The Future of Parallel Programming in the .NET Framework

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DISCLAIMER

- This is a talk about the {near} future…
  - All content is subject to change.
  - The technology being discussed…
    - …is mostly available in CTP form now.
    - …may never actually ship (but we're doing the best we can to make it).

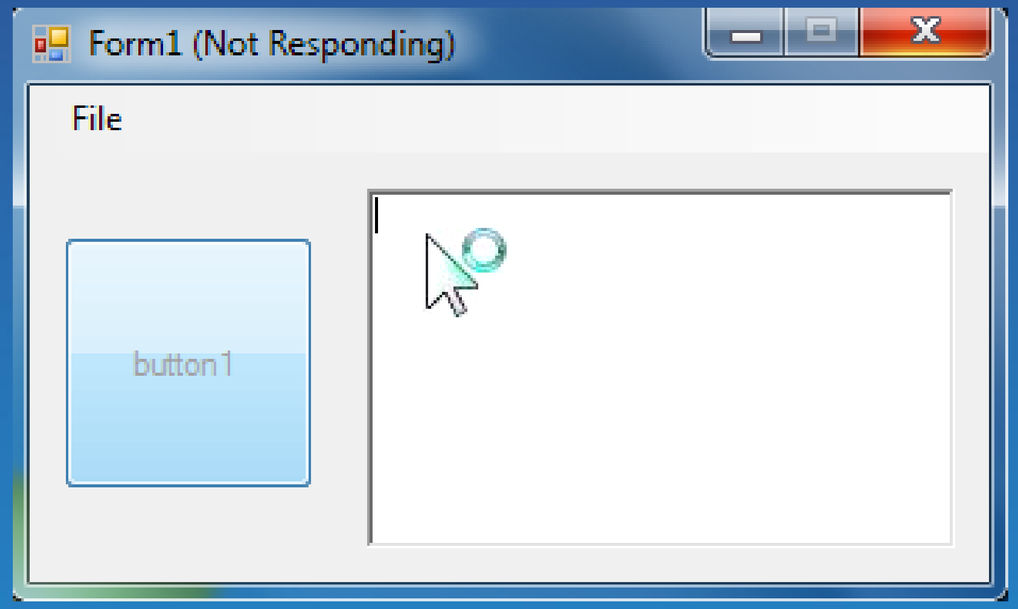
Agenda

- Future
  - Visual Studio Async
  - TPL Dataflow

Visual Studio Async
Trends

Increasingly connected applications

- More latency (e.g. everything as a service)
- More UI responsiveness problems
- User → =(



Visual Studio Async
Asynchronous Programming in .NET Today

```
// Synchronous
TResult Foo(...);
```

```
// Asynchronous Programming Model (APM)
IAsyncResult BeginFoo(..., AsyncCallback callback, object state);
TResult EndFoo(IAsyncResult asyncResult);
```

```
// Event-based Asynchronous Pattern (EAP)
public void FooAsync(...);
public event EventHandler<FooCompletedEventArgs> FooCompleted;
```

Visual Studio Async

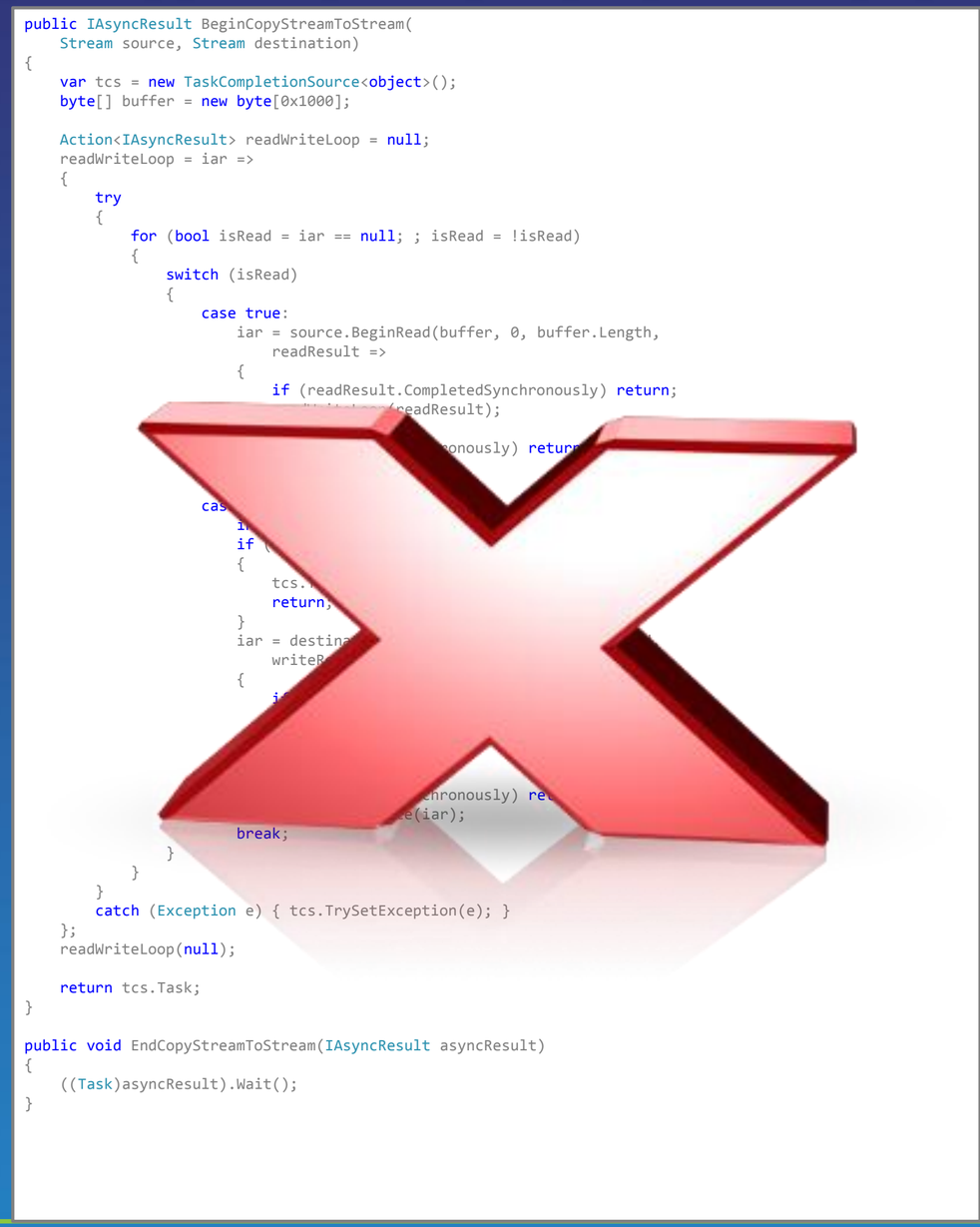
Your synchronous code with .NET 4…

```
public void CopyStreamToStream(Stream source, Stream destination)
{
    byte[] buffer = new byte[0x1000];
    int numRead;
    while ((numRead = source.Read(buffer, 0, buffer.Length)) != 0)
    {
        destination.Write(buffer, 0, numRead);
    }
}
```

Visual Studio Async

An *expert's* asynchronous code with .NET 4…

```
public void CopyStreamToStream(Stream source, Stream destination)
{
    byte[] buffer = new byte[0x1000];
    int numRead;
    while ((numRead = source.Read(buffer, 0, buffer.Length)) != 0)
    {
        destination.Write(buffer, 0, numRead);
    }
}
```



Visual Studio Async

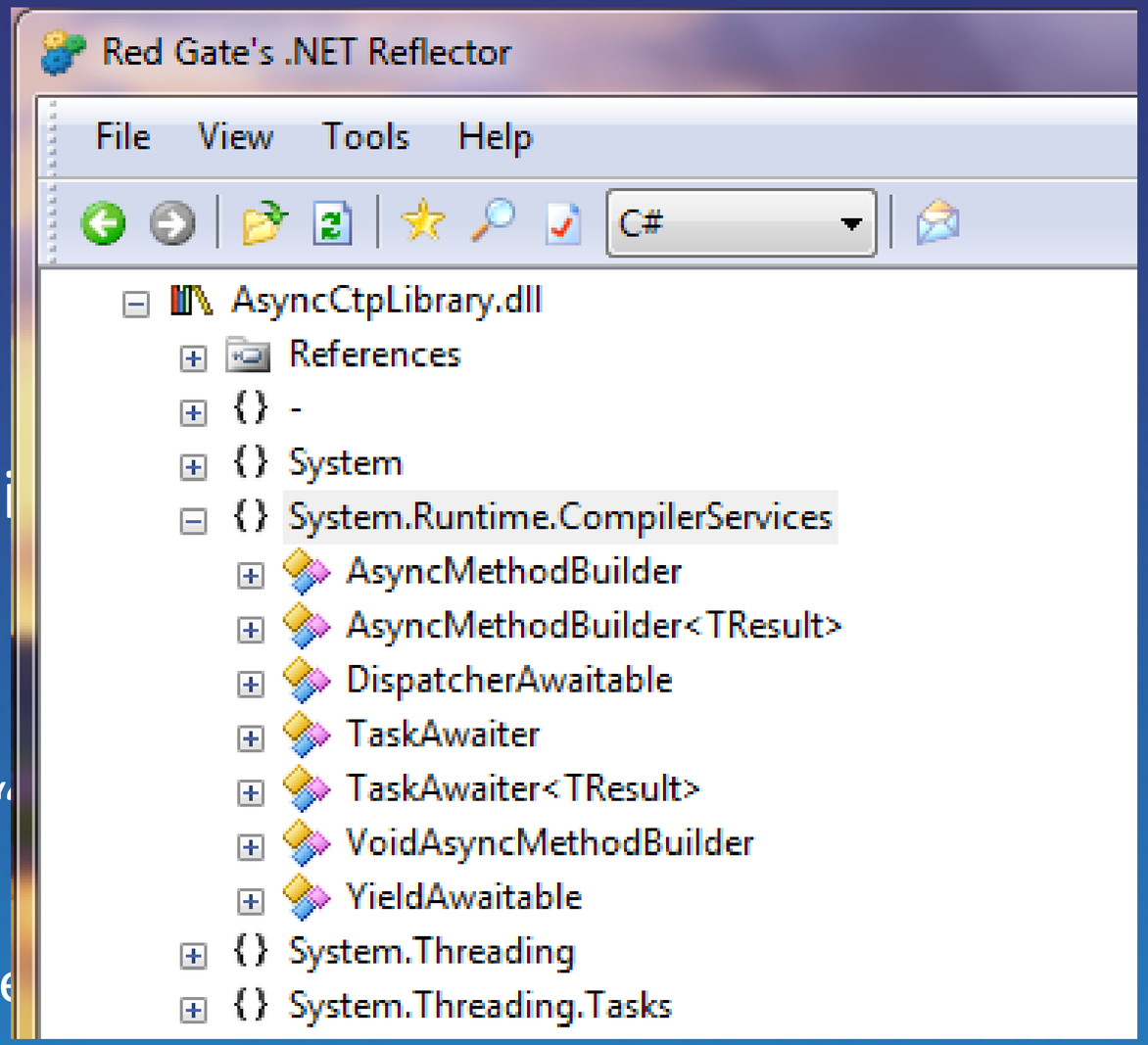
Your asynchronous code with the Visual Studio Async CTP…

```
public void CopyStreamToStream(Stream source, Stream destination)
{
    byte[] buffer = new byte[0x1000];
    int numRead;
    while ((numRead = source.Read(buffer, 0, buffer.Length)) != 0)
    {
        destination.Write(buffer, 0, numRead);
    }
}
```

```
public async Task CopyStreamToStreamAsync(Stream source, Stream destination)
{
    byte[] buffer = new byte[0x1000];
    int numRead;
    while ((numRead = await source.ReadAsync(buffer, 0, buffer.Length)) != 0)
    {
        await destination.WriteAsync(buffer, 0, numRead);
    }
}
```

Visual Studio Async
Tasks and Language

- Language
  - “async” modifier marks method or
  - “await” operator yields control unti
- Framework
  - Task and Task<TResult> represent “
    - E.g. Async I/O, background work, etc.
    - Single object for status, result, and exce
  - New APIs round out the experience



Visual Studio Async
Related Additions

- Combinators
  - Task.WhenAll, Task.WhenAny
- Timer integration
  - Task.Delay(TimeSpan), CancellationTokenSource.CancelAfter(TimeSpan)
- Task scheduling
  - ConcurrentExclusiveSchedulerPair
- Fine-grained control
  - TaskCreationOptions.DenyChildAttach
  - EnumerablePartitionerOptions
- ThreadLocal.Values

Visual Studio Async
Async in .NET Tomorrow

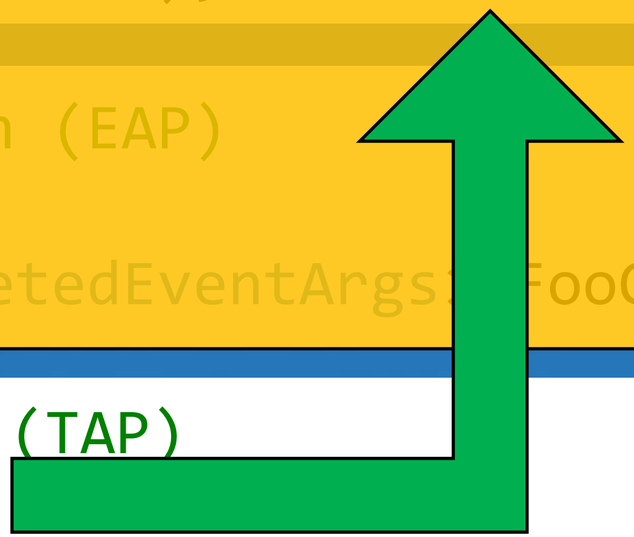
```
// Synchronous
TResult Foo(...);
```

```
// Asynchronous Programming Mod
IAsyncResult BeginFoo(..., Asyn
TResult EndFoo(IAsyncResult asyncResult);
```

```
// Event-based Asynchronous Pattern (EAP)
public void FooAsync(...);
public event EventHandler<FooCompletedEventArgs> FooCompleted;
```

```
// Task-based Asynchronous Pattern (TAP)
Task<TResult> FooAsync(...);
```

```
System.IO.Stream.ReadAsync(...);
                .WriteAsync(...);
                .FlushAsync();
                .CopyToAsync(...);
```



Visual Studio Async
Demo

- DEMO – Sleeping on the UI
- Async CTP: http://msdn.microsoft.com/en-us/vstudio/async.aspx

Agenda Checkpoint

- Future
  - Tasks and Language
  - **TPL Dataflow**

TPL Dataflow
Complementing Parallel Programming in .NET 4

- Proactive in nature
  - “Here’s the data. Now set up the computation.”
  - Primitives for task and data parallelism
- Missing the reactive piece
  - “Set up the computation. Now here’s the data.”
  - Primitives for dataflow parallelism

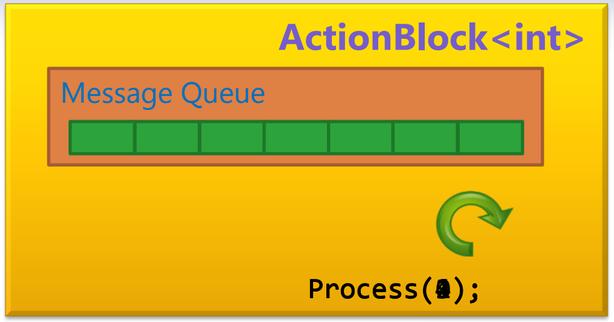
TPL Dataflow
Overview

- Primitives for in-process message passing
  - Blocks that can buffer and process data
  - Can be linked together to create networks
- Inspired by
  - Decades of computer science research/history
  - Related Microsoft technologies
    - Asynchronous Agents library in Visual C++ 2010
    - CCR from Microsoft Robotics
    - Axum incubation project

TPL Dataflow
Async Posting Example

```
var c = new ActionBlock<int>(i =>
{
    Process(i);
});

for(int i = 0; i < 5; i++)
{
    c.Post(i);
}
```



TPL Dataflow
Blocks for Buffering and Propagation

- BufferBlock<T>
  - Buffers an unlimited number of elements
  - Delivers each element to at most 1 target
- WriteOnceBlock<T>
  - Accepts and buffers only 1 element, ever
  - Delivers the 1 element to all linked targets
- BroadcastBlock<T>
  - Overwrites each element with the next (buffers until this happens)
  - Delivers each element to all linked targets

TPL Dataflow
Blocks for Executing

- ActionBlock<TInput>
  - Executes an Action<TInput> for each element
  - Buffers input until processed
- TransformBlock<TInput, TOutput>
  - Executes a Func<TInput, TOutput> for each element
  - Buffers input until processed and output until consumed
- TransformManyBlock<TInput, TOutput>
  - Executes a Func<TInput, IEnumerable<TOutput>> for each element
  - Buffers input until processed and output until consumed

TPL Dataflow
Blocks for Joining

- BatchBlock<T>
  - Groups multiple Ts into one T[]
  - Supports greedy and non-greedy
- JoinBlock<T1, T2>
  - Groups on T1 and one T2 to form a Tuple<T1, T2>
  - Supports greedy and non-greedy
- BatchedJoinBlock<T1, T2>
  - Groups T1s and T2s into one Tuple<IList<T1>, IList<T2>>

Related Content

- Parallel Programming Dev Center:
  - http://msdn.microsoft.com/en-us/concurrency
- Downloads
  - Async CTP: http://msdn.microsoft.com/en-us/vstudio/async.aspx
  - TPL Dataflow: http://msdn.microsoft.com/en-us/devlabs/tclabs
- Forums
  - Async: http://social.msdn.microsoft.com/Forums/en-US/async/threads
  - Parallel Extensions: http://social.msdn.microsoft.com/Forums/en-US/parallelextensions/threads

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