

Welcome

Rearchitect your code
towards `async/await`



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Goals

target

Why async is **the future**

How to **gradually move** your
code towards async / await

The toolbelt for an **async ninja**

Premise



Intro

Phases

WrapUp



Intro

Phases

WrapUp

The die
is

cast

javascript

ES2017

```
async function chainAnimationsPromise(elem, animations)
{
    let ret = null;
    try {
        for(const anim of animations) {
            ret = await anim(elem);
        }
    } catch(e) { /* ignore and keep going */ }
    return ret;
}
```

```
$ npm install babel-plugin-syntax-async-functions
```

```
$ npm install babel-plugin-transform-async-to-generator
```


httpClient

```
using (var client = new HttpClient()) {  
    var response = await  
        client.GetAsync("api/products/1");  
    if (response.IsSuccessStatusCode)  
    {  
        var product = await  
            response.Content.ReadAsAsync<Product>();  
    }  
}
```

Azure SDK

```
var queryable =  
client.CreateDocumentQuery<Entity>(...)  
    .AsDocumentQuery();
```

```
while (queryable.HasMoreResults)  
{  
    foreach (var e in await  
queryable.ExecuteNextAsync<Entity>())  
    {  
        // Iterate through entities  
    }  
}
```

async
event-driven



Task

uniform



Task

IO-bound



Task

CPU-bound



Recap

best-practices

Use `async Task` instead of `async void`

Recap

best-practices

Use `async Task` instead of `async void`

Async all the way, don't mix blocking and asynchronous code

Async / await ●
is viral

but

It kicks your
servers

butt

Task.Run
Task.Factory.StartNew
Parallel.For
Parallel.ForEach

Worker pool

I/O pool

await iobound
iobound.FireForget()



Task.Run
Task.Factory.StartNew
Parallel.For
Parallel.ForEach

Worker pool

I/O pool

await iobound
iobound.FireForget()



NServiceBus

Azure Service Bus	26 times
Azure Storage Queues	6 times
RabbitMQ	5 times
MSMQ	3 times

more message throughput

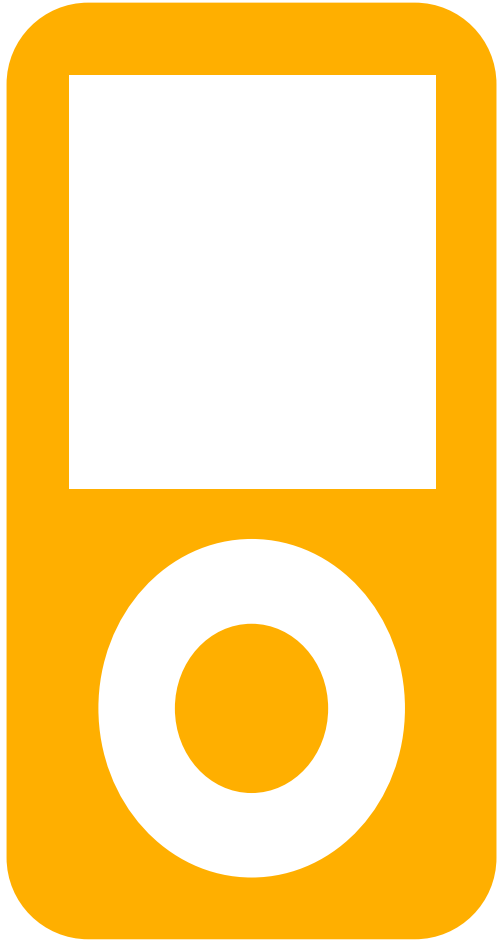
<https://particular.net/blog/rabbitmq-updates-in-nservicebus-6>

<https://github.com/Particular/EndToEnd/tree/master/src/PerformanceTests>

ASYNC



memegenerator.net



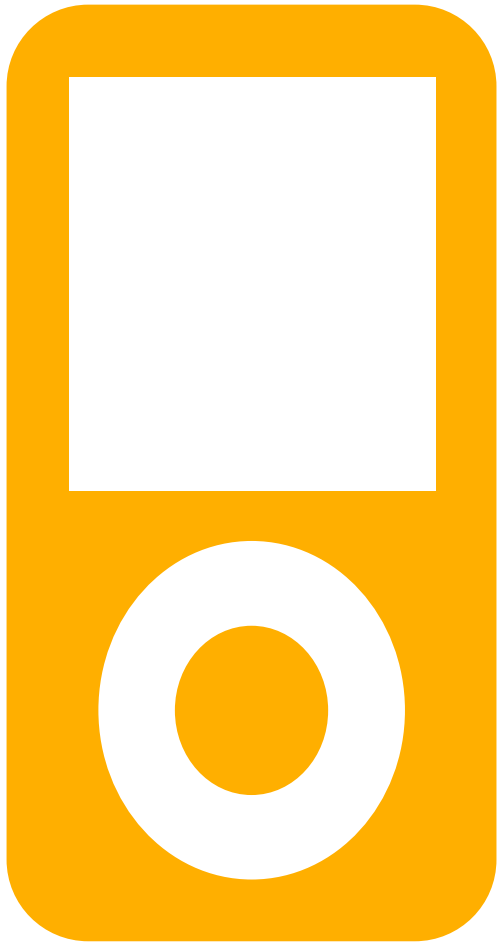
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Ex P lore
O vercome
b ring together



Intro

Phases

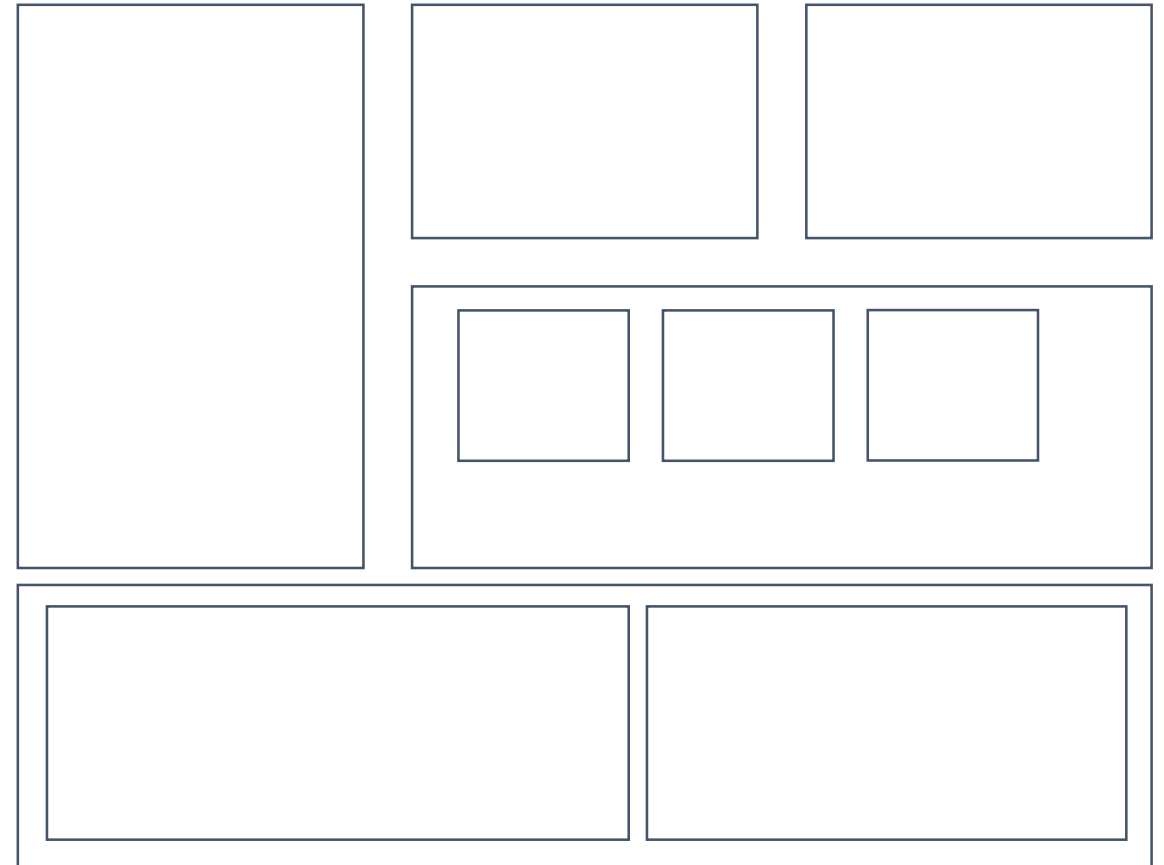
WrapUp



identify
Ex**P**lore
Overcome
bring together

Identify

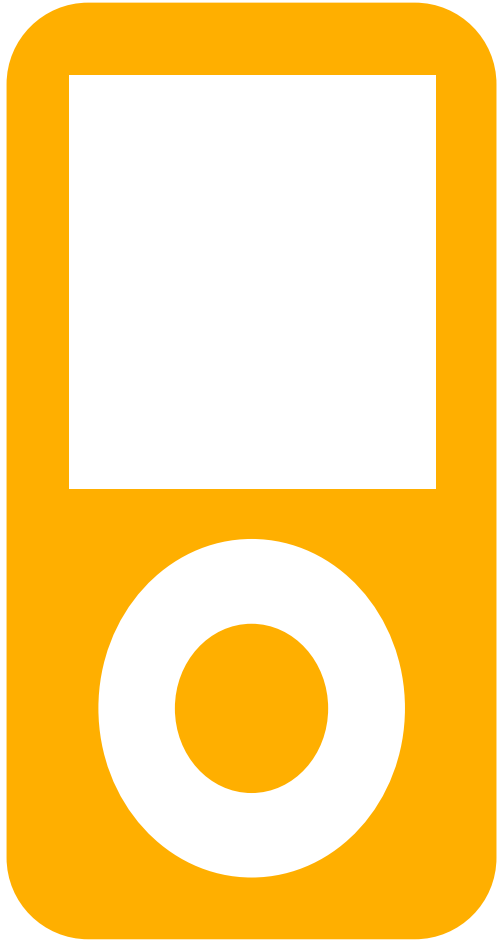
IO-bound



NServiceBus

IO-bound



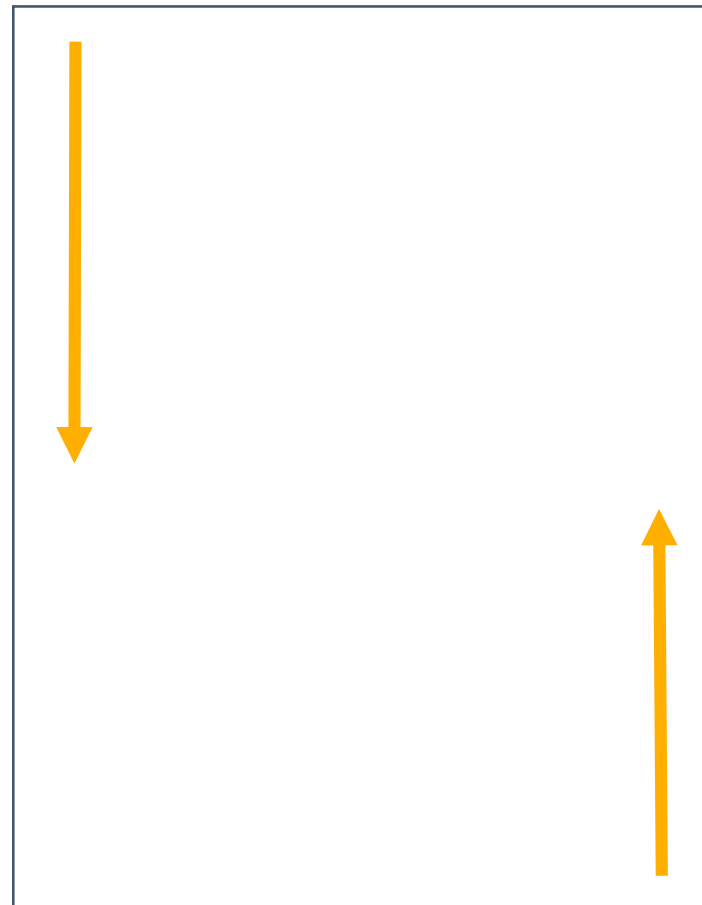


iIdentify
ExPlore
OOvercome
bbring together

Explore

IO-bound

High-level Spike

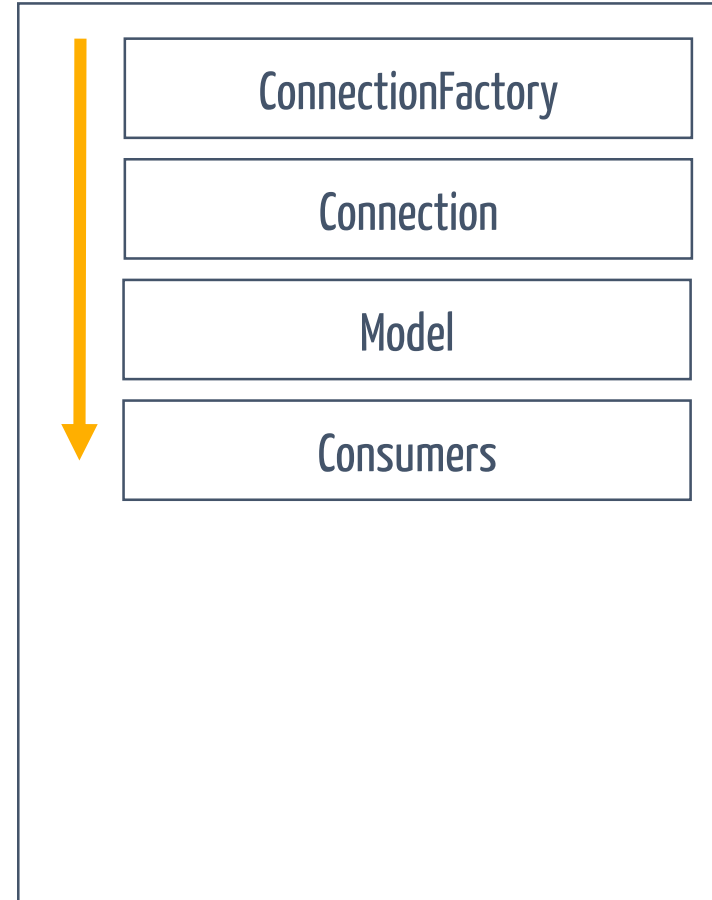


Low-level Spike

RabbitMQ Client

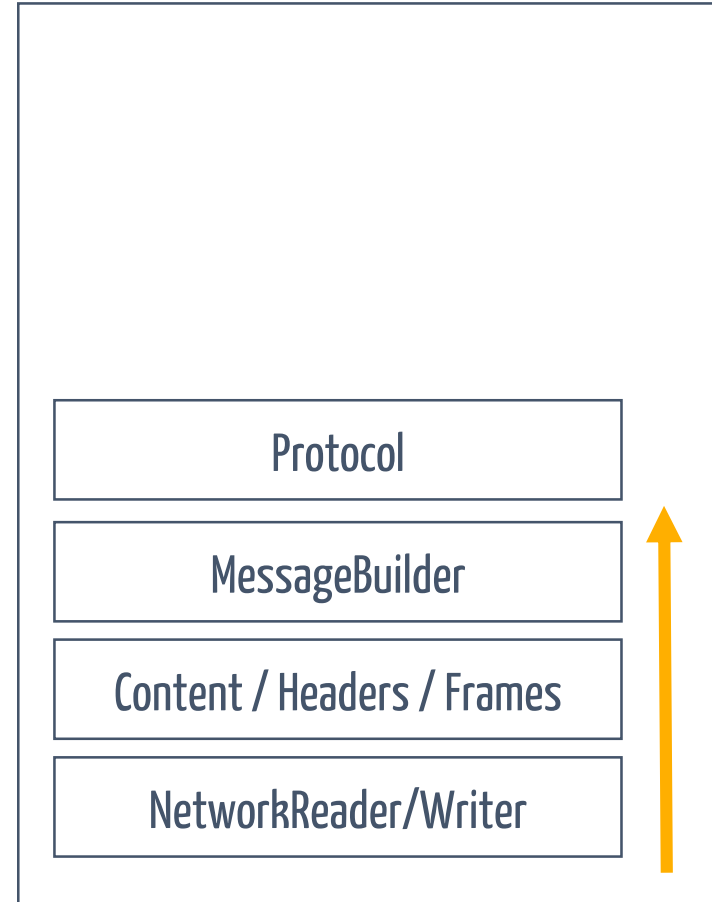
IO-bound

High-level Spike



RabbitMQ Client

IO-bound



Low-level Spike



Event handlers

Locks

Monitor

Semaphore / Mutex

Auto / ManualResetEvent

Ref/Out parameters

Thread

Ambient state

IO-bound calls in 3rd Party libs

Remote Procedure Calls

Event handler

Event handlers

```
public delegate void EventHandler(object sender, EventArgs e);
```

```
public delegate void EventHandler<TEventArgs>(object sender, TEventArgs e);
```



```
async void MyEventHandler(object sender, EventArgs e)
{
    await Task.Yield();
    throw new InvalidOperationException();
}
```

Event passed

Inside MyEventHandler

About to throw inside MyEventHandler

ManualResetEvent

ManualResetEvent



```
var syncEvent = new ManualResetEvent(false);
```

```
var t1 = Task.Run(() => {  
    syncEvent.WaitOne();  
});
```

```
var t2 = Task.Run(() => {  
    Thread.Sleep(2000);  
    syncEvent.Set();  
});
```

```
await Task.WhenAll(t1, t2);
```



void stinks wait smells

Remember

Async all the way means avoid blocking code

Locks

locks



```
var locker = new object();  
lock (locker)  
{  
    await Task.Yield();  
}
```

Error CS1996
Cannot await in the body of a lock statement

<http://stackoverflow.com/questions/7612602/why-cant-i-use-the-await-operator-within-the-body-of-a-lock-statement>

Ref / Out parameters

Ref/Out



```
static async Task Out(string content, out string parameter)
{
    var randomFileName = Path.GetTempFileName();
    using (var writer = new StreamWriter(randomFileName))
    {
        await writer.WriteLineAsync(content);
    }
    parameter = randomFileName;
}
```

Error CS1988

Async methods cannot have ref or out parameters

Remote Procedure

Remote Procedure

```
public class SyncClient : MarshalByRefObject {
```

```
    public void Run() {
```

```
        var service = new RemoteService();
```

```
        service.TimeConsumingRemoteCall();
```

```
    }
```

```
}
```



Ambient state

Ambient state



```
class ClassWithAmbientState
{
    static ThreadLocal<int> ambientState =
        new ThreadLocal<int>(() => 1);

    public void Do()
    {
        ambientState.Value++;
    }
}
```

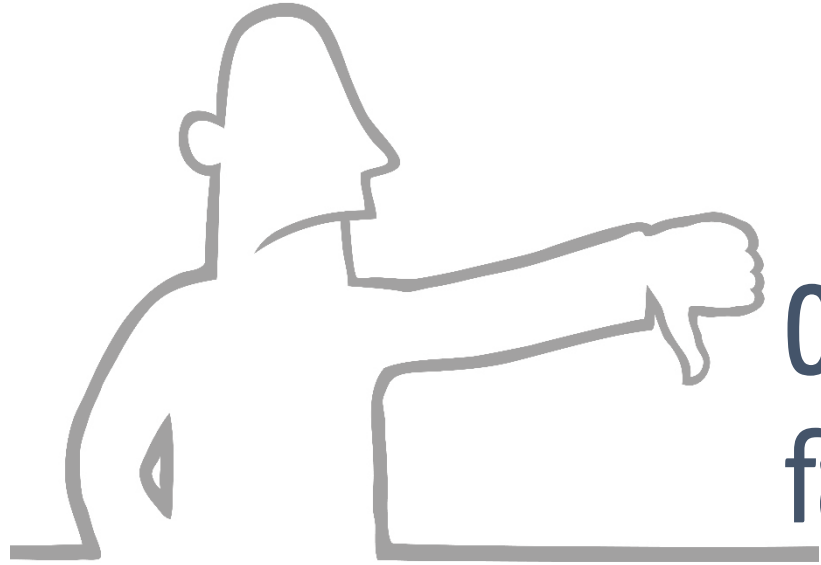
Ambient state



```
var instance = new ClassWithAmbientState();  
var tasks = new Task[3];  
for (int i = 0; i < 3; i++) {  
    tasks[i] = Task.Run(() => {  
        instance.Do();  
        Thread.Sleep(200);  
        instance.Do();  
    });  
}  
  
await Task.WhenAll(tasks);
```

AmbientState passed

```
05:50:09:187: Thread: 4, Value: 2  
05:50:09:187: Thread: 8, Value: 2  
05:50:09:187: Thread: 9, Value: 2  
05:50:09:390: Thread: 4, Value: 3  
05:50:09:391: Thread: 9, Value: 3  
05:50:09:391: Thread: 8, Value: 3
```

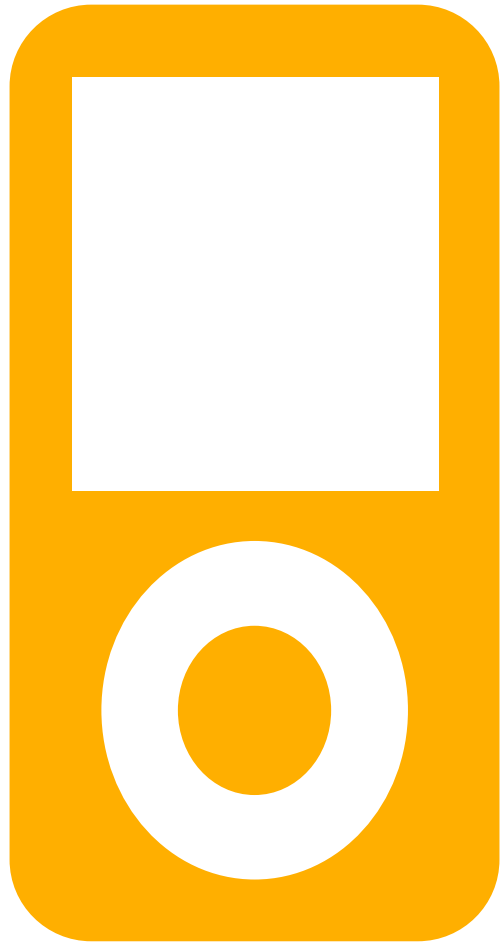


Older constructs **bound to threads**
fall apart in the async/await world

Remember

Forget thread!

think Task



iIdentify
ExPlore
OOvercome
bBring together



Event handlers

Locks

Monitor

Semaphore / Mutex

Auto / ManualResetEvent

Ref/Out parameters

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Ambient state

IO-bound calls in 3rd Party libs

Remote Procedure Calls

Event handler

```
public delegate void EventHandler(object sender, EventArgs e);
```

```
public delegate void EventHandler<TEventArgs>(object sender, TEventArgs e);
```

```
async void MyEventHandler(object sender, EventArgs e)
{
    await Task.Yield();
    throw new InvalidOperationException();
}
```

Event handlers

```
public delegate Task AsyncEventHandler(object sender, EventArgs e);
```

```
async Task MyAsyncEventHandler(object sender, EventArgs e) { }
```



```
async Task MyEventHandler(object sender, EventArgs e)
{
    await Task.Yield();
    throw new InvalidOperationException();
}
```

Event handlers



```
protected virtual Task OnMyAsyncEvent() {  
    var invocations = handler.GetInvocationList();  
    var handlerTasks = new Task[invocationList.Length];  
  
    for (int i = 0; i < invocations.Length; i++) {  
        handlerTasks[i] = ((AsyncEventHandler)invocations[i])(...);  
    }  
    return Task.WhenAll(handlerTasks);  
}
```

AsyncEvent passed

Inside MyAsyncEventHandler

About to throw inside MyAsyncEventHandler

Caught: Operation is not valid due to the current state of the object.

ManualResetEvent


```
var syncEvent = new ManualResetEvent(false);
```

```
var t1 = Task.Run(() => {  
    syncEvent.WaitOne();  
});
```

```
var t2 = Task.Run(() => {  
    Thread.Sleep(2000);  
    syncEvent.Set();  
});
```

```
await Task.WhenAll(t1, t2);
```

ManualResetEvent



```
var tcs = new TaskCompletionSource<object>();
```

```
var t1 = ((Func<Task>)(async () => {  
    await tcs.Task;  
}));
```

```
var t2 = ((Func<Task>)(async () => {  
    await Task.Delay(2000);  
    tcs.TrySetResult(null);  
}));
```

```
await Task.WhenAll(t1, t2);
```



TaskCompletionSource belongs
into your toolbox

Remember

ManualResetEvent



Works for **set once events** only.
For async reset events, an
approach is available on github

<https://github.com/danielmarbach/RearchitectTowardsAsyncAwait/blob/master/presentation/AsyncManualResetEvent.cs>

Locks

locks



Can we change the code so that
we don't have to await inside
the lock?

```
var locker = new object();  
lock (locker)  
{  
    await Task.Yield();  
}
```

Error CS1996

Cannot await in the body of a lock statement

locks



```
int sharedResource = 0;  
var semaphore = new SemaphoreSlim(1);
```

```
var tasks = new Task[3];  
for (int i = 0; i < 3; i++) {  
    tasks[i] = ((Func<Task>) (async () => {  
        await semaphore.WaitAsync();  
        sharedResource++;  
        semaphore.Release();  
    })))();  
}  
await Task.WhenAll(tasks);
```




SemaphoreSlim belongs
into your toolbelt

Remember

locks

```
using (await semaphore.LockAsync())  
{  
    sharedRessource++;  
}
```



<https://github.com/danielmarbach/RearchitectTowardsAsyncAwait/blob/master/presentation/AsyncLock.cs>

Ref / Out parameters

```
static async Task Out(string content, out string parameter)
{
    var randomFileName = Path.GetTempFileName();
    using (var writer = new StreamWriter(randomFileName))
    {
        await writer.WriteLineAsync(content);
    }
    parameter = randomFileName;
}
```

Error CS1988

Async methods cannot have ref or out parameters

Ref/Out



```
static async Task<string> Out(string content)
{
    var randomFileName = Path.GetTempFileName();
    using (var writer = new StreamWriter(randomFileName))
    {
        await writer.WriteLineAsync(content);
    }
    return randomFileName;
}
```

Remote Procedure

```
public class SyncClient : MarshalByRefObject {  
  
    public void Run() {  
        var service = new RemoteService();  
        service.TimeConsumingRemoteCall();  
    }  
  
}
```

Remote Procedure

```
public class AsyncClient : MarshalByRefObject {
```

```
    public async Task Run() {
```

```
        var service = new RemoteService();
```

```
        Func<string> call = service.TimeConsumingRemoteCall;
```

```
        var result = await Task.Factory.
```

```
            FromAsync(call.BeginInvoke, Callback, null);
```

```
    }
```

```
}
```



Remote Procedure

```
public class AsyncClient : MarshalByRefObject {
```

```
    [OneWay]
```

```
    public string Callback(IAsyncResult ar) {
```

```
        var del =
```

```
        (Func<string>)((AsyncResult)ar).AsyncDelegate;
```

```
        return del.EndInvoke(ar);
```

```
    }
```

```
}
```



Ambient state

```
class ClassWithAmbientState
{
    static ThreadLocal<int> ambientState =
        new ThreadLocal<int>(() => 1);

    public void Do()
    {
        ambientState.Value++;
    }
}
```

Ambient state



```
class ClassWithAmbientState {  
    static AsyncLocal<int> ambientState =  
        new AsyncLocal<int>();
```

```
    static ClassWithAmbientState() {  
        ambientState.Value = 1;  
    }
```

```
    public void Do() {  
        ambientState.Value++;  
    }  
}
```

Ambient state

```
var instance = new ClassWithAmbientState();
var tasks = new Task[3];
for (int i = 0; i < 3; i++) {
    tasks[i] = ((Func<Task>)(async () => {
        instance.Do();
        await Task.Delay(200).ConfigureAwait(false);
        instance.Do();
    }));
}
```

```
await Task.WhenAll(tasks);
```



AmbientState passed

```
06:00:54:979: Thread: 5, Value: 2
06:00:54:985: Thread: 5, Value: 2
06:00:54:985: Thread: 5, Value: 2
06:00:55:185: Thread: 4, Value: 3
06:00:55:199: Thread: 4, Value: 3
06:00:55:199: Thread: 9, Value: 3
```

Ambient state



Even better:
Can we change the code so that
we float state into methods
that need it?

Ambient state

```
class ClassWithAmbientState {
```

```
    public int Do(int current) {
```

```
        current++;
```

```
        return current;
```

```
    }
```

```
}
```



Ambient state

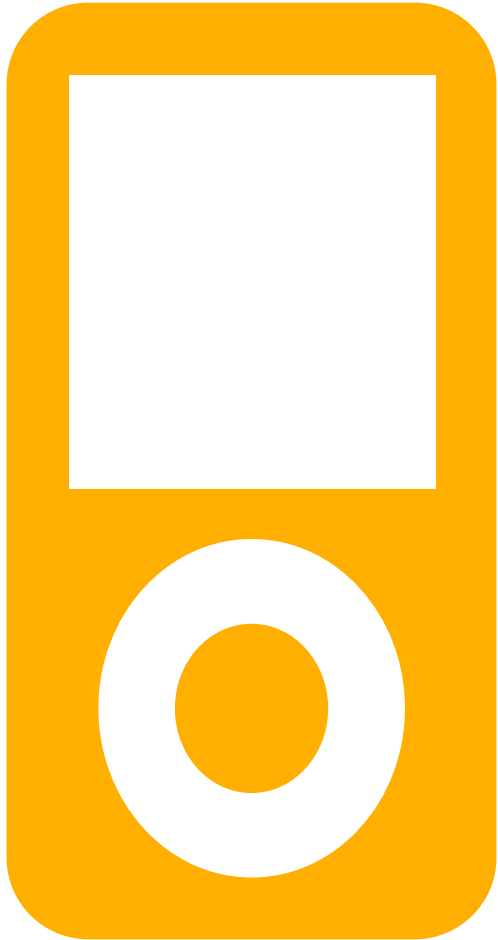


```
var instance = new ClassWithFloatingState();
```

```
var tasks = new Task[3];  
for (int i = 0; i < 3; i++) {  
    tasks[i] = ((Func<Task>)(async () => {  
        int current = 1;  
        current = instance.Do(current);  
        await Task.Delay(200).ConfigureAwait(false);  
        instance.Do(current);  
    })))();  
}  
await Task.WhenAll(tasks);
```

AmbientFloatingStateReturned passed

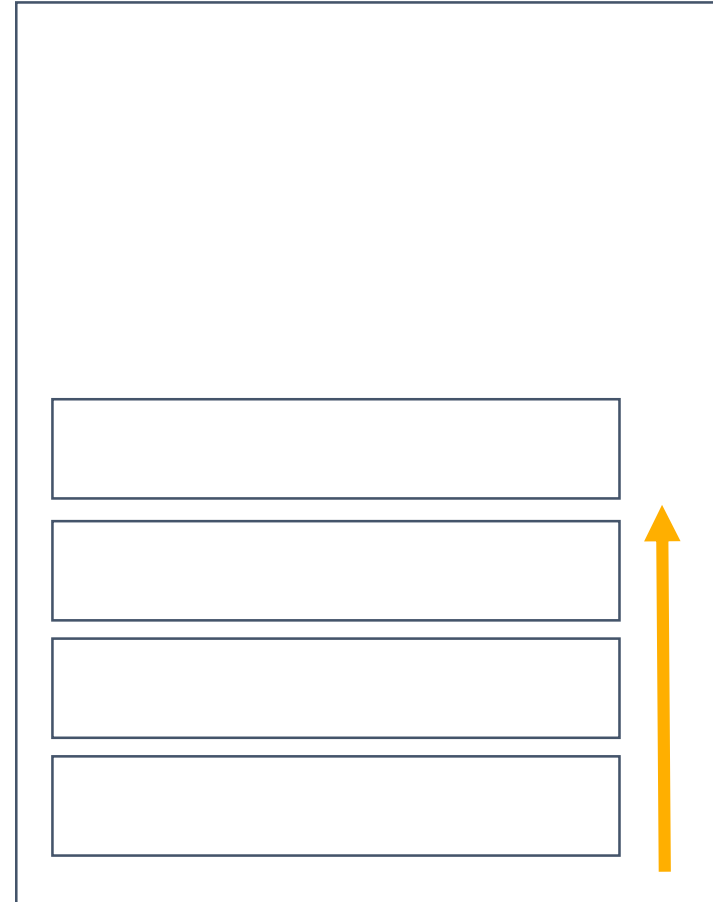
```
06:03:28:728: Thread: 5, Value: 2  
06:03:28:734: Thread: 5, Value: 2  
06:03:28:735: Thread: 5, Value: 2  
06:03:28:933: Thread: 4, Value: 3  
06:03:28:950: Thread: 4, Value: 3  
06:03:28:950: Thread: 9, Value: 3
```

Identify
ExPlore
Overcome
bring together

Bring it
together

High-level



Low-level

Bring it
together

```
void HighLevel() {  
    try {  
        MidLevel();  
    } catch(InvalidOperationException) { }  
}
```

```
void MidLevel() {  
    ...  
    LowLevel();  
    ...  
}
```

```
void LowLevel() {  
}
```

Bring it together

```
void HighLevel() {  
    try {  
        MidLevel();  
    } catch(InvalidOperationException) { }  
}
```

```
void MidLevel() {  
    ...  
    LowLevel().GetAwaiter().GetResult();  
    ...  
}
```

```
async Task LowLevel() {  
}
```

Commit. Push.

Bring it together

```
void HighLevel() {  
    try {  
        MidLevel().GetAwaiter().GetResult();  
    } catch(InvalidOperationException) { }  
}
```

```
async Task MidLevel() {  
    ...  
    await LowLevel().ConfigureAwait(false);  
    ...  
}
```

```
async Task LowLevel() {  
}
```

Commit. Push.

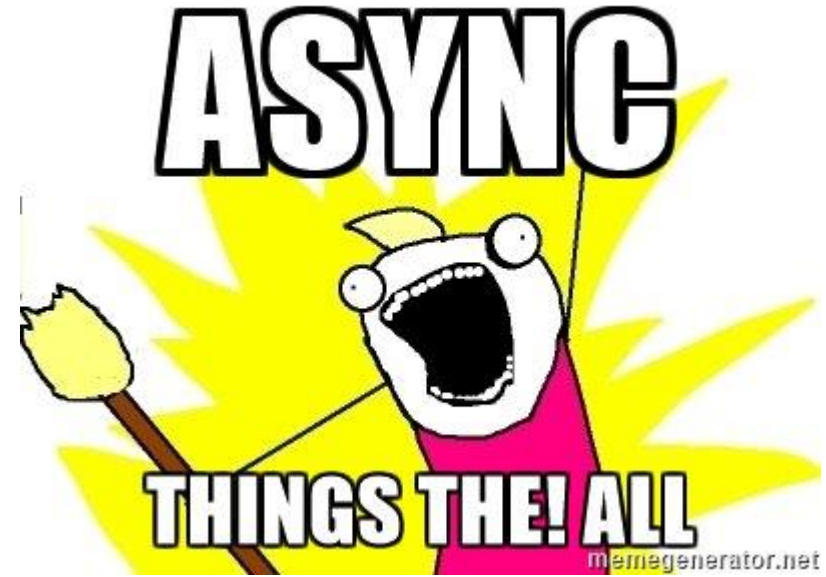
Bring it together

```
async Task HighLevel() {  
    try {  
        await MidLevel ().ConfigureAwait(false);  
    } catch(InvalidOperationException) { }  
}
```

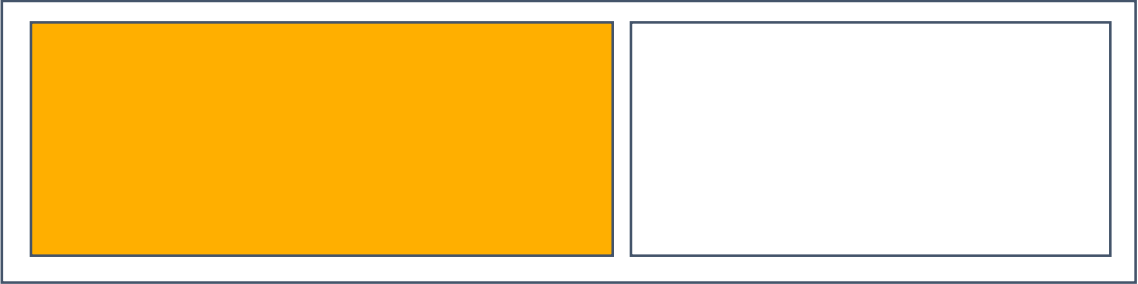
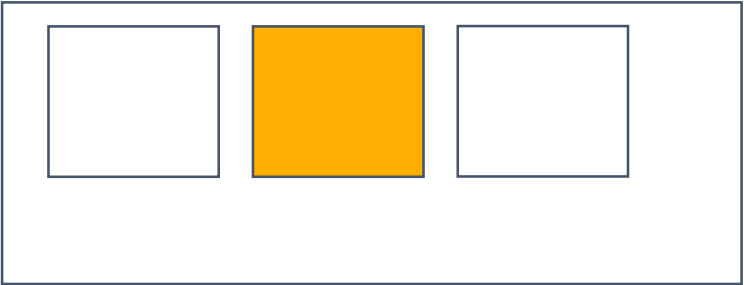
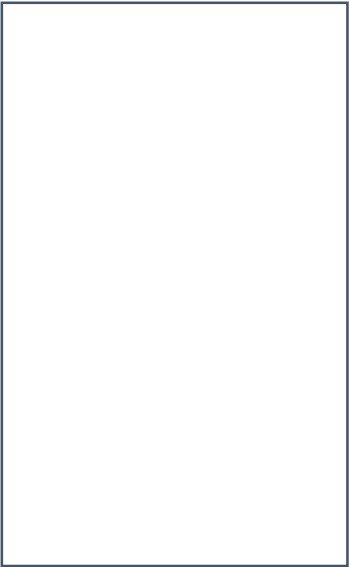
```
async Task MidLevel() {  
    ...  
    await LowLevel().ConfigureAwait(false);  
    ...  
}
```

```
async Task LowLevel() {  
}
```

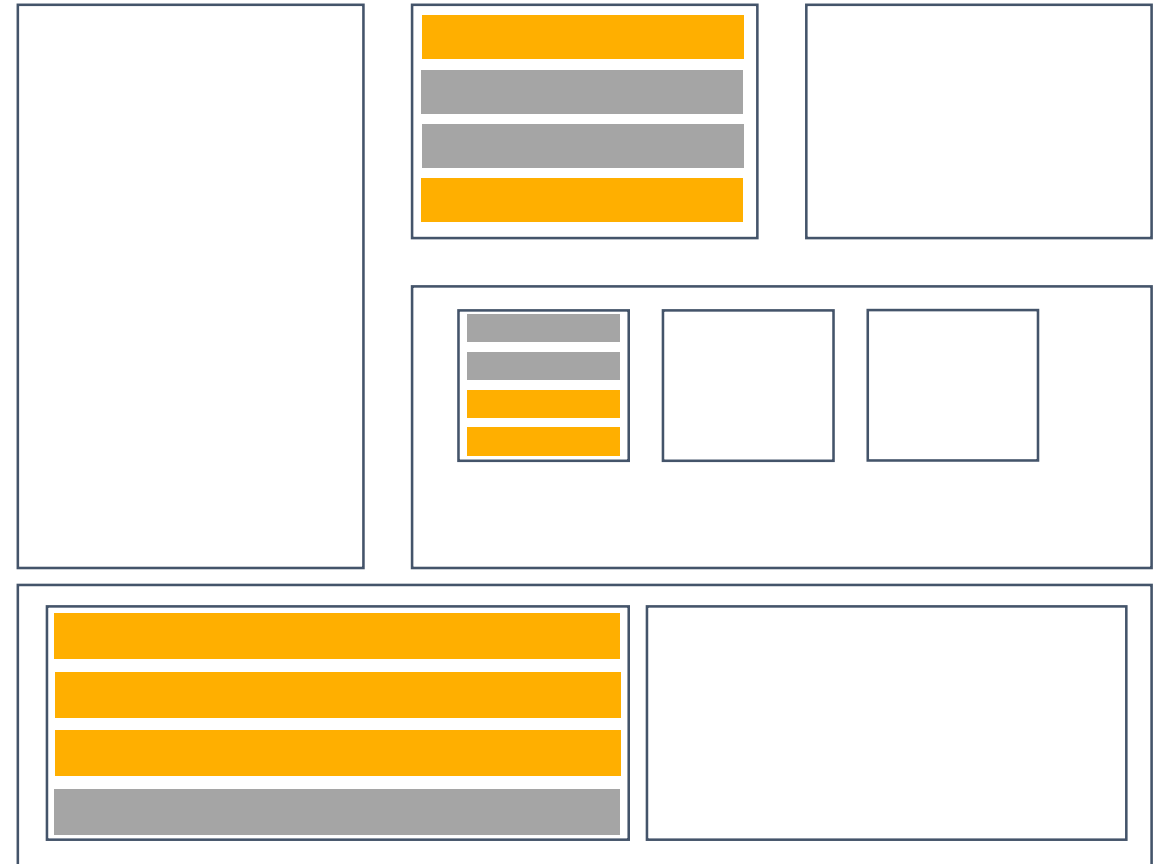

Yehaa!



Async all the way



Reality



Reality

```
void Entry() {  
    IOBound();  
    CPUBound();  
    CPUBound();  
    IOBound();  
}
```

```
async Task Entry() {  
    await IOBound();  
    CPUBound();  
    CPUBound();  
    await IOBound();  
}
```

Reality

```
async Task Entry() {  
    await IOBound();  
    HeavyCPUBound();  
    HeavyCPUBound();  
    await IOBound();  
}
```

```
async Task Entry() {  
    await IOBound();  
    await Task.Run(() => {  
        HeavyCPUBound();  
        HeavyCPUBound();  
    });  
    await IOBound();  
}
```

```
async Task Entry() {  
    await IOBound();  
    await IOBound();  
    await Task.Run(() => {  
        HeavyCPUBound();  
        HeavyCPUBound();  
    });  
}
```



Intro

Phases

WrapUp

Recap

reminder

Use **iPob** to move your code
step by step towards async / await

IO-bound paths benefit from async

Uniform API of Task allows to await
CPU-bound as well as IO-bound tasks

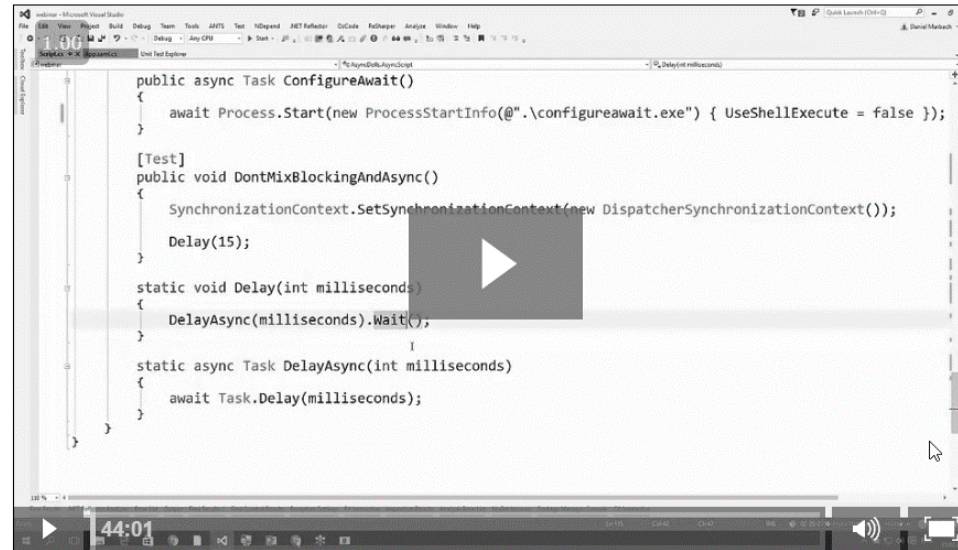
Slides, Links...

github.com/danielmarbach/RearchitectTowardsAsyncAwait

Async/Await Webinar Series: Best Practices

See how to avoid common pitfalls in asynchronous code bases

go.particular.net/ddc17



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Summary

Daniel Marbach shows how to avoid common pitfalls in asynchronous code bases.

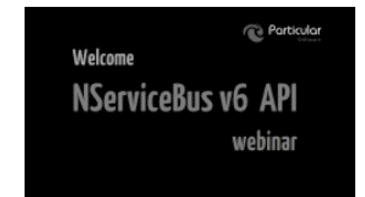
Learn how to:

- Differentiate between IO-bound vs CPU-bound work and how this relates to Threads and Tasks
- Avoid serious production bugs as a result of asynchronous methods returning void
- Opt-out from context capturing when necessary
- Deal with synchronous code in the context of asynchronous code

OTHER VIDEOS IN THE SERIES



► TPL & Message Pumps



► NServiceBus v6 API Update

await Q & A

Thanks