized Thread
            //Console.WriteLine("3. ParameterizedThread();  Parameterized Thread =================");
            //ParameterizedThread();
            //4. ==========================================================
            //Thread Join(), IsAlive.
            ////4.1. ----------------------------------------------------
            //Console.WriteLine("4.1. ThreadJoinAndIsAlive();    Thread Join(), IsAlive.
=================");
            //ThreadJoinAndIsAlive();
            //4.2. -----------------------------------------------------
            Console.WriteLine("4.2. ThreadJoinAndIsAlive2();   Thread Join(), IsAlive.
=================");
            ThreadJoinAndIsAlive2();
            Console.ReadLine();
        }




        //1. ==========================================================
        //No Task, No Thread
        static void RunSlow()
        {
            Stopwatch stopwatch = Stopwatch.StartNew();
            slowMethodA();
            slowMethodB();
            slowMethodC();
            slowMethodD();
            new Gamer().RunSlowE();
            Console.WriteLine($"Environment.ProcessorCount == {Environment.ProcessorCount} ; this is the
number of CPU cores");
            stopwatch.Stop();
            Console.WriteLine($"RunSlow
stopwatch.ElapsedMilliseconds : {stopwatch.ElapsedMilliseconds} milliseconds");
        }
        //Stopwatch stopwatch = Stopwatch.StartNew();
        //stopwatch.Stop();
        //stopwatch.ElapsedMilliseconds
        //will return the timespan by milliseconds



        static void slowMethodA()
        {
            Console.WriteLine("beginning of slowMethodA()");
            // Sleep for N million seconds.
            Thread.Sleep(1999);
            Console.WriteLine("End of slowMethodA()");
        }




        static void slowMethodB()
        {
            Console.WriteLine("beginning of slowMethodB()");
            // Sleep for N million seconds.
            Thread.Sleep(2000);
            Console.WriteLine("End of slowMethodB()");
        }




        static void slowMethodC()
        {
            Console.WriteLine("beginning of slowMethodC()");
            // Sleep for N million seconds.
            Thread.Sleep(1998);
            Console.WriteLine("End of slowMethodC()");
        }




        static void slowMethodD()
        {
            Console.WriteLine("beginning of slowMethodD()");
            // Sleep for N million seconds.
            Thread.Sleep(1997);
            Console.WriteLine("End of slowMethodD()");
        }




        //2. ==========================================================
        //Thread
        //Tread parameter can be Anonymous methods,
        //static, non-static method, or more.
        //2.1. --------------------------------------------------------
        static void RunSlow2()
        {
            Stopwatch stopwatch = Stopwatch.StartNew();
            Thread slowMethodAThread = new Thread(new ThreadStart(slowMethodA));
            slowMethodAThread.Start();
            Thread slowMethodBThread = new Thread(slowMethodB);
            slowMethodBThread.Start();
            Thread slowMethodCThread = new Thread(delegate () { slowMethodC(); });
            slowMethodCThread.Start();
            Thread slowMethodDThread = new Thread(() => slowMethodD());
            slowMethodDThread.Start();
            Thread slowMethodEThread = new Thread(new Gamer().RunSlowE);
            slowMethodEThread.Start();
            stopwatch.Stop();
```

```
            Console.WriteLine($"RunSlow2
stopwatch.ElapsedMilliseconds : {stopwatch.ElapsedMilliseconds} milliseconds");
        }




        //3. ==========================================================
        //Parameterized Thread
        static void printIntInput(object input)
        {
            Console.WriteLine($"Beginning of static void printIntInput(object input), input is {input} ---
--------");
            Console.WriteLine(
                int.TryParse(input.ToString(), out int intInput) ?
                $"intInput == {intInput}" :
                $"intInput is not int");
            Console.WriteLine($"End of static void printIntInput(object input), input is {input} ---------
-");
        }




        static void ParameterizedThread()
        {
            //3.1. ----------------------------------
            // Create an instance ParameterizedThreadStart delegate
            // with static printIntInput() method as parameter.
            // ParameterizedThreadStart delegate has only one Object type parameter.
            // Thus, printIntInput(object input) need to match it.
            Thread parameterizedThread = new Thread(new ParameterizedThreadStart(printIntInput));
            //Now, parameterizedThread represent a Thread to run printIntInput(object input).
            //So we need to pass an object into it.
            //Here, 7 is int, but it need to be casted to object type
            //in order to pass into printIntInput(object input).
            parameterizedThread.Start((object)7);
            //3.2. ----------------------------------
            // The previous code can be rewrited as the following.
            //The .Net will automatically convert new Thread(printIntInput)
            //to new Thread(new ParameterizedThreadStart(printIntInput)).
            // In addition, it will automatically convert parameterizedThread2.Start(8)
            //to parameterizedThread.Start((object)8)
            Thread parameterizedThread2 = new Thread(printIntInput);
            parameterizedThread2.Start(8);
            //ParameterizedThreadStart delegate and Thread.Start(Object) is not type safe.
            //It will have a compiler error
            //if you pass (object)"AAA" into printIntInput(object input).
            //Thread and Mutex is a little bit out of date.
            //Using Async and Await is better.
            //But it is still good to understand Thread concept.
        }
```

```
//4. ==========================================================
//Thread Join(), IsAlive.
//4.1. ---------------------------------------------------
static void ThreadJoinAndIsAlive()
{
    Console.WriteLine("Beginning of ThreadJoinAndIsAlive() ----------------- ");
    Thread slowMethodAThread = new Thread(slowMethodA);
    slowMethodAThread.Start();
    Thread slowMethodBThread = new Thread(slowMethodB);
    slowMethodBThread.Start();
    for (int i = 1; i <= 10; i++)
    {
        Console.WriteLine($"slowMethodAThread.IsAlive : {slowMethodAThread.IsAlive}");
        if (slowMethodAThread.IsAlive)
            Thread.Sleep(300);
        else
            break;
    }
    Console.WriteLine(slowMethodAThread.Join(1000) ?
        "slowMethodAThread has finished" :
        "slowMethodAThread is time out after 1 second.");
    //Return true if the thread has been terminated;
    //Return false if the thread has not been terminated and time out.
    slowMethodBThread.Join();
    Console.WriteLine("slowMethodBThread has finished");
    Console.WriteLine("End of ThreadJoinAndIsAlive() ----------------- ");
}



//4.2. ---------------------------------------------------
static void ThreadJoinAndIsAlive2()
{
    Console.WriteLine("Beginning of ThreadJoinAndIsAlive2() ----------------- ");
    Thread slowMethodAThread = new Thread(slowMethodA);
    slowMethodAThread.Start();
    Thread slowMethodBThread = new Thread(slowMethodB);
    slowMethodBThread.Start();
    Console.WriteLine(slowMethodAThread.Join(1000) ?
        "slowMethodAThread has finished" :
        "slowMethodAThread is time out after 1 second.");
    slowMethodBThread.Join();
    Console.WriteLine("slowMethodBThread has finished");
    for (int i = 1; i <= 10; i++)
    {
        Console.WriteLine($"slowMethodAThread.IsAlive : {slowMethodAThread.IsAlive}");
        if (slowMethodAThread.IsAlive)
            Thread.Sleep(300);
        else
            break;
    }
    Console.WriteLine("End of ThreadJoinAndIsAlive2() ----------------- ");
}



//1.
```

```
        //ThreadObject.Join()
        //ThreadObject.Join(int millisecondsTimeout)
        //ThreadObject.Join(TimeSpan timeout)
        //Reference:
        //https://msdn.microsoft.com/en-us/library/system.threading.thread.join(v=vs.110).aspx
        //Blocks the calling thread until ThreadObject terminates or until timeout.
        //Return true if the thread has been terminated;
        //Return false if the thread has not been terminated and time out.
        //2.
        //Thread.IsAlive
        //Reference:
        //https://msdn.microsoft.com/en-us/library/system.threading.thread.isalive(v=vs.110).aspx
        //Return true if this thread has been started
        //and has not terminated normally or aborted;
        //otherwise, false.
    }
}


//1. =======================================================
namespace OnlineGame
{
    public class Gamer
    {
        public int Id { get; set; }
        public string Name { get; set; }




        public override string ToString()
        {
            return $"Id=={Id} ; Name=={Name}";
        }




        public void RunSlowE()
        {
            Console.WriteLine("beginning of slowMethodE()");
            // Sleep for N million seconds.
            Thread.Sleep(1996);
            Console.WriteLine("End of slowMethodE()");
        }
    }
}


/*
1.
Thread
1.1.
In computing, a process is an instance of
a computer program that is being executed.
Windows Task Manager provide limit functions
to control the process in Windows operation system.
A process has one main thread and
might have some other threads.
```

```
Each tread executes the different piece of code.
For a single core machine,
Asynchronous Programming might reduce performance
because of context-switching.
However, Most machine nowadays normally have multiple cores CPU
which allows Asynchronous Programming provide a way
to run thread/Tasks simultaneously.
1.2.
Thread member.
1.2.1.
ThreadObject.Join()
ThreadObject.Join(int millisecondsTimeout)
ThreadObject.Join(TimeSpan timeout)
Reference:
https://msdn.microsoft.com/en-us/library/system.threading.thread.join(v=vs.110).aspx
Blocks the calling thread until ThreadObject terminates or until timeout.
Return true if the thread has been terminated;
Return false if the thread has not been terminated and time out.
1.2.2.
Thread.IsAlive
Reference:
https://msdn.microsoft.com/en-us/library/system.threading.thread.isalive(v=vs.110).aspx
Return true if this thread has been started
and has not terminated normally or aborted;
otherwise, false.
----------------------------
2.
//Stopwatch stopwatch = Stopwatch.StartNew();
//stopwatch.Stop();
//stopwatch.ElapsedMilliseconds
will return the timespan by milliseconds
----------------------------
3.
Get the number of CPU cores.
3.1.
See the Task Manager.
3.2.
In .Net,
Environment.ProcessorCount
3.3.
In command line,
echo %NUMBER_OF_PROCESSORS%
*/



/*
1. RunSlow() ; No Task, No Thread =================
beginning of slowMethodA()
End of slowMethodA()
beginning of slowMethodB()
End of slowMethodB()
beginning of slowMethodC()
End of slowMethodC()
beginning of slowMethodD()
End of slowMethodD()
beginning of slowMethodE()
End of slowMethodE()
Environment.ProcessorCount == 8 ; this is the number of CPU cores
RunSlow stopwatch.ElapsedMilliseconds : 9993 milliseconds
==================
每次跑的時候, 肯定是 ABCDE 順序不變
*/



/*
2. RunSlow2(); Thread =================
beginning of slowMethodB()
beginning of slowMethodA()
beginning of slowMethodC()
beginning of slowMethodD()
RunSlow2 stopwatch.ElapsedMilliseconds : 26 milliseconds
beginning of slowMethodE()
End of slowMethodB()
End of slowMethodA()
End of slowMethodD()
End of slowMethodE()
End of slowMethodC()
========================
每次跑的時候 ABCDE 順序都不一樣
*/



/*
3. ParameterizedThread();  Parameterized Thread =================
Beginning of static void printIntInput(object input), input is 8 -----------
intInput == 8
End of static void printIntInput(object input), input is 8 ----------
Beginning of static void printIntInput(object input), input is 7 -----------
intInput == 7
End of static void printIntInput(object input), input is 7 ----------
==============
每次跑的時候，都不一樣，有可能 8 在前面，有可能 7 在前面
*/



/*
4.1. ThreadJoinAndIsAlive();    Thread Join(), IsAlive. =================
Beginning of ThreadJoinAndIsAlive() -----------------
slowMethodAThread.IsAlive : True
beginning of slowMethodA()
beginning of slowMethodB()
slowMethodAThread.IsAlive : True
slowMethodAThread.IsAlive : True
slowMethodAThread.IsAlive : True
slowMethodAThread.IsAlive : True
slowMethodAThread.IsAlive : True
slowMethodAThread.IsAlive : True
End of slowMethodA()
End of slowMethodB()
slowMethodAThread.IsAlive : False
slowMethodAThread has finished
slowMethodBThread has finished
End of ThreadJoinAndIsAlive() -----------------
=============================
A.
slowMethodAThread.IsAlive 是在 for loop 裡面
他會每隔 300ms 檢查一次
slowMethodAThread.IsAlive ()
看看是否 slowMethodAThread 還活著
-----------------
B.
我們知道 slowMethodA 裡面有
Thread.Sleep(1999);
所以 slowMethodA 的執行時間會比 1999ms 還要多一點
然後每隔 300ms 檢查一次 slowMethodAThread.IsAlive ()
所以 slowMethodAThread.IsAlive : True
大概會執行 7 次
因為 300ms * 7 = 2100ms
估計大概是 6~7 次
-----------------
C.
```

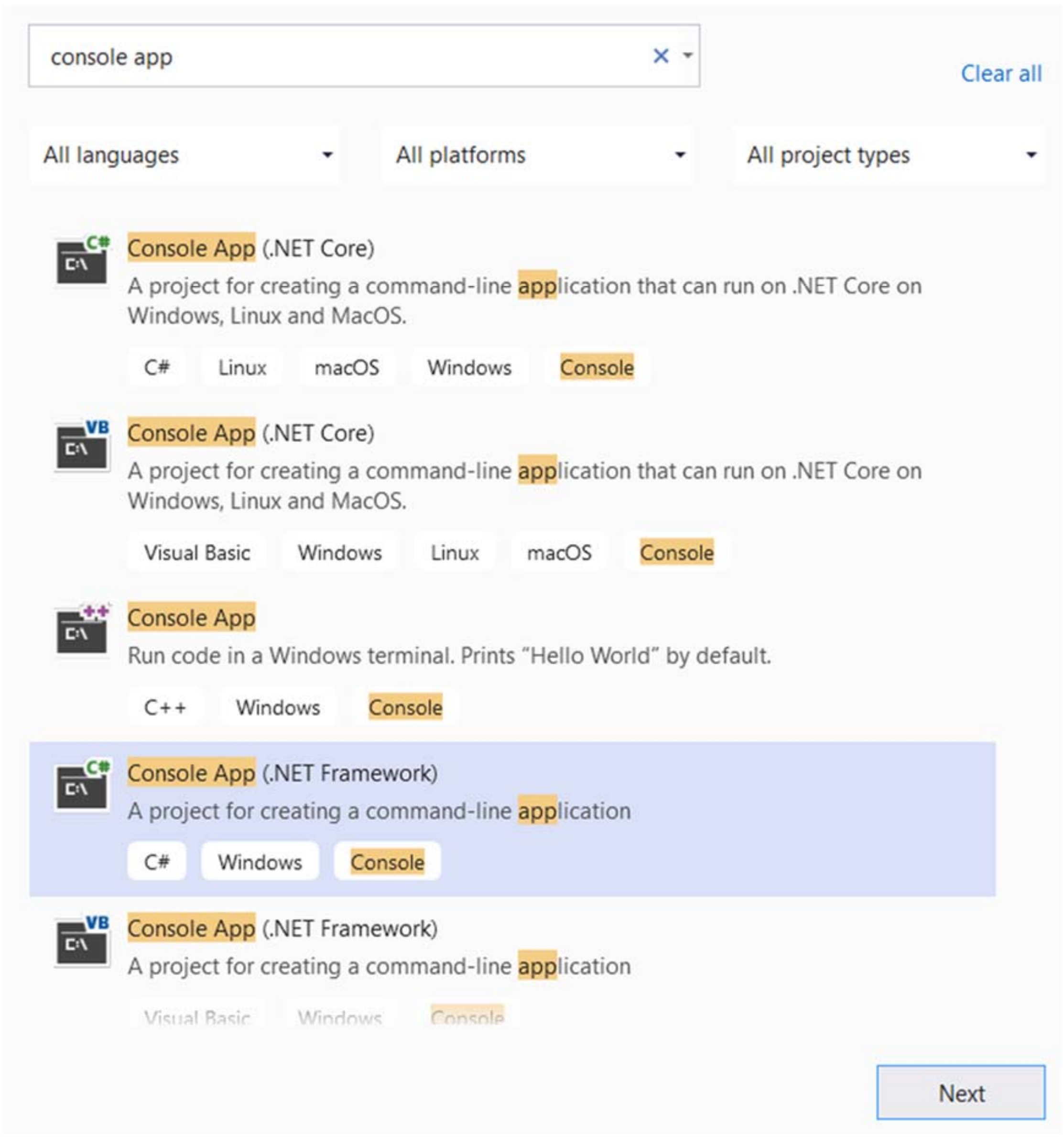
```
在的 for loop 的時候
要到 slowMethodAThread.IsAlive : False 的時候
也就是當要到 slowMethodAThread 結束的時候
才會脫離 for loop
接著, 才執行
Console.WriteLine(slowMethodAThread.Join(1000) ?
"slowMethodAThread has finished" :
"slowMethodAThread is time out after 1 second.");
首先 Join(timeout)的用法是
Return true if the thread has been terminated;
Return false if the thread has not been terminated and time out.
所以, 不管你使用.Join(1000)或是.Join(1)
也就是不管你等待 1000ms 或是 等待 1ms
都會是 return true.
因為 slowMethodAThread 早就結束了
*/



/*
4.2. ThreadJoinAndIsAlive2();   Thread Join(), IsAlive. =================
Beginning of ThreadJoinAndIsAlive2() -----------------
beginning of slowMethodA()
beginning of slowMethodB()
slowMethodAThread is time out after 1 second.
End of slowMethodB()
End of slowMethodA()
slowMethodBThread has finished
slowMethodAThread.IsAlive : False
End of ThreadJoinAndIsAlive2() -----------------
=============================
A.
我們知道 slowMethodA 裡面有
Thread.Sleep(1999);
所以 slowMethodA 的執行時間會比 1999ms 還要多一點
接著, 才執行
Console.WriteLine(slowMethodAThread.Join(1000) ?
"slowMethodAThread has finished" :
"slowMethodAThread is time out after 1 second.");
首先 Join(timeout)的用法是
Return true if the thread has been terminated;
Return false if the thread has not been terminated and time out.
所以 Join(1000) 意思是
等待 1000ms 後，
因為 slowMethodA 還沒執行完畢
所以產生 timeout (過時)
所以 Join(1000) 會 Return false
因此會 WriteLine 出
"slowMethodAThread is time out after 1 second."
至此
slowMethodA 已經因為 timeout 而結束執行
所以 WriteLine 出
"End of slowMethodA()"
-----------------
B.
slowMethodAThread.IsAlive 是在 for loop 裡面
他會每隔 300ms 檢查一次
slowMethodAThread.IsAlive ()
看看是否 slowMethodAThread 還活著
但是, 現在問題是
在還沒進入 for loop 之前
slowMethodA 已經因為 timeout 而結束執行
所以一進入 for loop 的時候
第一輪的時候
```

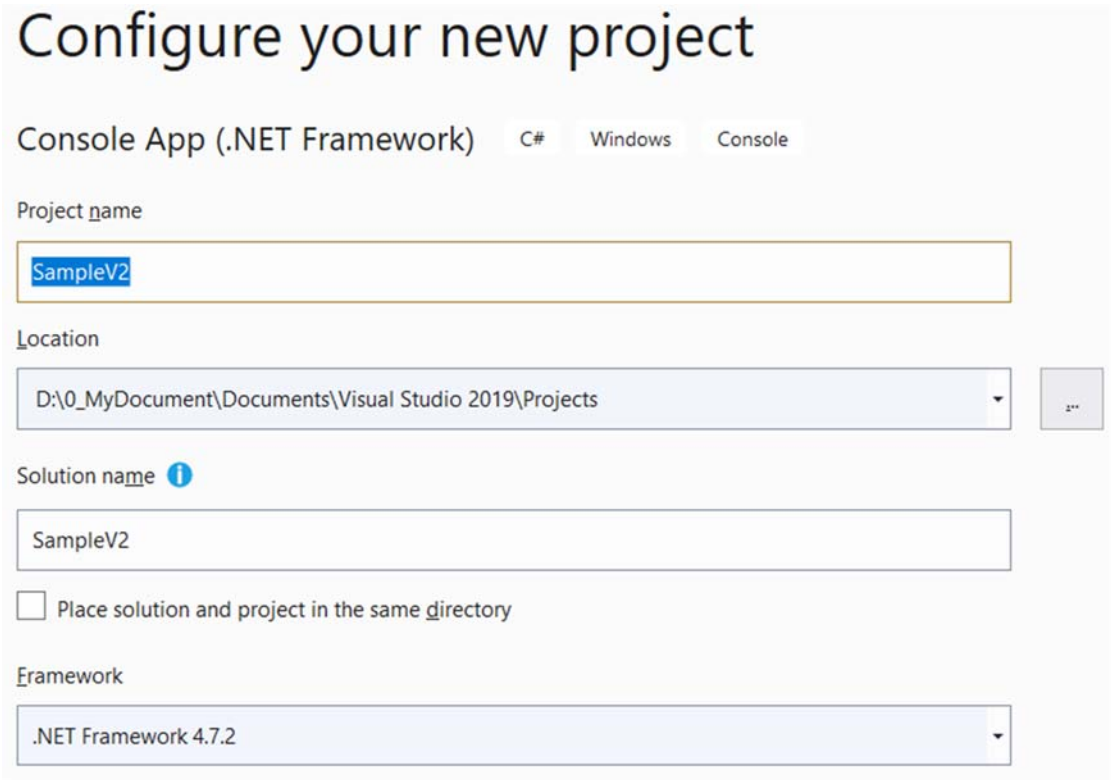
```
馬上 WriteLine 出
"slowMethodAThread.IsAlive : False"
*/
```

3. Console App(.NET Framework) - SampleV2 - Program.cs

Console App(.NET Framework) - SampleV2

1.
https://www.facebook.com/groups/934567793358849/posts/1979140725568212/
Console App(.NET Framework)
-->
SampleV2


console app
Clear all
All languages
All platforms
All project types
Console App (.NET Core)
A project for creating a command-line application that can run on .NET Core on Windows, Linux and MacOS.
C# Linux macOS Windows Console
Console App (.NET Core)
A project for creating a command-line application that can run on .NET Core on Windows, Linux and MacOS.
Visual Basic Windows Linux macOS Console
Console App
Run code in a Windows terminal. Prints "Hello World" by default.
C++ Windows Console
Console App (.NET Framework)
A project for creating a command-line application
C# Windows Console
Console App (.NET Framework)
A project for creating a command-line application
Visual Basic Windows Console
Next


Configure your new project

Console App (.NET Framework)

Project name: SampleV2

Location: D:\0_MyDocument\Documents\Visual Studio 2019\Projects

Solution name: SampleV2

Place solution and project in the same directory

Framework: .NET Framework 4.7.2

2.

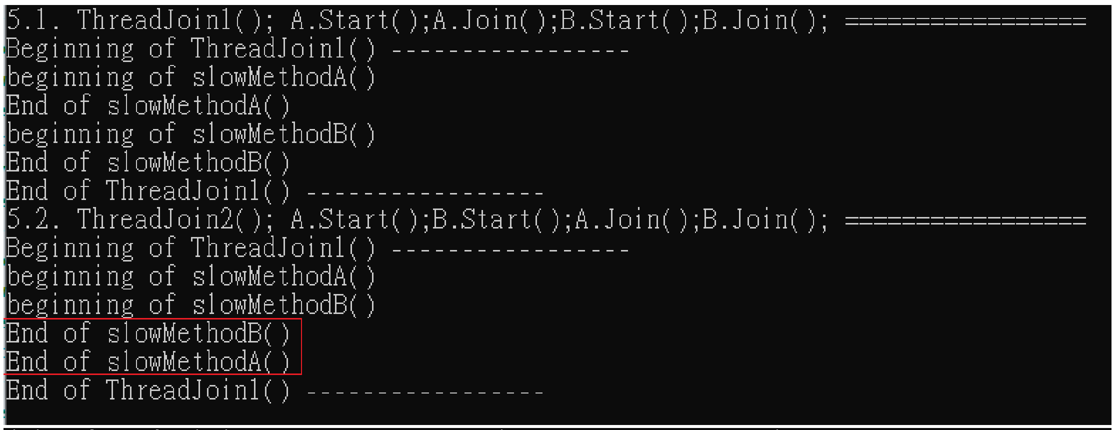
Program.cs

```
using System;
using System.Threading;
namespace SampleV2
{
    class Program
    {
        static void Main(string[] args)
        {
            //5. =========================================================
            //Thread Join()
            ////5.1. -----------------------------------------------------
            Console.WriteLine("5.1. ThreadJoin1(); A.Start();A.Join();B.Start();B.Join();
=================");
            ThreadJoin1();
            //5.2. -----------------------------------------------------
            Console.WriteLine("5.2. ThreadJoin2(); A.Start();B.Start();A.Join();B.Join();
=================");
            ThreadJoin2();
            Console.ReadLine();
        }



        //1. =========================================================
        //No Task, No Thread
        static void slowMethodA()
        {
            Console.WriteLine("beginning of slowMethodA()");
            // Sleep for N million seconds.
            Thread.Sleep(1999);
            Console.WriteLine("End of slowMethodA()");
        }




        static void slowMethodB()
        {
            Console.WriteLine("beginning of slowMethodB()");
            // Sleep for N million seconds.
            Thread.Sleep(2000);
            Console.WriteLine("End of slowMethodB()");
        }




        //5. ==========================================================
        //Thread Join()
        static void ThreadJoin1()
        {
            Console.WriteLine("Beginning of ThreadJoin1() ----------------- ");
            Thread slowMethodAThread = new Thread(slowMethodA);
            Thread slowMethodBThread = new Thread(slowMethodB);
            slowMethodAThread.Start();
            slowMethodAThread.Join();
            slowMethodBThread.Start();
            slowMethodBThread.Join();
            Console.WriteLine("End of ThreadJoin1() ----------------- ");
        }




        static void ThreadJoin2()
        {
            Console.WriteLine("Beginning of ThreadJoin2() ----------------- ");
            Thread slowMethodAThread = new Thread(slowMethodA);
            Thread slowMethodBThread = new Thread(slowMethodB);
            slowMethodAThread.Start();
            slowMethodBThread.Start();
            slowMethodAThread.Join();
            slowMethodBThread.Join();
            Console.WriteLine("End of ThreadJoin2() ----------------- ");
        }
    }
}




/*
5.1. ThreadJoin1(); A.Start();A.Join();B.Start();B.Join(); =================
Beginning of ThreadJoin1() -----------------
beginning of slowMethodA()
End of slowMethodA()
beginning of slowMethodB()
End of slowMethodB()
End of ThreadJoin1() -----------------
5.2. ThreadJoin2(); A.Start();B.Start();A.Join();B.Join(); =================
Beginning of ThreadJoin2() -----------------
beginning of slowMethodA()
beginning of slowMethodB()
```

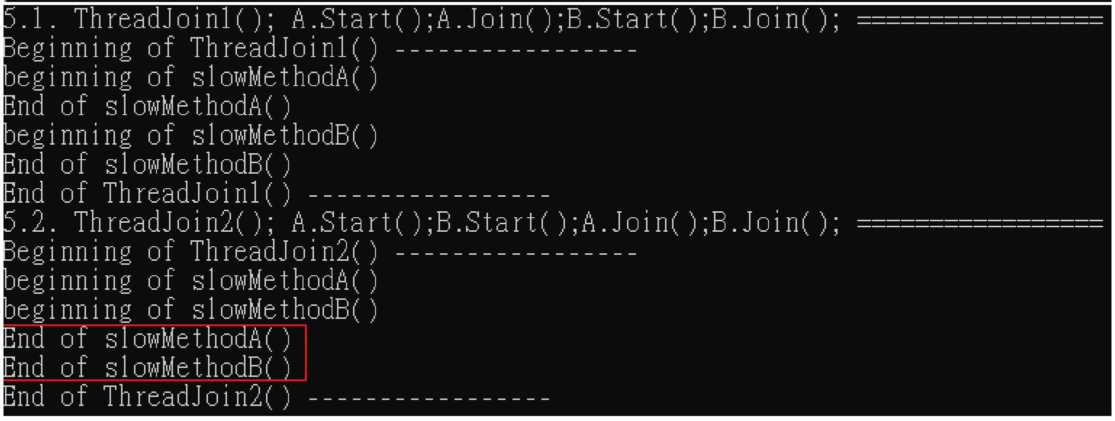
```
End of slowMethodB()
End of slowMethodA()
End of ThreadJoin2() -----------------
*/




/*
5.1. ThreadJoin1(); A.Start();A.Join();B.Start();B.Join(); =================
Beginning of ThreadJoin1() -----------------
beginning of slowMethodA()
End of slowMethodA()
beginning of slowMethodB()
End of slowMethodB()
End of ThreadJoin1() -----------------
5.2. ThreadJoin2(); A.Start();B.Start();A.Join();B.Join(); =================
Beginning of ThreadJoin2() -----------------
beginning of slowMethodA()
beginning of slowMethodB()
End of slowMethodA()
End of slowMethodB()
End of ThreadJoin2() -----------------
*/




/*
1.
//static void ThreadJoin1()
//{
//    Console.WriteLine("Beginning of ThreadJoin1() ----------------- ");
//    Thread slowMethodAThread = new Thread(slowMethodA);
//    Thread slowMethodBThread = new Thread(slowMethodB);
//    slowMethodAThread.Start();
//    slowMethodAThread.Join();
//    slowMethodBThread.Start();
//    slowMethodBThread.Join();
//    Console.WriteLine("End of ThreadJoin1() ----------------- ");
//}
-----------------------------------------
"ThreadJoin1" is "CurrentThread"
"slowMethodAThread" is "ChildThread" of the "CurrentThread"
"slowMethodBThread" is "ChildThread" of the "CurrentThread"
----------------
//slowMethodAThread.Start();
"CurrentThread" has started first, and then "slowMethodAThread" started.
----------------
//slowMethodAThread.Join();
"slowMethodAThread" join the "CurrentThread".
It means "slowMethodAThread" has to be finished,
and then "CurrentThread" can continue.
----------------
//slowMethodBThread.Start();
While "CurrentThread" is still runing, and then "slowMethodBThread" started,
----------------
//slowMethodAThread.Join();
"slowMethodBThread" join the "CurrentThread".
It means "slowMethodBThread" has to be finished,
and then "CurrentThread" can continue.
---------------------------------
"ThreadJoin1"是"CurrentThread"(目前 Thread)
"slowMethodAThread"是"CurrentThread"(目前 Thread)的"ChildThread"(子 Thread)
"slowMethodBThread"是"CurrentThread"(目前 Thread)的"ChildThread"(子 Thread)
----------------
```

```
//slowMethodAThread.Start();
"CurrentThread"先開始跑,然後"slowMethodAThread"才開始跑
----------------
//slowMethodAThread.Join();
"slowMethodAThread" join the "CurrentThread".
這意思是"slowMethodAThread"必須先結束
"CurrentThread"才可以繼續跑
----------------
//slowMethodBThread.Start();
當"CurrentThread"還在繼續跑,然後"slowMethodBThread"才開始跑
----------------
//slowMethodBThread.Join();
"slowMethodBThread" join the "CurrentThread".
這意思是"slowMethodBThread"必須先結束
"CurrentThread"才可以繼續跑
--------------------------------------------------------------------
2.
static void ThreadJoin2()
//{
//     Console.WriteLine("Beginning of ThreadJoin2() ----------------- ");
//     Thread slowMethodAThread = new Thread(slowMethodA);
//     Thread slowMethodBThread = new Thread(slowMethodB);
//     slowMethodAThread.Start();
//     slowMethodBThread.Start();
//     slowMethodAThread.Join();
//     slowMethodBThread.Join();
//     Console.WriteLine("End of ThreadJoin2() ----------------- ");
//}
-----------------------------------------
"ThreadJoin1" is "CurrentThread"
"slowMethodAThread" is "ChildThread" of the "CurrentThread"
"slowMethodBThread" is "ChildThread" of the "CurrentThread"
----------------
//slowMethodAThread.Start();
"CurrentThread" has started first, and then "slowMethodAThread" started.
----------------
//slowMethodBThread.Start();
While "CurrentThread" is still runing, and then "slowMethodBThread" started,
----------------
//slowMethodAThread.Join();
"slowMethodAThread" join the "CurrentThread".
It means "slowMethodAThread" has to be finished,
and then "CurrentThread" can continue.
However, the "slowMethodBThread" is still runing.
Therefore, "slowMethodBThread" might be finished first.
----------------
//slowMethodAThread.Join();
"slowMethodBThread" join the "CurrentThread".
It means "slowMethodBThread" has to be finished,
and then "CurrentThread" can continue.
---------------------------------
"ThreadJoin1"是"CurrentThread"(目前 Thread)
"slowMethodAThread"是"CurrentThread"(目前 Thread)的"ChildThread"(子 Thread)
"slowMethodBThread"是"CurrentThread"(目前 Thread)的"ChildThread"(子 Thread)
----------------
//slowMethodAThread.Start();
"CurrentThread"先開始跑,然後"slowMethodAThread"才開始跑
----------------
//slowMethodBThread.Start();
當"CurrentThread"還在繼續跑,然後"slowMethodBThread"才開始跑
----------------
//slowMethodAThread.Join();
"slowMethodAThread" join the "CurrentThread".
這意思是"slowMethodAThread"必須先結束
"CurrentThread"才可以繼續跑
但是其實"slowMethodBThread"還在繼續跑
```

```
所以"slowMethodBThread"有可能會先結束(看運氣)
----------------
//slowMethodBThread.Join();
"slowMethodBThread" join the "CurrentThread".
這意思是"slowMethodBThread"必須先結束
"CurrentThread"才可以繼續跑
*/
```



```
5.1. ThreadJoin1(); A.Start();A.Join();B.Start();B.Join(); ==================
Beginning of ThreadJoin1() -----------------
beginning of slowMethodA()
End of slowMethodA()
beginning of slowMethodB()
End of slowMethodB()
End of ThreadJoin1() -----------------
5.2. ThreadJoin2(); A.Start();B.Start();A.Join();B.Join(); ==================
Beginning of ThreadJoin1() -----------------
beginning of slowMethodA()
beginning of slowMethodB()
End of slowMethodB()
End of slowMethodA()
End of ThreadJoin1() -----------------
```



```
5.1. ThreadJoin1(); A.Start();A.Join();B.Start();B.Join(); ==================
Beginning of ThreadJoin1() -----------------
beginning of slowMethodA()
End of slowMethodA()
beginning of slowMethodB()
End of slowMethodB()
End of ThreadJoin1() -----------------
5.2. ThreadJoin2(); A.Start();B.Start();A.Join();B.Join(); ==================
Beginning of ThreadJoin2() -----------------
beginning of slowMethodA()
beginning of slowMethodB()
End of slowMethodA()
End of slowMethodB()
End of ThreadJoin2() -----------------
```
