Particular Software

Welcome

Rearchitect your code

towards async/await

```
Task.Run(async () =>
{
   while(!cancelled) {
     Func<Task> receive = () => {

        var connection = new SqlConnection();
         await connection.OpenAsync()
            .ConfigureAwait(false);
     }
     receive().Ignore();
     await Task.Delay(100).ConfigureAwait(false);
   }
})
```

```
Task.Run(async () =>
{
   while(!cancelled) {
     Func<Task> receive = () => {
        await Task.Yield();
        var connection = new SqlConnection();
         await connection.OpenAsync()
            .ConfigureAwait(false);
     }
     receive().Ignore();
     await Task.Delay(100).ConfigureAwait(false);
   }
})
```

Particular Software

Software Engineer
Enthusiastic Software Engineer
Microsoft MVP for systems integration

@danielmarbach
particular.net/blog
planetgeek.ch

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 Threadpool

IO Threadpool

await iobound
iobound.FireForget()

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

Worker Threadpool

IO Threadpool

await iobound
iobound.FireForget()

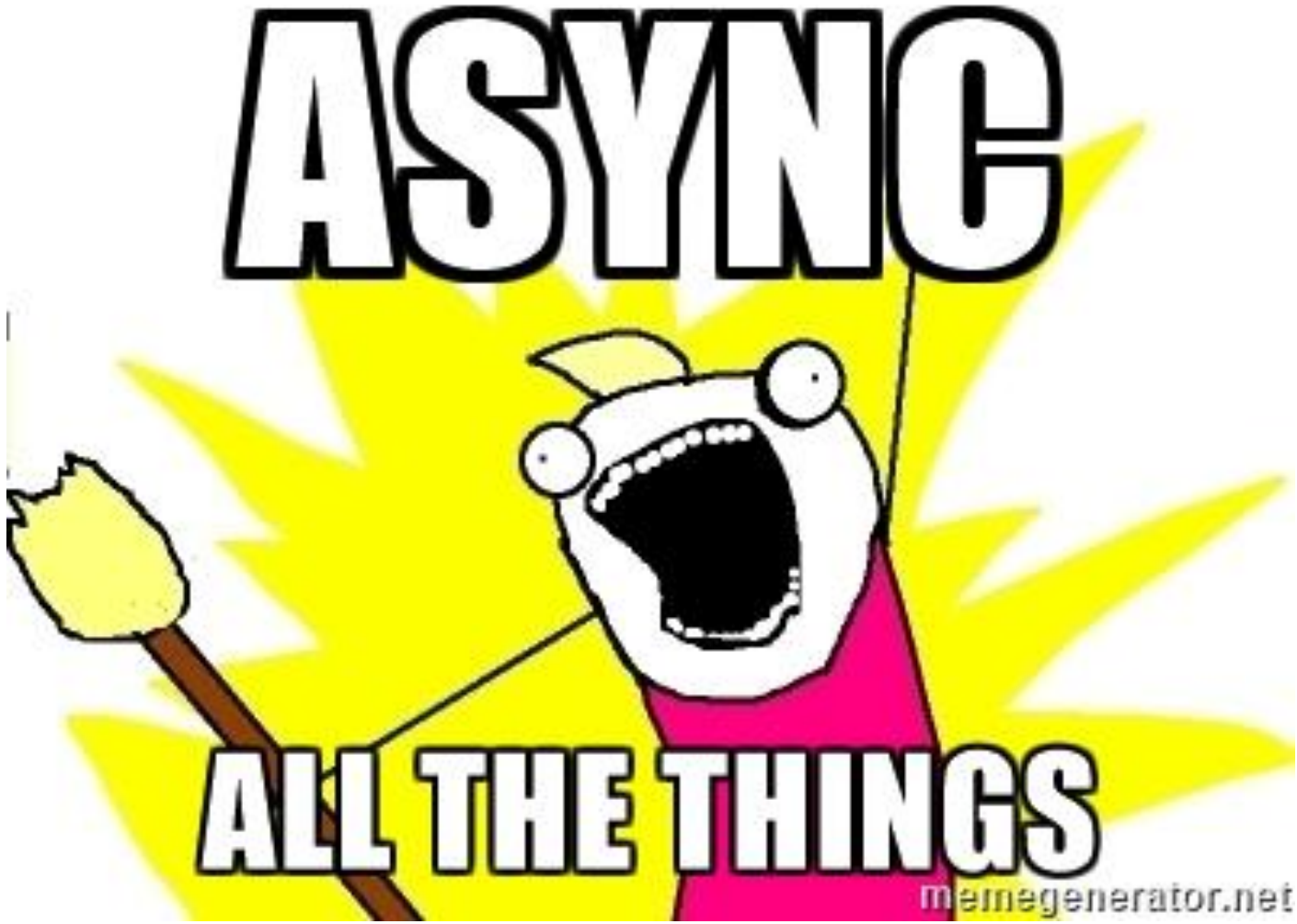
NServiceBus

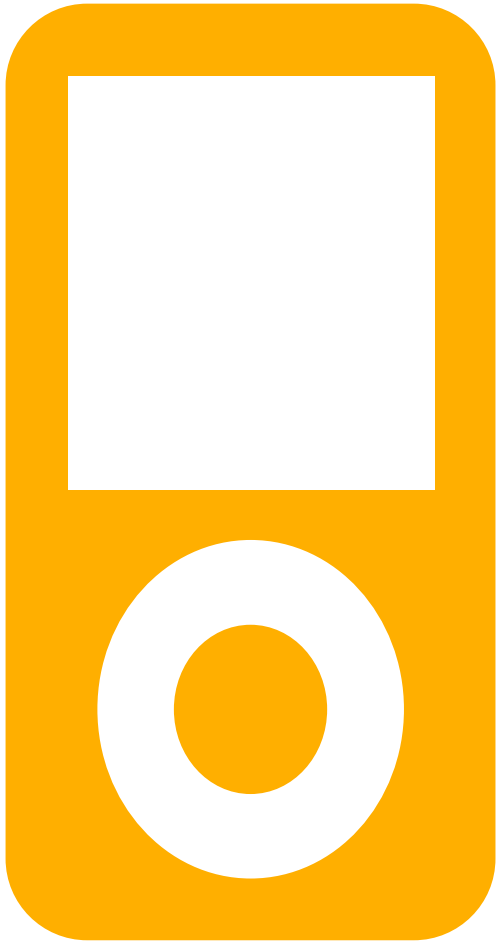
Azure Service Bus	26 times
Azure Storage Queues	6 times
RabbitMQ	5 times
MSMQ	3 times

more message throughput

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

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


ASYNC
ALL THE THINGS
memegenerator.net



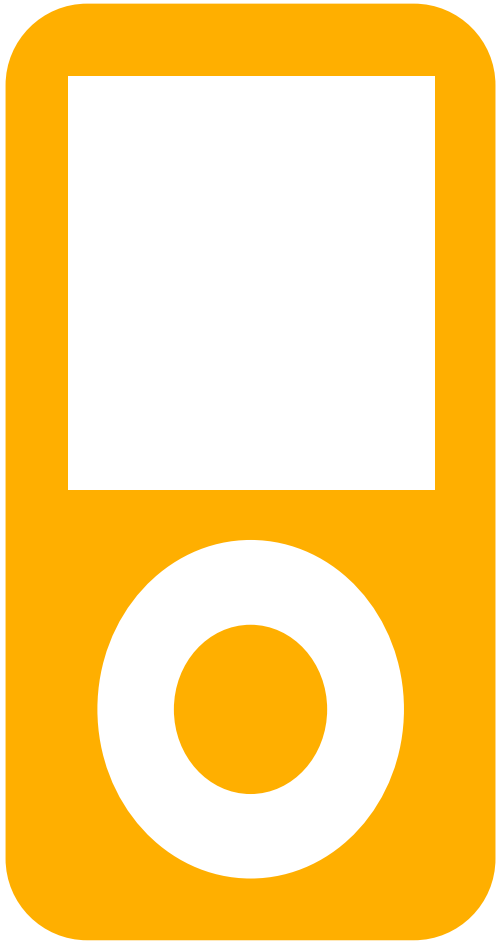
identify

Ex**P**lore

Overcome

bring together


Intro
Phases
WrapUp



identify

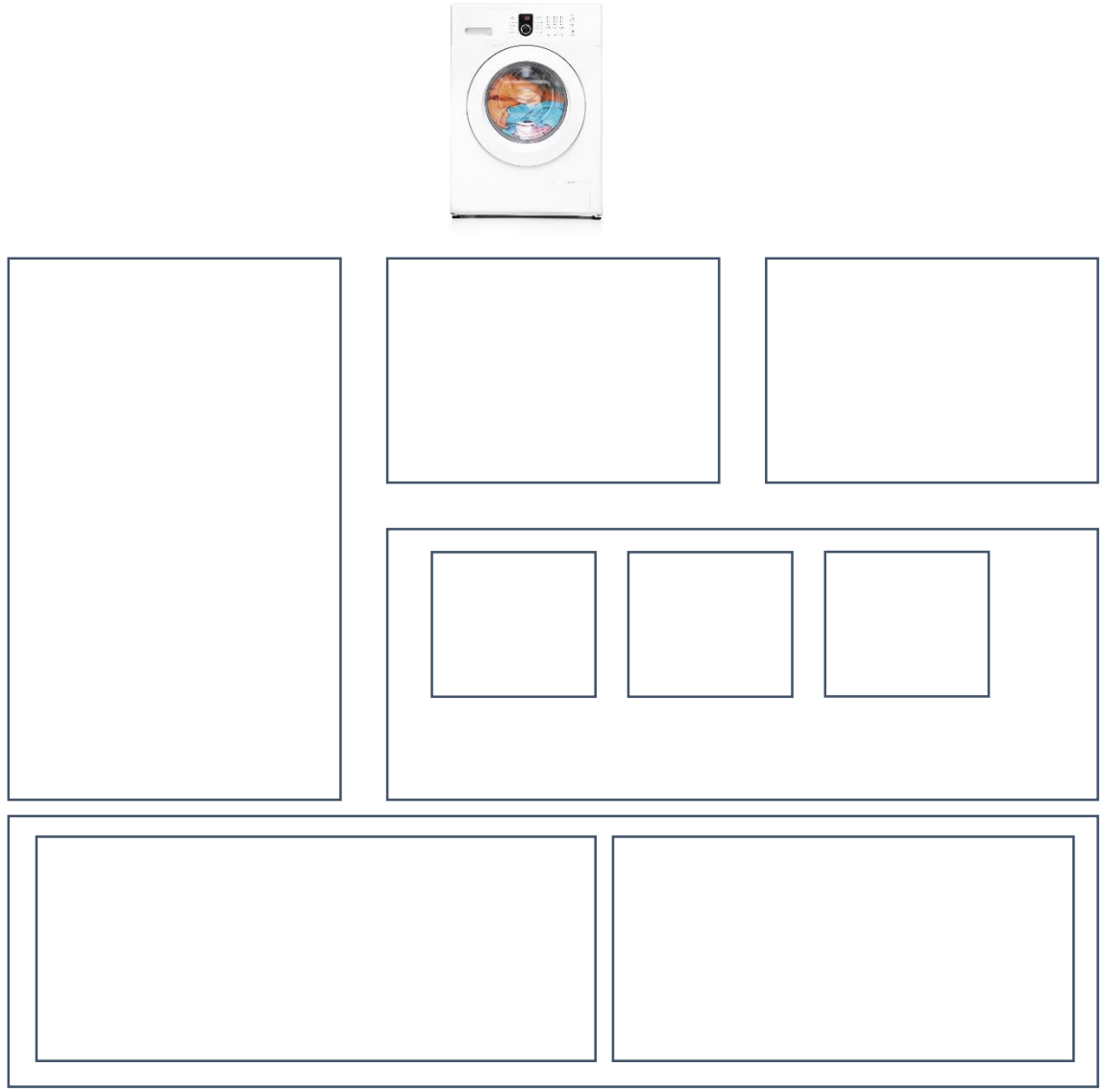
ExPlore

Overcome

bring together

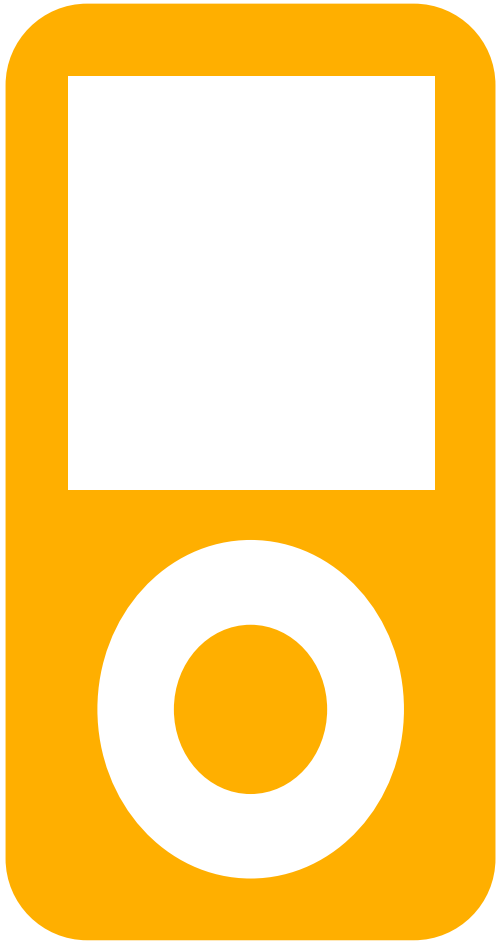
Identify

IO-bound



NServiceBus

IO-bound



identify

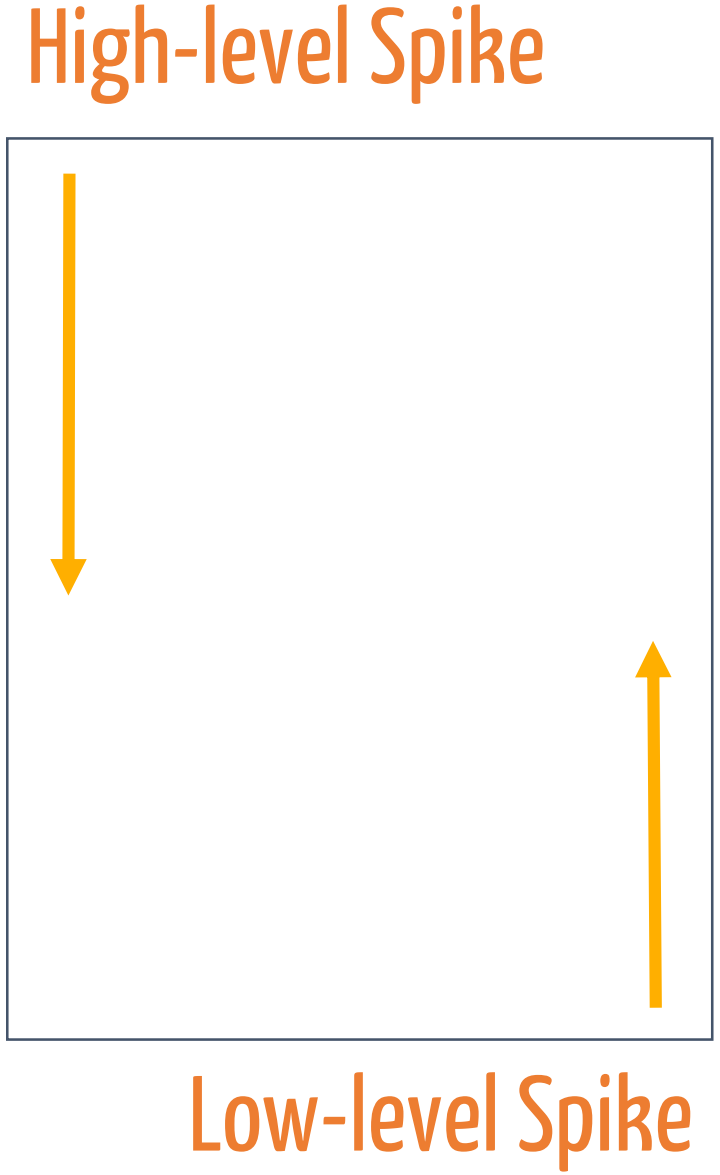
Ex**P**lore

Overcome

bring together

Explore

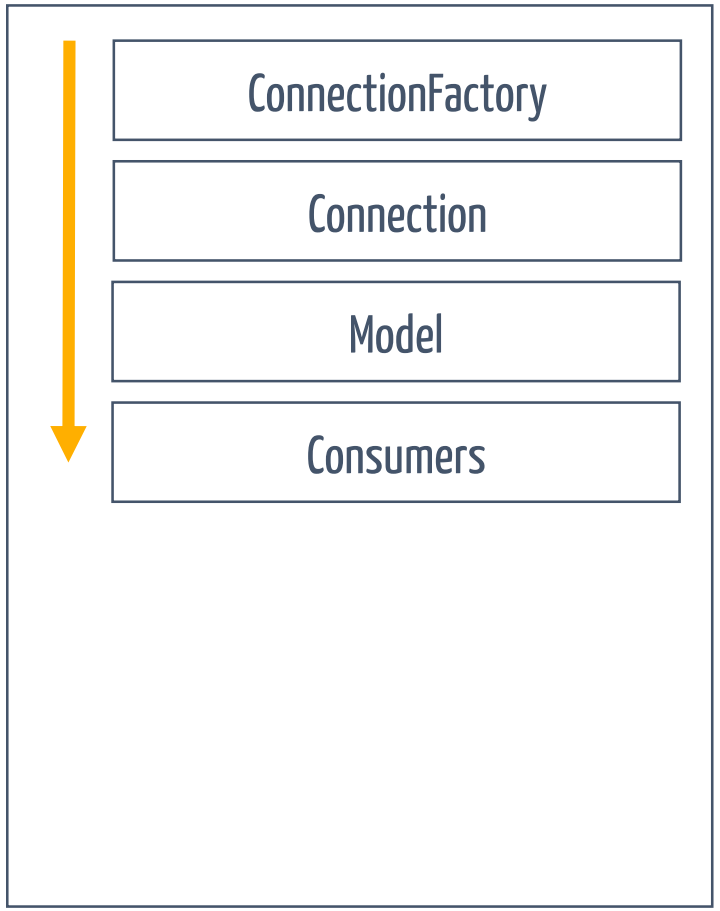
IO-bound



RabbitMQ Client

IO-bound

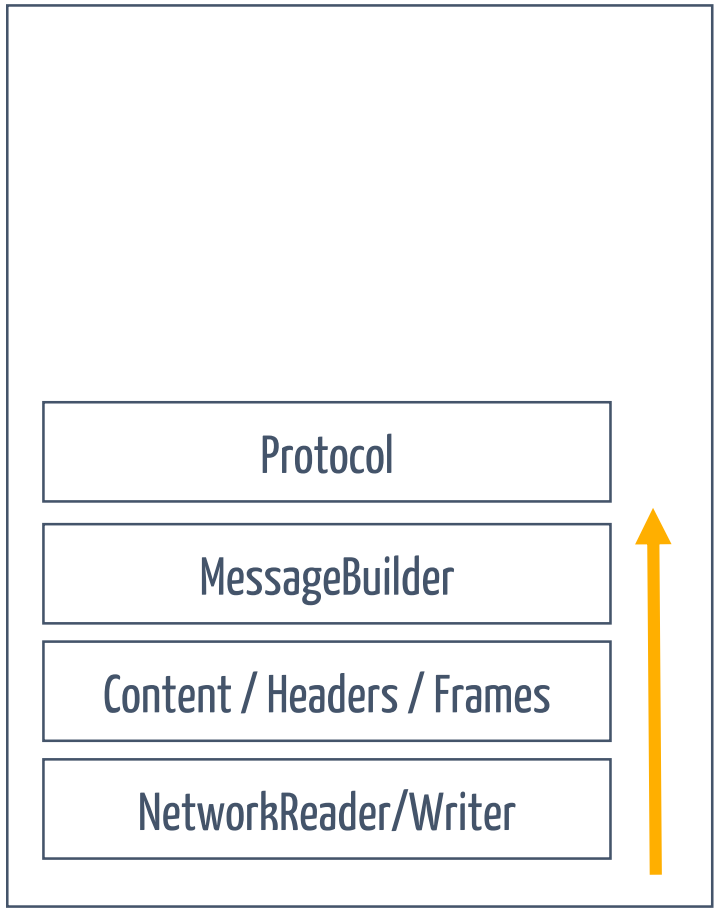
High-level Spike



github.com/rabbitmq/rabbitmq-dotnet-client/pull/151

RabbitMQ Client

IO-bound



Low-level Spike

github.com/rabbitmq/rabbitmq-dotnet-client/pull/149

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++;
  }
}
```

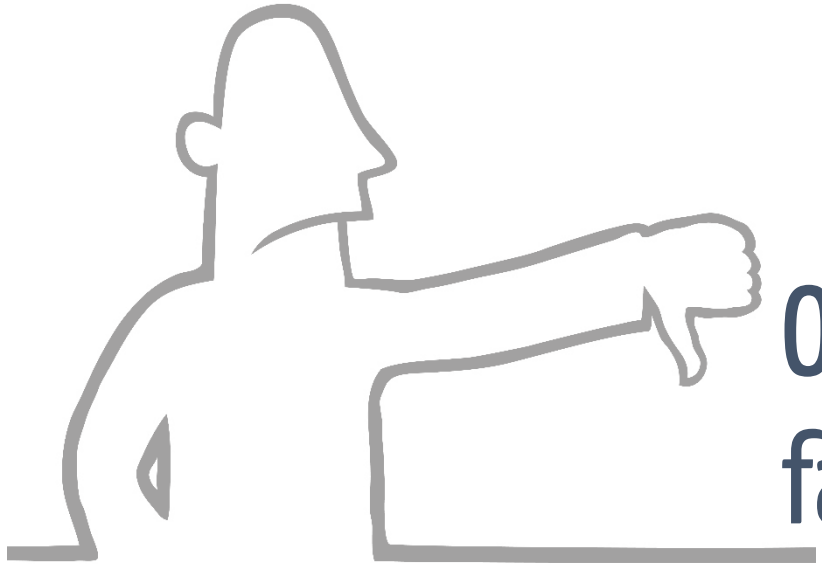
Ambient state


```
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
```

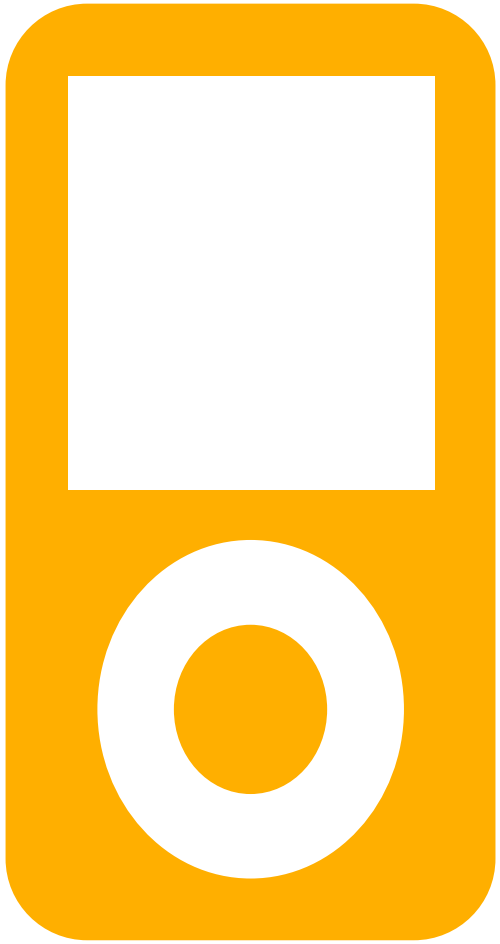


Older constructs bound to threads
fall apart in the async/await world

Remember

Forget thread!

think Task



identify

ExPlore

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bring together

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```
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);
```

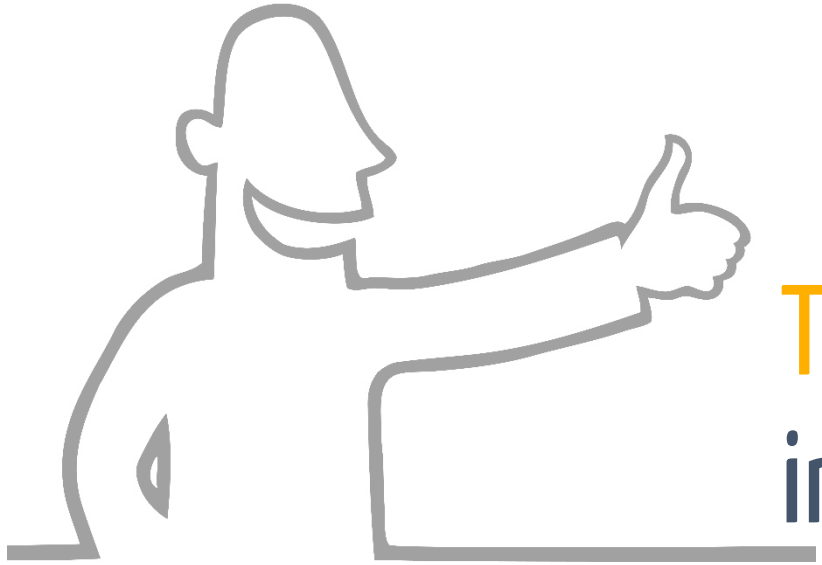
ManualResetEvent


```
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 toolbelt

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();
}
```

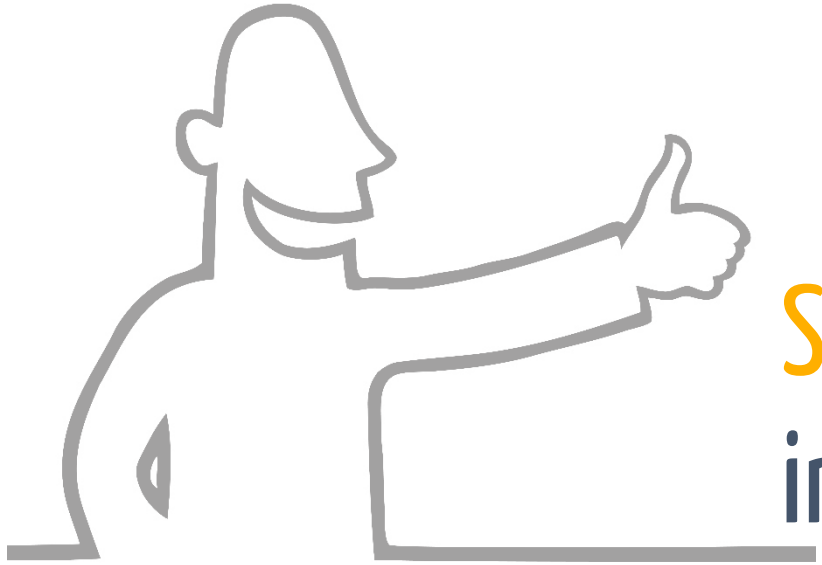
Error CS1996

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;
  }
}
```

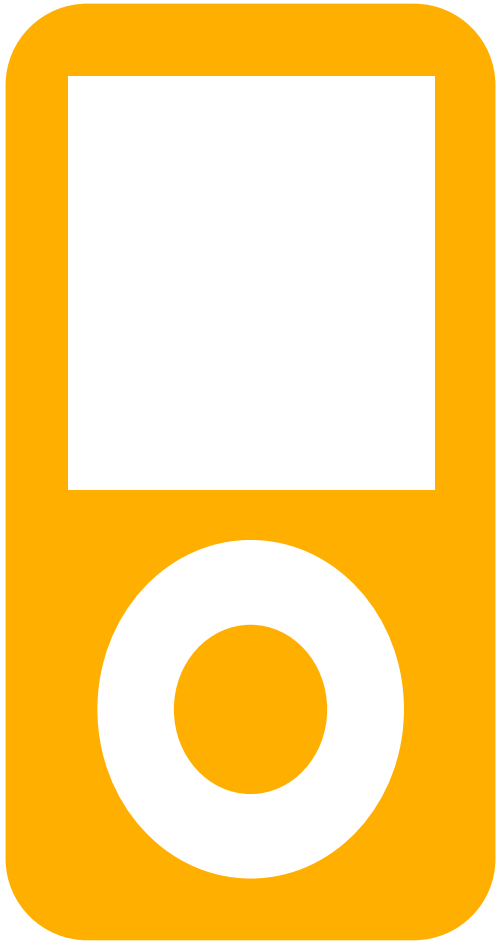
Ambient state


```
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
```



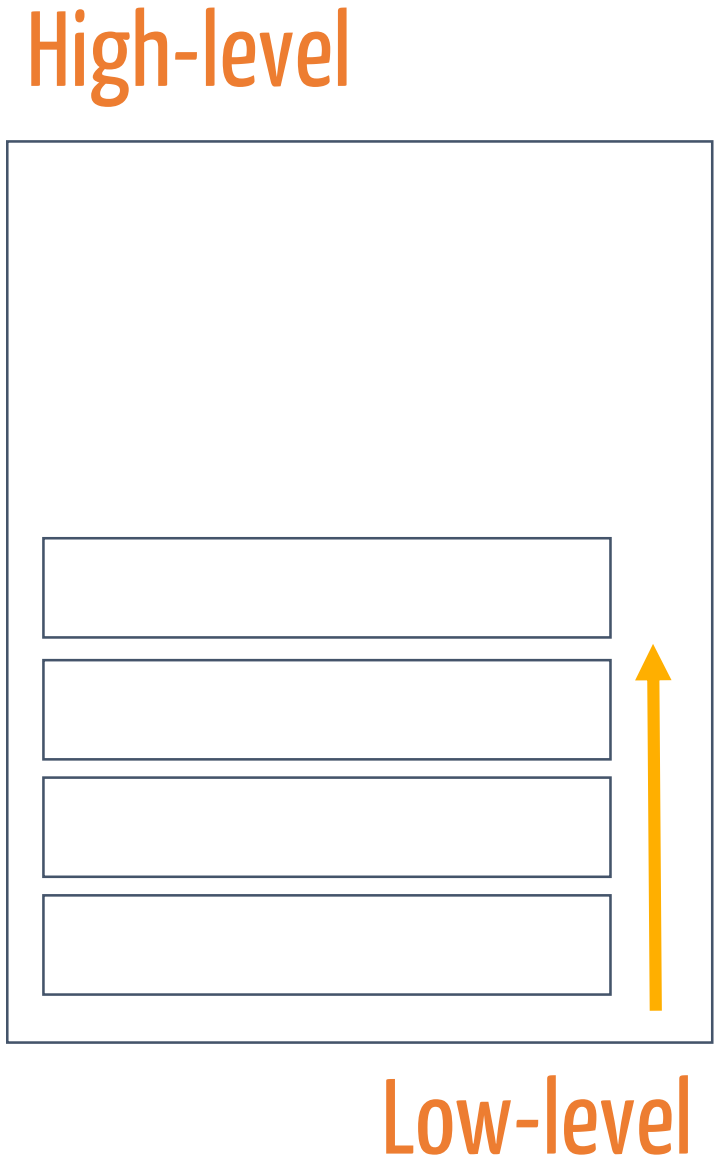
identify

Ex**P**lore

Overcome

bring together

Bring it together



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.

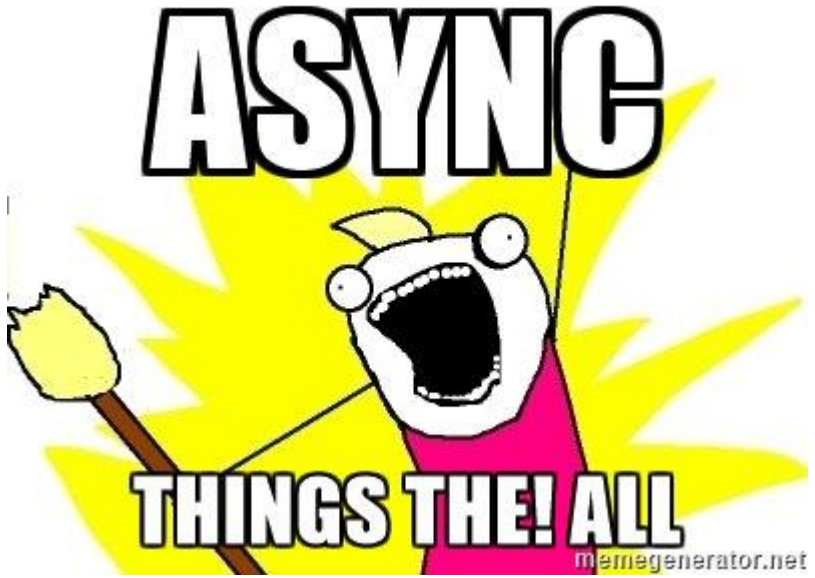
Bring it together

```
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

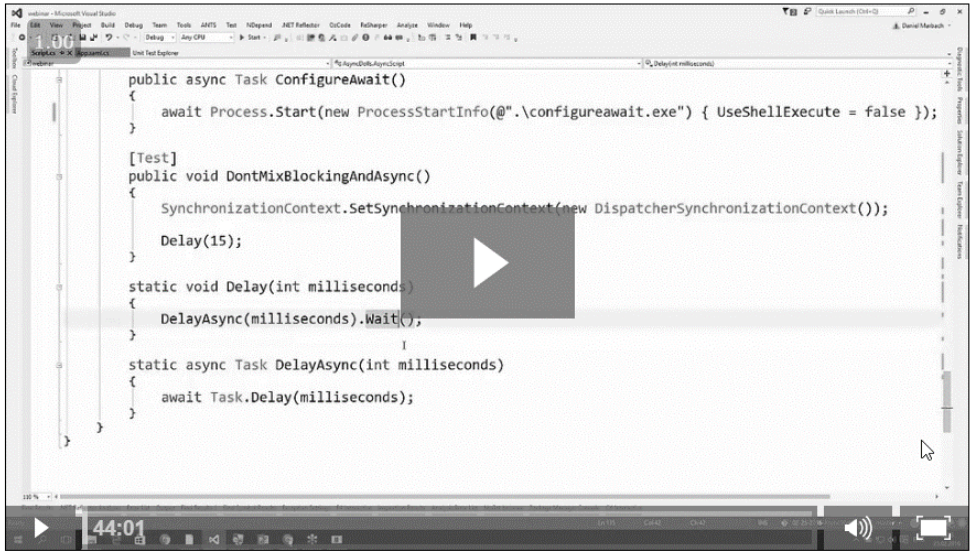
Slides, Links...

github.com/danielmarbach/RearchitectTowardsAsyncAwait

particular.net/webinars/async-await-best-practices

Async/Await Webinar Series: Best Practices

See how to avoid common pitfalls in asynchronous code bases



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OTHER VIDEOS IN THE SERIES

▸ TPL & Message Pumps

▸ NServiceBus v6 API Update

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

Particular Software

await Q & A

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Thanks