(T27)討論 MultiThread(多執行緒)、Monitor(監視)、Lock(鎖)
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(T27)討論 MultiThread(多執行緒)、Monitor(監視)、Lock(鎖)
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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%

==========

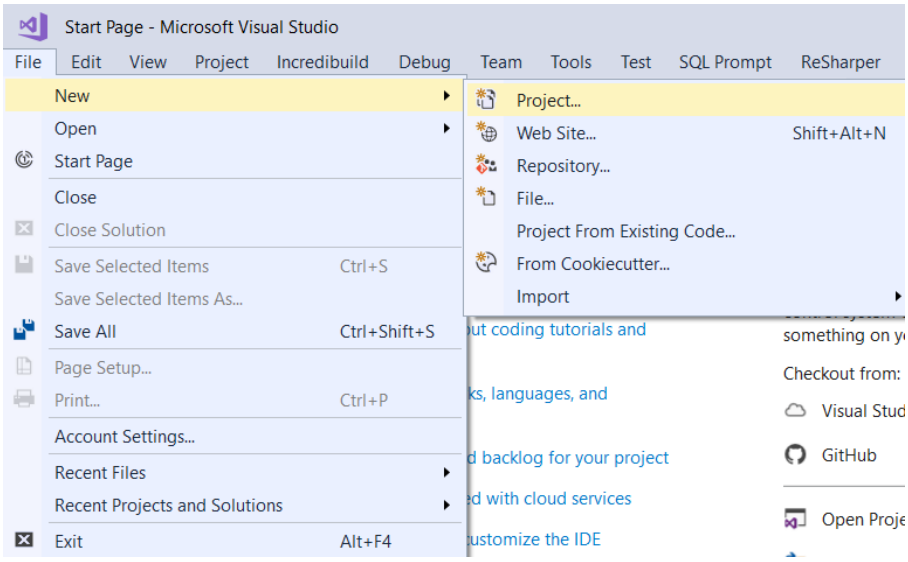
1. New Project

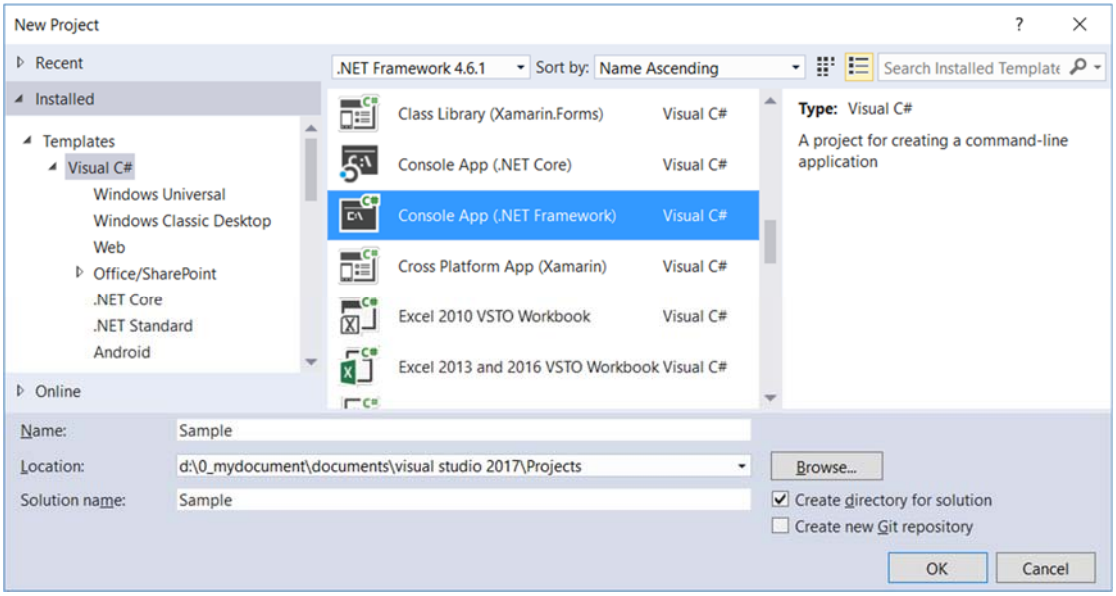
1.1. Create New Project : Sample

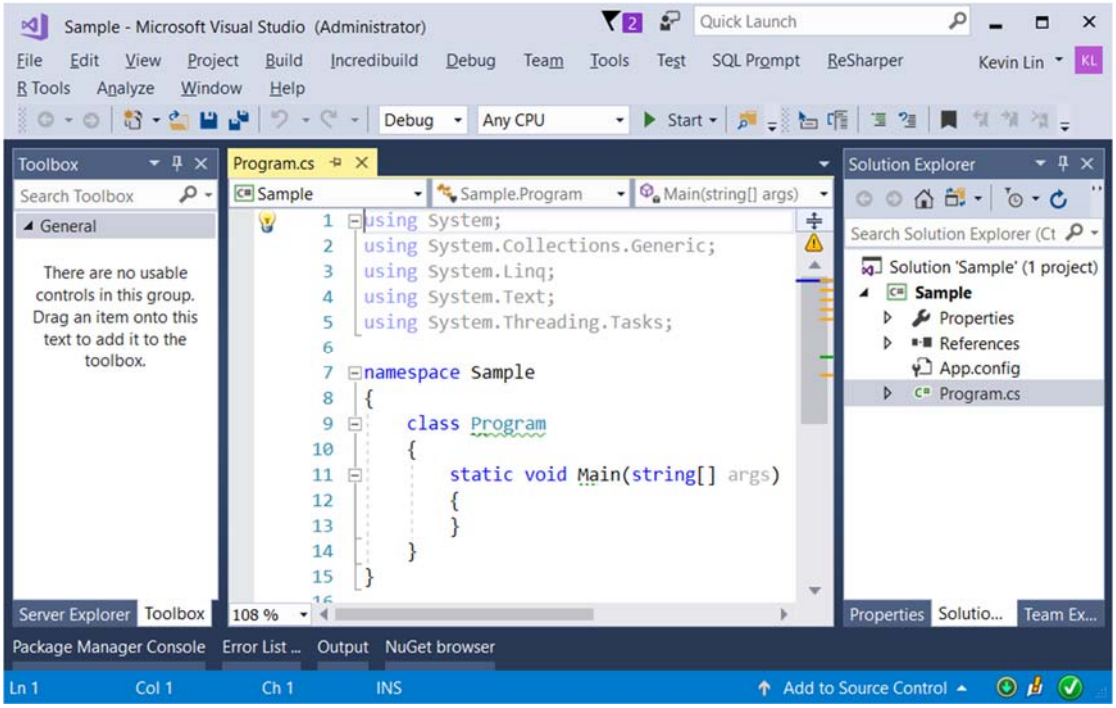
File --> New --> Project... -->

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

Name: **Sample**







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2. Sample : Program.cs

```
using System;
using System.Threading;



namespace Sample
{
    class Program
```

```
    {
        static void Main(string[] args)
        {
            // 1. ============================================
            // NoThreadNoTask();
            Console.WriteLine("1. NoThreadNoTask(); ====================");
            NoThreadNoTask();
            // 2. ============================================
            // UnprotectedThread();
            Console.WriteLine("2. UnprotectedThread(); ====================");
            UnprotectedThread();
            // 3. ============================================
            // ProtectedThreadV3(), Interlocked
            Console.WriteLine("3. ProtectedThreadV3(), Interlocked ====================");
            ProtectedThreadV3();
            // 4. ============================================
            // ProtectedThreadV4(), lock()
            Console.WriteLine("4. ProtectedThreadV4(), lock() ====================");
            ProtectedThreadV4();
            // 5. ============================================
            // ProtectedThreadV5(), Monitor.Enter
            Console.WriteLine("5. ProtectedThreadV5(), Monitor.Enter ====================");
            ProtectedThreadV5();
            // 6. ============================================
            //ProtectedThreadV6(), Monitor.Enter(Object obj, Boolean lockTaken)
            Console.WriteLine(
                "6. ProtectedThreadV6(), Monitor.Enter(Object obj, Boolean lockTaken)
====================");
            ProtectedThreadV6();
            Console.ReadLine();
        }


        // 1. ============================================
        // NoThreadNoTask();
        static int Total = 0;




        static void SumTo10000()
        {
            for (int i = 1; i <= 10000; i++)
            {
                Total++;
            }
        }




        static void NoThreadNoTask()
        {
            Console.WriteLine("Beginning of NoThreadNoTask()");
            SumTo10000();
            SumTo10000();
            SumTo10000();
            Console.WriteLine("Total = " + Total);
            Console.WriteLine("End of NoThreadNoTask()");
        }
```

```
/*
1. NoThreadNoTask(); ====================
Beginning of NoThreadNoTask()
Total = 30000
End of NoThreadNoTask()
*/




// 2. ============================================
// UnprotectedThread();
static int Total2 = 0;




static void SumTo10000V2()
{
    for (int i = 1; i <= 10000; i++)
    {
        Total2++;
    }
}




static void UnprotectedThread()
{
    Console.WriteLine("Beginning of UnprotectedThread()");
    Thread t1 = new Thread(SumTo10000V2);
    Thread t2 = new Thread(SumTo10000V2);
    Thread t3 = new Thread(SumTo10000V2);
    t1.Start();
    t2.Start();
    t3.Start();
    t1.Join();
    t2.Join();
    t3.Join();
    Console.WriteLine($"Total2=={Total2}");
    Console.WriteLine("End of UnprotectedThread()");
}
/*
2. UnprotectedThread(); ====================
Beginning of UnprotectedThread()
Total2==23489
End of UnprotectedThread()
--------------
A.
每次跑的時候，我們都將得到不同的結果
這裡的 23489 是目前這次的結果，
下次再跑的時候，就不一定是 23489
原因是因為，這裡的 Total2 是一個 global variable
Total2 同時被 t1, t2, t3 所共用
舉例來說，當 t1 執行的時候，t1 正在把 Total2++
然後"同時"剛好 t2 想要存取 Total2
但是此時 Total2 剛好被 t1 佔用了
所以，t2 沒辦法執行 Total2++
t2 只好暫時跳過 for loop 此輪，進入下一輪
因此，此次的 Total2++就被忽略了
```

```
以此類推，
運氣好的話，Total2 最高可達 30000
但是運氣不好的話，Total2 會得到 30000 以下的任何一個數字
//------
B.
由此可知，我們需要一個 Lock 來確保永遠可以得到 30000
我們下一點來解釋 Lock
--------------
Every time we get the different output of total.
Because int Total field is a shared resource which
is unprotected from concurrent access by multiple threads.
Thus, it need lock or interlock for shared resource.
 */


// 3. ============================================
// ProtectedThreadV3(), Interlocked
static int Total3 = 0;




static void SumTo10000V3()
{
    for (int i = 1; i <= 10000; i++)
    {
        Interlocked.Increment(ref Total3);
    }
}




static void ProtectedThreadV3()
{
    Console.WriteLine("Beginning of ProtectedThreadV3()");
    Thread t1 = new Thread(SumTo10000V3);
    Thread t2 = new Thread(SumTo10000V3);
    Thread t3 = new Thread(SumTo10000V3);
    t1.Start();
    t2.Start();
    t3.Start();
    t1.Join();
    t2.Join();
    t3.Join();
    Console.WriteLine($"Total3=={Total3}");
    Console.WriteLine("End of ProtectedThreadV3()");
}
/*
3. ProtectedThreadV3(), Interlocked ====================
Beginning of ProtectedThreadV3()
Total3==30000
End of ProtectedThreadV3()
-----------------------
A.
Reference:
https://docs.microsoft.com/en-us/dotnet/api/system.threading.interlocked?view=netframework-4.8
Interlocked.Increment(ref Total3);
這行的意思就是，執行 Total3++
只是執行的時候會把 Total3 給"安全地"鎖住
讓 Total3 不會被其他的其他 thread 所影響
//------
```

```
B.
Interlocked 會經過 Dot Net 自己特別的運算機制,
你不需要太過了解機制是怎麼運作的
你只需要知道, 通常 Interlocked 速度很快
你可以很安心的使用
----------------------
Interlocked is safe and effectively does
the read, increment, and write in 'one hit'
which can't be interrupted.
Because of this it won't affect any other code,
and you don't need to remember to lock elsewhere either.
It's also very fast
(as MSDN says, on modern CPUs this is often literally a single CPU instruction).
*/



// 4. ============================================
//ProtectedThreadV4(), lock()
static int Total4 = 0;
static object _lockV4 = new object();




static void SumTo10000V4()
{
    for (int i = 1; i <= 10000; i++)
    {
        lock (_lockV4)
        {
            Total4++;
        }
    }
}




static void ProtectedThreadV4()
{
    Console.WriteLine("Beginning of ProtectedThreadV4()");
    Thread t1 = new Thread(SumTo10000V4);
    Thread t2 = new Thread(SumTo10000V4);
    Thread t3 = new Thread(SumTo10000V4);
    t1.Start();
    t2.Start();
    t3.Start();
    t1.Join();
    t2.Join();
    t3.Join();
    Console.WriteLine($"Total4=={Total4}");
    Console.WriteLine("End of ProtectedThreadV4()");
}
/*
4. ProtectedThreadV4(), lock() ====================
Beginning of ProtectedThreadV4()
Total4==30000
End of ProtectedThreadV4()
----------------------
A.
static object _lockV4 = new object();
這邊我們用創立一個_lockV4 object 當作我們的 lock
```

```
lock (_lockV4)
{
    Total4++;
}
```
我們用手動的方式檢查將_lockV4 object 這個 lock 上鎖
然後在上鎖期間，執行 Total4++;
然後才將_lockV4 object 這個 lock 解鎖
所以 Total4 並不會被其他 thread 影響

B.
Interlocked V.S. Lock
Interlocked 的 performance(執行效率)通常會比手動的 lock 好
Reference:
https://stackoverflow.com/questions/154551/volatile-vs-interlocked-vs-lock
https://docs.microsoft.com/en-us/dotnet/standard/threading/interlocked-operations
B.1.
Lock 通常會"鎖住"其他的 thread
並且期待 current thread 可以"安全地"
去 update 這個共用的 global variable.
但是，"手動上鎖"這個動作，對效率是很傷的
B.2.
所以微軟特別提供 Interlocked
Interlocked 會經過 Dot Net 自己特別的運算機制，
你不需要太過了解機制是怎麼運作的
你只需要知道，通常 Interlocked 速度很快
你可以很安心的使用
B.3.
Interlocked 有許多使用上的限制
有的時候並不能滿足我們的需求
所以逼不得已的時候，還是得使用"手動 lock"
但是如果能使用 Interlocked 的時候
請盡量使用 Interlocked

1.
Interlocked V.S. Lock
Interlocked has better performance than lock.
Reference:
https://stackoverflow.com/questions/154551/volatile-vs-interlocked-vs-lock
https://docs.microsoft.com/en-us/dotnet/standard/threading/interlocked-operations
1.1.
Locking locks all other threads and except current thread
update the shared field, Total variable, and ensure that
the Total variable is updated safely,
However, locking reduce the performance.
1.2.
Interlocked is safe and effectively does
the read, increment, and write in 'one hit'
which can't be interrupted.
Because of this it won't affect any other code,
and you don't need to remember to lock elsewhere either.
It's also very fast
(as MSDN says, on modern CPUs this is often literally a single CPU instruction).
*/

```
// 5. ============================================
//ProtectedThreadV5(), Monitor.Enter
static int Total5 = 0;
static object _lockV5 = new object();
```

```
public static void SumTo10000V5()
{
    for (int i = 1; i <= 10000; i++)
    {
        // Acquires the exclusive lock
        Monitor.Enter(_lockV5);
        try
        {
            Total5++;
        }
        finally
        {
            // Releases the exclusive lock
            Monitor.Exit(_lockV5);
        }
    }
}
```

```
static void ProtectedThreadV5()
{
    Console.WriteLine("Beginning of ProtectedThreadV5()");
    Thread t1 = new Thread(SumTo10000V5);
    Thread t2 = new Thread(SumTo10000V5);
    Thread t3 = new Thread(SumTo10000V5);
    t1.Start();
    t2.Start();
    t3.Start();
    t1.Join();
    t2.Join();
    t3.Join();
    Console.WriteLine($"Total5=={Total5}");
    Console.WriteLine("End of ProtectedThreadV5()");
}
/*
5. ProtectedThreadV5(), Monitor.Enter ====================
Beginning of ProtectedThreadV5()
Total5==30000
End of ProtectedThreadV5()
-----------------
A.
lock 其實是 Monitor.Enter 的"縮寫語法"
其實他們都是在做"手動上鎖"這個作用相同的事情
只是 Monitor.Enter 這個語法允許你做
Monitor.Exit(_lockV5);
來釋放你的"特定的 lock"
通常 Monitor.Enter 會搭配 try-catch-finally 一起使用
https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/keywords/try-catch-finally
可以在 finally 裡面執行
Monitor.Exit(_lockV5);
確保_lockV5 肯定會被"手動解鎖"
--------
B.
lock (_lockV4)
{
    Total4++;
}
如果你只使用 lock 語法
那麼你必須等到系統"自動解鎖"
系統通常都是火燒屁股的才動手
```

```
這對效率可能會有點影響
所以建議盡量使用
Monitor.Enter 會搭配 try-catch-finally 一起使用
-----------------
1.
lock is a shortcut of Monitor.Enter.
Both are doing the same things.
Monitor.Enter provide more options to control.
1.1.
lock (_lockV4)
{
    Total4++;
}
1.2.
Monitor.Enter(_lockV5);
try
{
    Total5++;
}
finally
{
    // Releases the exclusive lock
    Monitor.Exit(_lockV5);
}
*/


// 6. ============================================
//ProtectedThreadV6(), Monitor.Enter(Object obj, Boolean lockTaken)
static int Total6 = 0;
static object _lockV6 = new object();




public static void SumTo10000V6()
{
    for (int i = 1; i <= 10000; i++)
    {
        bool lockTaken = false;
        Monitor.Enter(_lockV6, ref lockTaken);
        try
        {
            Total6++;
        }
        finally
        {
            // Releases the exclusive lock
            if (lockTaken)
                Monitor.Exit(_lockV6);
        }
    }
}




static void ProtectedThreadV6()
{
    Console.WriteLine("Beginning of ProtectedThreadV6()");
    Thread t1 = new Thread(SumTo10000V6);
```

```
Thread t2 = new Thread(SumTo10000V6);
Thread t3 = new Thread(SumTo10000V6);
t1.Start();
t2.Start();
t3.Start();
t1.Join();
t2.Join();
t3.Join();
Console.WriteLine($"Total6=={Total6}");
Console.WriteLine("End of ProtectedThreadV6()");
/*
6. ProtectedThreadV6(), Monitor.Enter(Object obj,?Boolean lockTaken) ====================
Beginning of ProtectedThreadV6()
Total6==30000
End of ProtectedThreadV6()
---------------------------------
A.
Monitor.Enter(Object obj,?Boolean lockTaken)
這個語法, 又比上面討論的
Monitor.Enter(_lockV5);
又更嚴謹一點, 推薦盡量使用
Monitor.Enter(Object obj,?Boolean lockTaken)
---------
B.
bool lockTaken = false;
Monitor.Enter(_lockV6, ref lockTaken);
try
{
    Total6++;
}
finally
{
    // Releases the exclusive lock
    if (lockTaken)
        Monitor.Exit(_lockV6);
}
-----
B.1.
這邊我們介紹一下
Monitor.Enter(_lockV6, ref lockTaken);
這個語法的固定用法
-----
B.2.
bool lockTaken = false;
首先, 我們必須要先設立一個 bool variable
***也就是 lockTaken, 並且 value 一定要設為 false***
-----
B.3.
接著, 把這個 bool variable 也就是 lockTaken
放進 Monitor.Enter(_lockV6, ref lockTaken);
***要確認這邊必須要使用 ref 這個 keyword***
-----
B.4.
當_lockV6 這個 object 還在被"上鎖的時候"
Monitor.Enter 會把 ref lockTaken 這個變數設為 true.
所以在
finally
{
    // Releases the exclusive lock
    if (lockTaken)
        Monitor.Exit(_lockV6);
}
我們可以判斷
如果 lockTaken==true
代表這個_lockV6 object 還正在被上鎖中
```

```
            所以我們使用
            Monitor.Exit(_lockV6);
            來將_lockV6 object 解鎖
            -----
            B.5.
            因為我們有先用 if 確認是否有上鎖
            如果有上鎖
            才解鎖
            不像之前討論的 sample code
            是不分青紅皂白, 不管有沒有上鎖, 都直接解鎖
            因為多了一層 if 來確認是否上鎖
            所以這種寫法更嚴謹一點,
            請盡量使用
            Monitor.Enter(_lockV6, ref lockTaken);
            這是此篇 tutorial 的結論
            --------------------------------
            1.
            Monitor.Enter(Object obj, Boolean lockTaken)
            1.1.
            Acquires an exclusive lock on the specified object,
            and atomically sets a value that
            indicates whether the lock was taken.
            1.2.
            Boolean lockTaken
            The result of the attempt to acquire the lock, passed by reference.
            The input must be false.
            The output is true if the lock is acquired
            */
        }
    }
}
```

```
1. NoThreadNoTask(); ====================
Beginning of NoThreadNoTask()
Total = 30000
End of NoThreadNoTask()
2. UnprotectedThread(); ====================
Beginning of UnprotectedThread()
Total2==20988
End of UnprotectedThread()
3. ProtectedThreadV3(), Interlocked ====================
Beginning of ProtectedThreadV3()
Total3==30000
End of ProtectedThreadV3()
4. ProtectedThreadV4(), lock() ====================
Beginning of ProtectedThreadV4()
Total4==30000
End of ProtectedThreadV4()
5. ProtectedThreadV5(), Monitor.Enter ====================
Beginning of ProtectedThreadV5()
Total5==30000
End of ProtectedThreadV5()
6. ProtectedThreadV6(), Monitor.Enter(Object obj,?Boolean lockTaken) ====================
Beginning of ProtectedThreadV6()
Total6==30000
End of ProtectedThreadV6()
```