Most Common Mistakes in Using Tasks and in Asynchronous Code

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Why asynchronous?

- Offloading
  - I.e. free UI thread
  - Not all threads are equal
- Concurrency
  - Multiple operations at once
- Scalability
  - (not) wasting resources

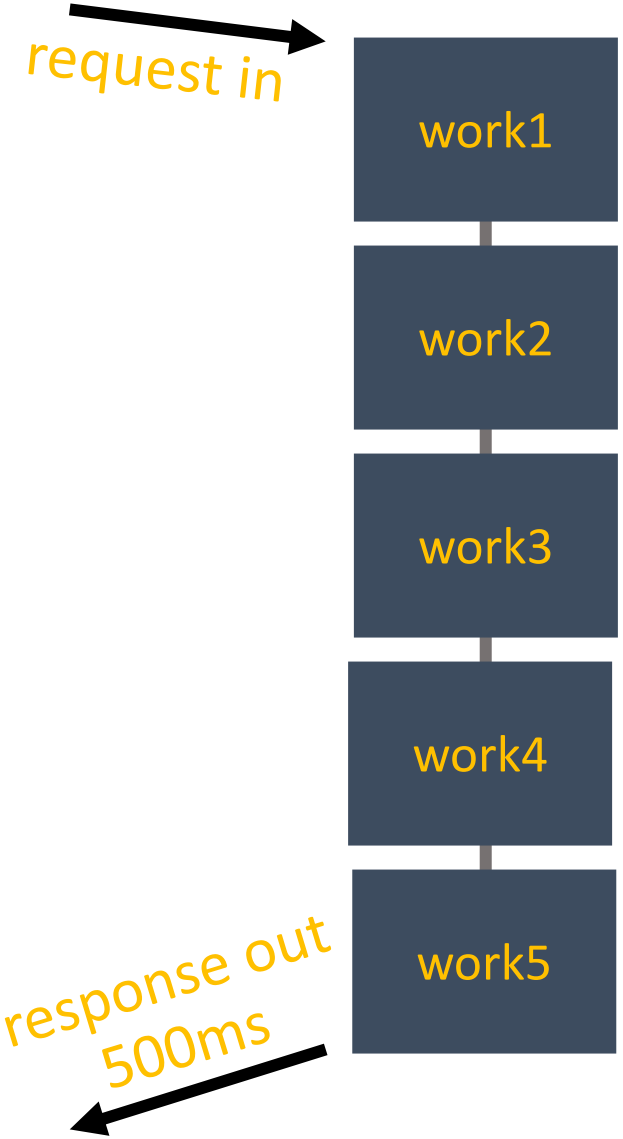
Why asynchronous?

- Asynchronous operations existed since stone age
  - BeginXxx, EndXxx (APM)
  - EAP
- *async*/*await* is not about creating (from nothing) async methods…
- …but a way to compose/consume async methods

CPU bound vs IO bound operations

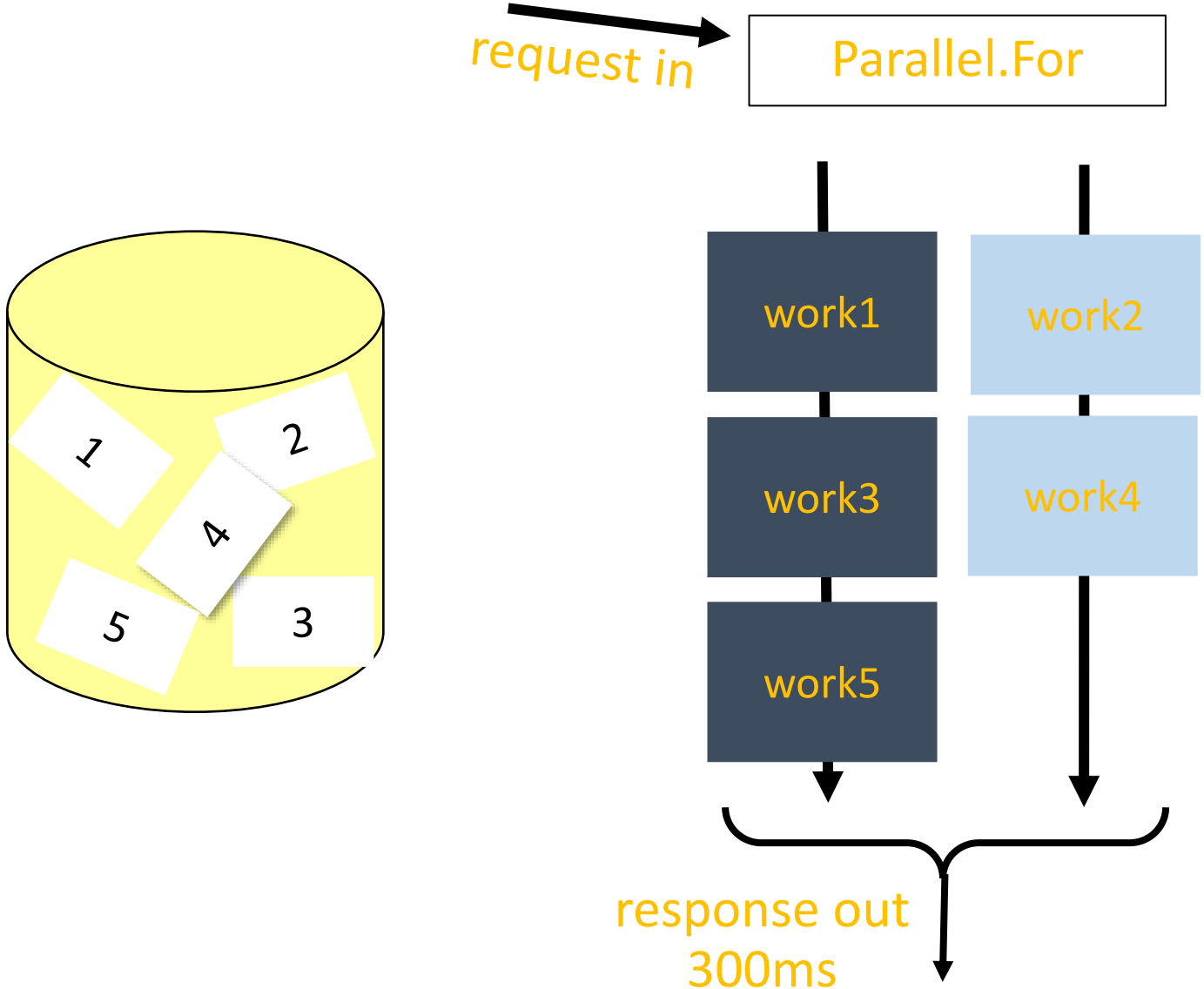
```
public List<Something> LoadSomething()
{
  var result = new List<Something>();
  for (var i = 1; i <= 5; i++)
  {
    var s = Something.LoadFromNetwork(id: i);
    result.Add(s);
  }
  return result;
}
```

CPU bound vs IO bound operations



Source: Lucian Wischik

CPU bound vs IO bound operations



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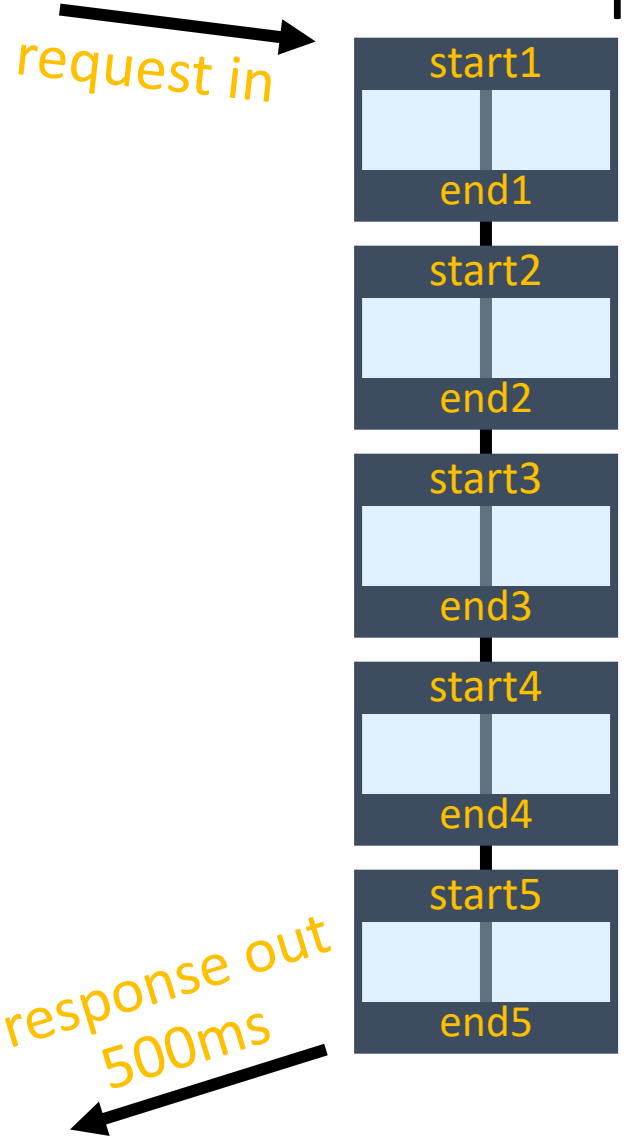
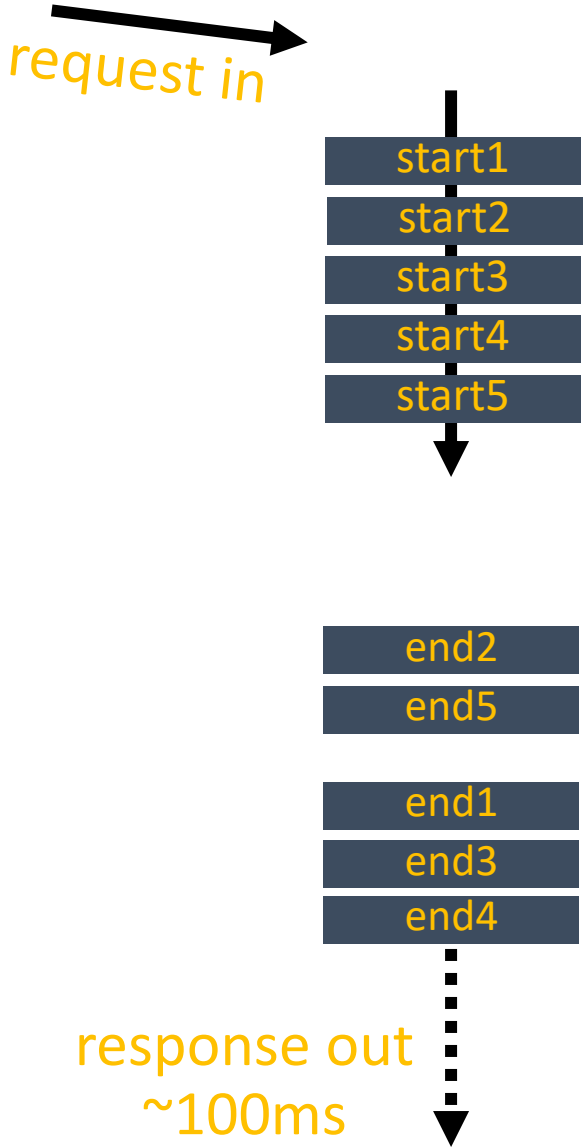
CPU bound vs IO bound operations



Source: Lucian Wischik

CPU bound vs IO bound operations



Source: Lucian Wischik

CPU bound vs IO bound operations

- CPU bound
  - *Parallel.For*, *Task.Run, …*
- IO bound
  - *async* (real async code)

Async method runs on…

- … thread
  - True? False?
- … thread pool
  - True? False?
- False. False.
  - Scalability
  - Asynchronous operations are performed by HW (then I/O completion port)

Task.FromResult for “known” data

```
public Task<int> AddAsync(int a, int b)
{
  return Task.Run(() => a + b);
}

public Task<int> AddAsync(int a, int b)
{
  return Task.FromResult(a + b);
}
```

Task.FromResult for “known” data

- Task is a reference type (=> on heap)
- *ValueTask<T>*

```
public ValueTask<int> AddAsync(int a, int b)
{
  return new ValueTask<int>(a + b);
}
```

Long-running operations

- Long-running = background processing, sleep-wake
- Thread pool thread blocked
  - Injection solves it, but that doesn’t make it correct
- No `TaskCreationOptions.LongRunning`
  - Creates a thread and first `await` destroys is

```
public class QueueProcessor
{
    private readonly BlockingCollection<Message> _messageQueue = new BlockingCollection<Message>();

    public void StartProcessing()
    {
        Task.Run(ProcessQueue);
    }

    public void Enqueue(Message message)
    {
        _messageQueue.Add(message);
    }

    private void ProcessQueue()
    {
        foreach (var item in _messageQueue.GetConsumingEnumerable())
        {
            ProcessItem(item);
        }
    }

    private void ProcessItem(Message message) { }
}
```

```
public class QueueProcessor
{
    private readonly BlockingCollection<Message> _messageQueue = new BlockingCollection<Message>();

    public void StartProcessing()
    {
        var thread = new Thread(ProcessQueue)
        {
            // This is important as it allows the process to exit while this thread is running
            IsBackground = true
        };
        thread.Start();
    }

    public void Enqueue(Message message)
    {
        _messageQueue.Add(message);
    }

    private void ProcessQueue()
    {
        foreach (var item in _messageQueue.GetConsumingEnumerable())
        {
             ProcessItem(item);
        }
    }

    private void ProcessItem(Message message) { }
}
```

await task === task.Wait();???

- *.Wait()* is blocking
  - Waiting for completions
- *await* jumps back here as soon as the operation is completed
  - Continuations and coroutines

Task.Result and Task.Wait

- Sync over async
- Better call synchronous API directly

- Uses up to 2 threads
  - Blocked + callback
  - Thread pool starvation

- Deadlocks via `SynchronizationContext`
  - Do not invent stuff

Async must be everywhere

```
public int DoSomethingAsync()
{
  var result = CallDependencyAsync().Result;
  return result + 1;
}

public async Task<int> DoSomethingAsync()
{
  var result = await CallDependencyAsync();
  return result + 1;
}
```

Async must be everywhere

```
public string DoOperationBlocking()
{
    return Task.Run(() => DoAsyncOperation()).Result;
}
```

- Blocking the thread that enters.
- *DoAsyncOperation* will be scheduled on the default task scheduler, and remove the risk of deadlocking.
- In the case of an exception, this method will throw an *AggregateException* wrapping the original exception.

Async must be everywhere

```
public string DoOperationBlocking2()
{
    return Task.Run(() => DoAsyncOperation()).GetAwaiter().GetResult();
}
```

- Blocking the thread that enters.
- *DoAsyncOperation* will be scheduled on the default task scheduler, and remove the risk of deadlocking.

Async must be everywhere

```
public string DoOperationBlocking3()
{
    return Task.Run(() => DoAsyncOperation().Result).Result;
}
```

- Blocking the thread that enters, and blocking the thead pool thread inside.
- In the case of an exception, this method will throw an *AggregateException* containing another *AggregateException*, containing the original exception

Async must be everywhere

```
public string DoOperationBlocking4()
{
    return Task.Run(() => DoAsyncOperation().GetAwaiter().GetResult()).GetAwaiter().GetResult();
}
```

- Blocking the thread that enters, and blocking the theadpool thread inside.

Async must be everywhere

```
public string DoOperationBlocking5()
{
    return DoAsyncOperation().Result;
}
```

- Blocking the thread that enters.
- No effort has been made to prevent a present *SynchonizationContext* from becoming deadlocked.
- In the case of an exception, this method will throw an *AggregateException* wrapping the original exception.

Async must be everywhere

```
public string DoOperationBlocking6()
{
    return DoAsyncOperation().GetAwaiter().GetResult();
}
```

- Blocking the thread that enters.
- No effort has been made to prevent a present *SynchonizationContext* from becoming deadlocked.

Async must be everywhere

```
public string DoOperationBlocking7()
{
    var task = DoAsyncOperation();
    task.Wait();
    return task.GetAwaiter().GetResult();
}
```

- Blocking the thread that enters.
- No effort has been made to prevent a present *SynchonizationContext* from becoming deadlocked.


BLOCKING IS BAD
IT'S FINE
BLOCKING. IS. BAD.
MY APP
WORKS FINE
ASYNC!


.NET ASYNC!
.NET ASYNC, EVERYWHERE!
makeameme.org

Task.Result and Task.Wait (2)

- Constructors

```
public class Service : IService
{
  readonly IRemoteConnection _connection;

  public Service(IRemoteConnectionFactory connectionFactory)
  {
    _connection = connectionFactory.ConnectAsync().Result;
  }
}
```

- Factory

```
public static async Task<Service> CreateAsync(IRemoteConnectionFactory
connectionFactory)
{
  return new Service(await connectionFactory.ConnectAsync());
}
```

Await instead of ContinueWith

- `ContinueWith` existed before *await*
  - I.e. ignores `SynchronizationContext`

```
public Task<int> DoSomethingAsync()
{
  return CallDependencyAsync().ContinueWith(task =>
  {
    return task.Result + 1;
  });
}

public async Task<int> DoSomethingAsync()
{
  var result = await CallDependencyAsync();
  return result + 1;
}
```

TaskCompletionSource<T>

- Try/Set(Result/Exception/Canceled) runs inline
- Very dangerous
  - Re-entrancy, deadlocks, thread pool starvation, broken state, …
- `TaskCreationOptions.RunContinuationsAsynchronously`

```
var tcs = new TaskCompletionSource<int>(
  TaskCreationOptions.RunContinuationsAsynchronously);
var operation = new SomeOperation();
operation.Completed += result => { tcs.SetResult(result); };
return tcs.Task;
```

Passing CancellationToken

```
public async Task<string> DoAsyncThing(CancellationToken
cancellationToken = default)
{
  var buffer = new byte[1024];
  var read = await _stream.ReadAsync(buffer, 0, buffer.Length);
  return Encoding.UTF8.GetString(buffer, 0, read);
}

public async Task<string> DoAsyncThing(CancellationToken
cancellationToken = default)
{
  var buffer = new byte[1024];
  var read = await _stream.ReadAsync(buffer, 0, buffer.Length,
cancellationToken);
  return Encoding.UTF8.GetString(buffer, 0, read);
}
```

TimerQueue

- TimerQueue per CPU core
- Linked list of Timers
- Callbacks run on thread pool
- TimerQueue uses lock
- Disposing Timer removes it from TimerQueue

CancellationTokenSource for timeouts

```
public async Task<Stream> HttpClientAsyncWithCancellationBad() {
  var cts = new CancellationTokenSource(TimeSpan.FromSeconds(10));
  using (var client = _httpClientFactory.CreateClient()) {
    var response = await client.GetAsync("http://backend/api/1", cts.Token);
    return await response.Content.ReadAsStreamAsync();
  }
}

public async Task<Stream> HttpClientAsyncWithCancellationGood() {
  using (var cts = new CancellationTokenSource(TimeSpan.FromSeconds(10))) {
    using (var client = _httpClientFactory.CreateClient()) {
      var response = await client.GetAsync("http://backend/api/1", cts.Token);
      return await response.Content.ReadAsStreamAsync();
    }
  }
}
```

Timeout Task

```
public static async Task<T> TimeoutAfter<T>(this Task<T> task, TimeSpan timeout) {
  var delayTask = Task.Delay(timeout);
  var resultTask = await Task.WhenAny(task, delayTask);
  if (resultTask == delayTask) {
    throw new OperationCanceledException();
  }
  return await task;
}

public static async Task<T> TimeoutAfter<T>(this Task<T> task, TimeSpan timeout) {
  using (var cts = new CancellationTokenSource()) {
    var delayTask = Task.Delay(timeout, cts.Token);
    var resultTask = await Task.WhenAny(task, delayTask);
    if (resultTask == delayTask) {
      throw new OperationCanceledException();
    } else {
      cts.Cancel();
    }
    return await task;
  }
}
```

FlushAsync for Stream/StreamWriter

```
using (var streamWriter = new StreamWriter(s))
{
  await streamWriter.WriteAsync("Hello World");
}

using (var streamWriter = new StreamWriter(s))
{
  await streamWriter.WriteAsync("Hello World");
  await streamWriter.FlushAsync();
}
```

Timer callbacks

```
public class Pinger
{
  readonly Timer _timer;
  readonly HttpClient _client;

  public Pinger(HttpClient client)
  {
    _client = client;
    _timer = new Timer(Heartbeat, null, 1000, 1000);
  }

  public async void Heartbeat(object state)
  {
    await _client.GetAsync("http://mybackend/api/ping");
  }
}
```

Timer callbacks (2)

```
public class Pinger
{
  readonly Timer _timer;
  readonly HttpClient _client;

  public Pinger(HttpClient client)
  {
    _client = client;
    _timer = new Timer(Heartbeat, null, 1000, 1000);
  }

  public void Heartbeat(object state)
  {
    _ = DoAsyncPing();
  }

  private async Task DoAsyncPing()
  {
    await _client.GetAsync("http://mybackend/api/ping");
  }
}
```

Implicit async void

```
public class BackgroundQueue
{
  public static void FireAndForget(Action action) { }
}

BackgroundQueue.FireAndForget(async () => { await … });

public class BackgroundQueue
{
  public static void FireAndForget(Action action) { }
  public static void FireAndForget(Func<Task> action) { }
}
```

ConcurrentDictionary.GetOrAdd

```
static ConcurrentDictionary<int, Person> _cache;
var person = _cache.GetOrAdd(id, k => db.People.FindAsync(k).Result);

static ConcurrentDictionary<int, Task<Person>> _cache;
var person = _cache.GetOrAdd(id, k => db.People.FindAsync(k));

static ConcurrentDictionary<int, Lazy<Task<Person>>> _cache;
var person = await _cache.GetOrAdd(id, k => new Lazy<Task<Person>>(() =>
db.People.FindAsync(k), …)).Value;
```