Module 05:
”The Thread Pool”

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Agenda

- **The Thread Pool**
- Asynchronous Delegates
- Timers

The Thread Pool

The Thread Pool

- A regiment of virtual threads at your disposal
- Avoids the overhead of creating and managing threads manually
  - Resource consumption
  - Timing overhead at creation
  - No administrative burdens
  - Automatic queueing and ”lining up” for more work
- Limits the amount of worker threads running concurrently

Use Cases for Thread Pool

- Explicitly queuing using ThreadPool class
- Invoking asynchronous delegates
- Timer ticks

Up shortly

- WPF, WCF, ASP.NET frameworks

- Using Task Parallel Library (Day 2)
  - Parallel class
  - PLINQ
  - CPU-bound tasks

Later...

Using the Thread Pool

- Explicitly queue for **`ThreadPool`** execution

```
for (int i = 0; i < 100; i++)
{
    ThreadPool.QueueUserWorkItem(Go); // <-- Parameter is null
    ThreadPool.QueueUserWorkItem(Go, i);
    ThreadPool.QueueUserWorkItem(_ => Console.WriteLine(i));
}
```

```
void Go(object parameter)
{
    Console.WriteLine($"{number} printed");
}
```

- Executed **`WaitCallback`** should be "small and quick"

Thread Pool Important Facts

- Pooled threads are <u>always</u> background threads
- Thread priority can be changed temporarily
  - Will revert back to Normal when recycled

- Cumbersome to debug
  - `Name` property cannot be set
  - `Thread.CurrentThread.IsThreadPoolThread` property
  - But short-lived anyway…!

Optimizing the Thread Pool

- The Thread Pool has advanced heurestics for adding and removing thread pool threads when it sees fit

```
ThreadPool.GetAvailableThreads( out int availWT, out int availCPT);

ThreadPool.GetMaxThreads(out int maxWT, out int maxCPT);

ThreadPool.GetMinThreads(out int minWT, out int minCPT);
```

- Actual min/max thread counts depend upon
  - hardware,
  - CLR version,
  - hosting environment,
  - …

- You should probably never touch these numbers directly!

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Best Practices for using Thread Pool

- Do…
  - Keep executed methods short-lived
- Don't…
  - Block (too many) thread pool threads!
  - Interfere with Thread Pool intrinsics by invoking
    - `ThreadPool.SetMinThreads()`
    - `ThreadPool.SetMaxThreads()`

Agenda

- Thread Pool
- **Asynchronous Delegates**
- Timers

Synchronous Delegate Invocation

- Usual delegate invocation is synchronous

```
Func<int, int, int> del = Add;
int result = del.Invoke(42, 87);
Console.WriteLine(result);
```

```
int Add(int a, int b)
{
   return a + b;
}
```

Asynchronous Delegate Invocation

- All delegates can be invoked asynchronously as well

```
Func<int, int, int> del = Add;
IAsyncResult state = del.BeginInvoke(42, 87, null, null);

// ...

int result = del.EndInvoke(state);
Console.WriteLine(result);
```

```
int Add(int a, int b)
{
   return a + b;
}
```

BeginInvoke() and EndInvoke()

- `BeginInvoke`
  - Starts computation on thread pool thread.
  - Returns **`IAsyncResult`** to caller immediately ("ticket")

- `EndInvoke`
  - Waits for the computation to finish, i.e. blocks!
  - Receives return (and **`out`** and **`ref`**) value(s)
  - Throws any unhandled exception from computation to caller

Asynchronous Callback

- All delegates can be invoked ”nonblocking” with callback

```
Func<int, int, int> del = Add;
IAsyncResult state = del.BeginInvoke(42, 87, Callback, del);

// ...
```

```
static void Callback( IAsyncResult state )
{
    var del = state.AsyncState as Func<int,int,int>;
    int result = del.EndInvoke(state);

    Console.WriteLine(result);
}
```

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- **Timers**

An Overview of Timers

- We will see three interesting timer classes
- ThreadPool-based:
  - `System.Threading.Timer`
  - `System.Timers.Timer`

Up shortly

- Dispatcher-based:
  - `System.Windows.Threading.DispatcherTimer`

Case Study A

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System.Threading.Timer

- A simplistic timer

```
Timer timer = new Timer(
    OnTimerCallback,
    null,
    2000,
    1000
);
```

```
void OnTimerCallback(object data)
{
    Console.WriteLine( $"The time is {DateTime.Now}");
}
```

- Keeps ticking
  - Use **`Timer.Change()`** to change intervals (or disable) timer

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System.Timers.Timer

- Adds functionality to **`System.Threading.Timer`**

```
Timer timer = new Timer( 3000 );
timer.Elapsed += OnTimerElapsed; // CLR event
timer.AutoReset = false;         // <-- Raise only once
timer.Start();
...
Timer.Stop();
```

```
void OnTimerElapsed(object sender, ElapsedEventArgs e)
{
    Console.WriteLine($"The time is {e.SignalTime}");}
}
```

- Also contains **`SynchronizingObject`** property for WPF

Summary

- Thread Pool
- Asynchronous Delegates
- Timers

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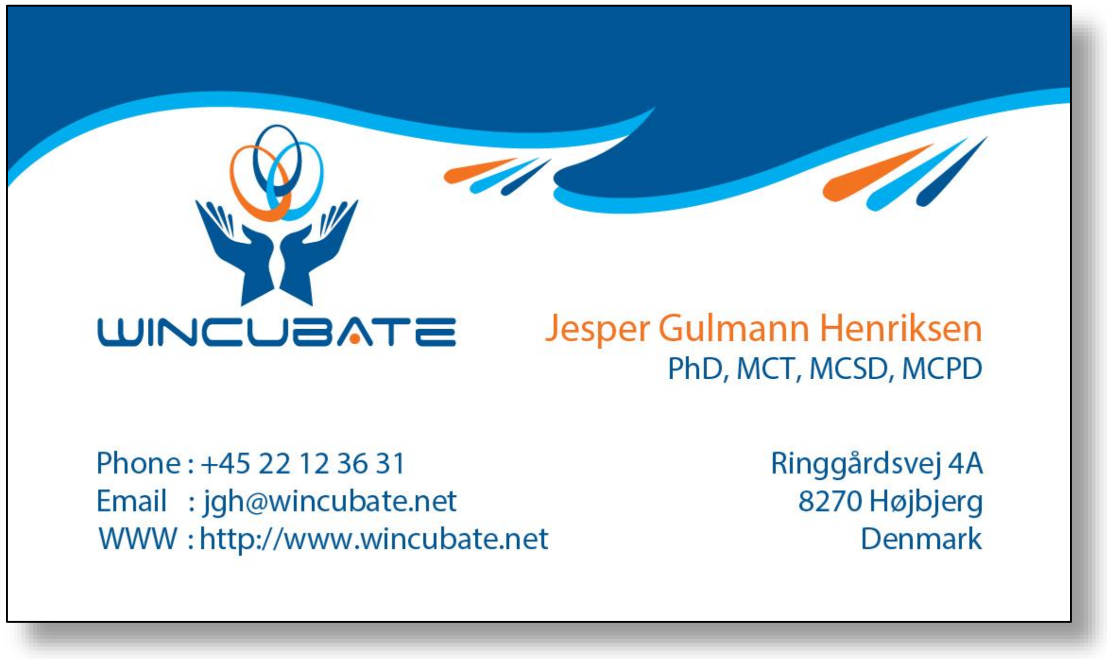

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