

Leveraging AOP in SharePoint Custom Development

*@spmcdonough on Twitter
(for heckling purposes)*



Sean P. McDonough

Bitstream Foundry LLC
Microsoft MVP (Office Apps & Services)



My background

- Developing software since mid '90s

My interests

- Helping people learn technology

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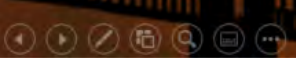
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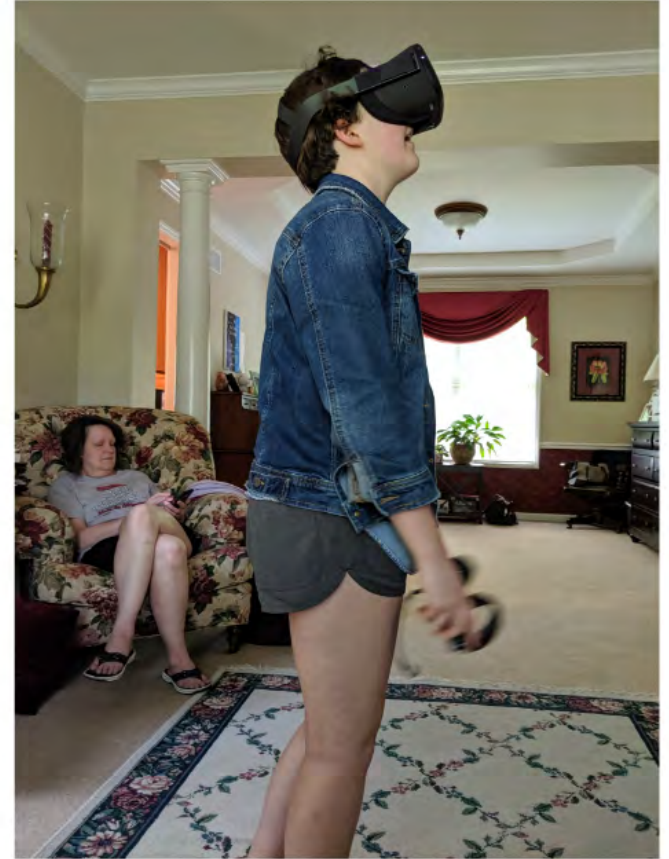
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- Many roles: developer, administrator, product manager, evangelist, and more
- Nowadays, independent consulting
- Community focus: free solutions, writing, speaking, and mentoring

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- Augmented reality and virtual reality
- Boardgaming, Videogaming, xxx-gaming ...
- Being a dad and husband :-)
- More recently, MTG: Arena (Solace#18161 for a friendly game)





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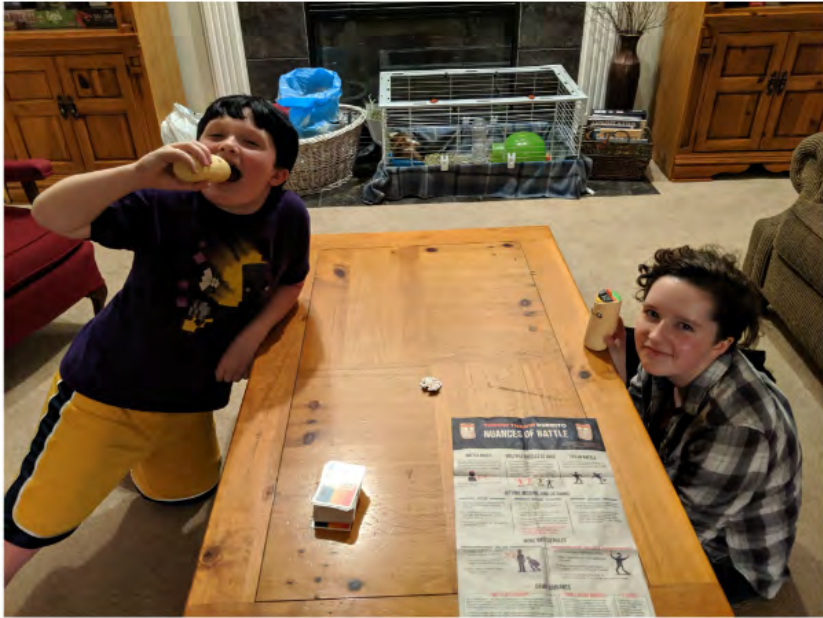
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name)



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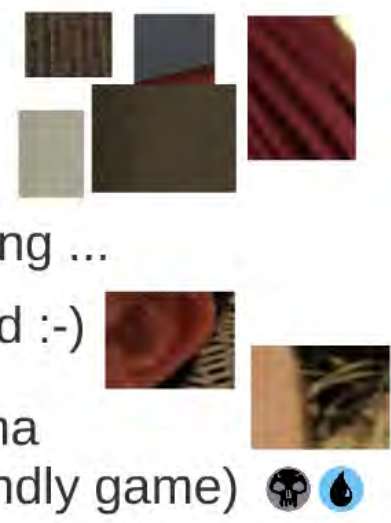


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Our Agenda for this Session

- Problems solved with AOP
- AOP terminology and concepts
- Tools that enable AOP in .NET
- Creating aspects
- Potential watch-outs with AOP
- Q&A throughout!





What
sort of
"problems?"



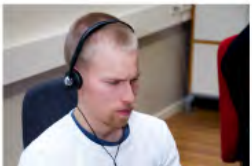
Our Age

- Problems
- AOP termi
- Tools that
- Creating a



Let's illustrate with an

example



You've been tasked with building a new enterprise-class, full-trust SharePoint solution or provider-

Let's illustrate with an

example

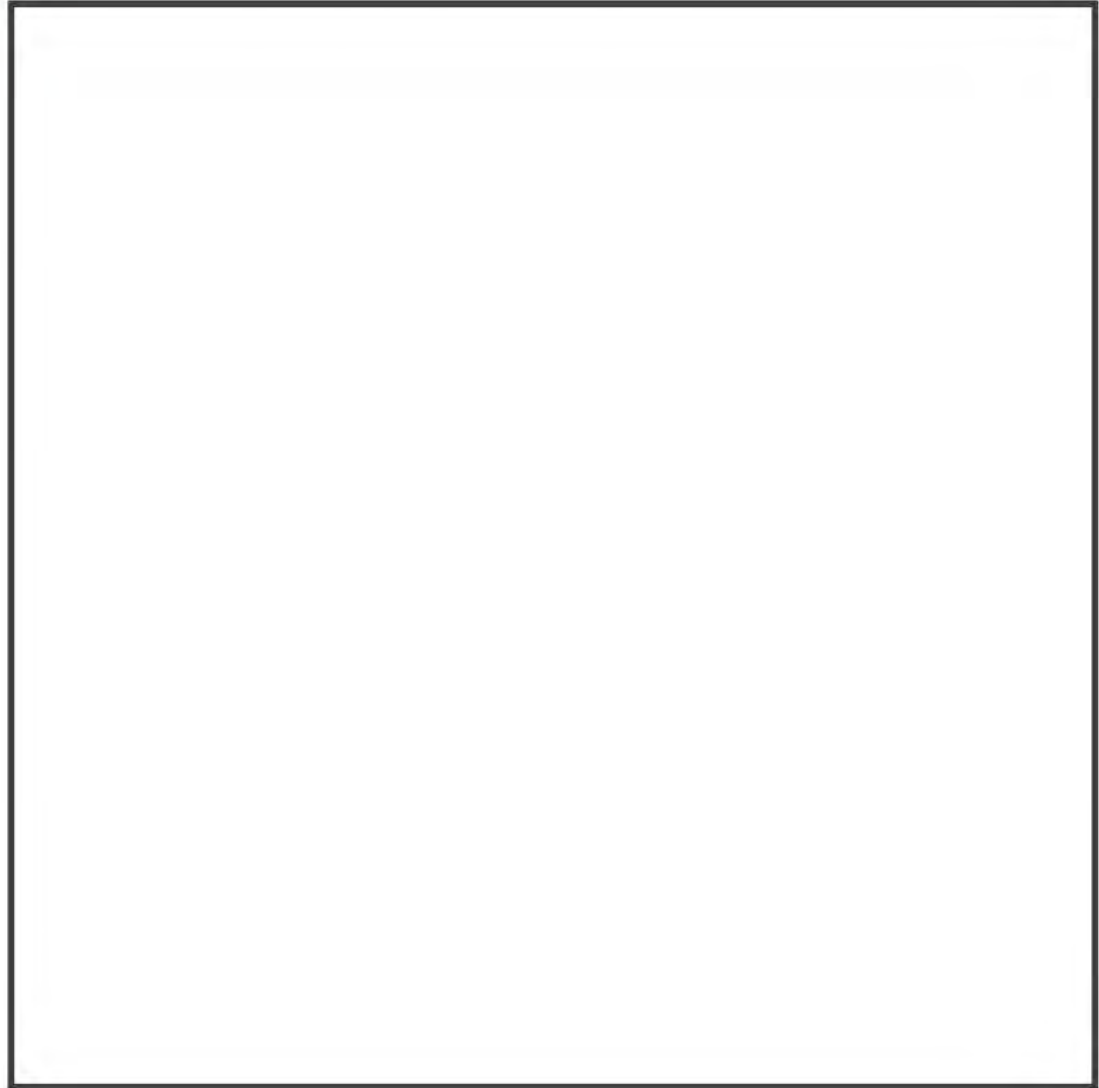


You've been tasked with building a new enterprise-class, full-trust SharePoint solution or provider-hosted application - complete with a wide-array of functional and non-functional requirements



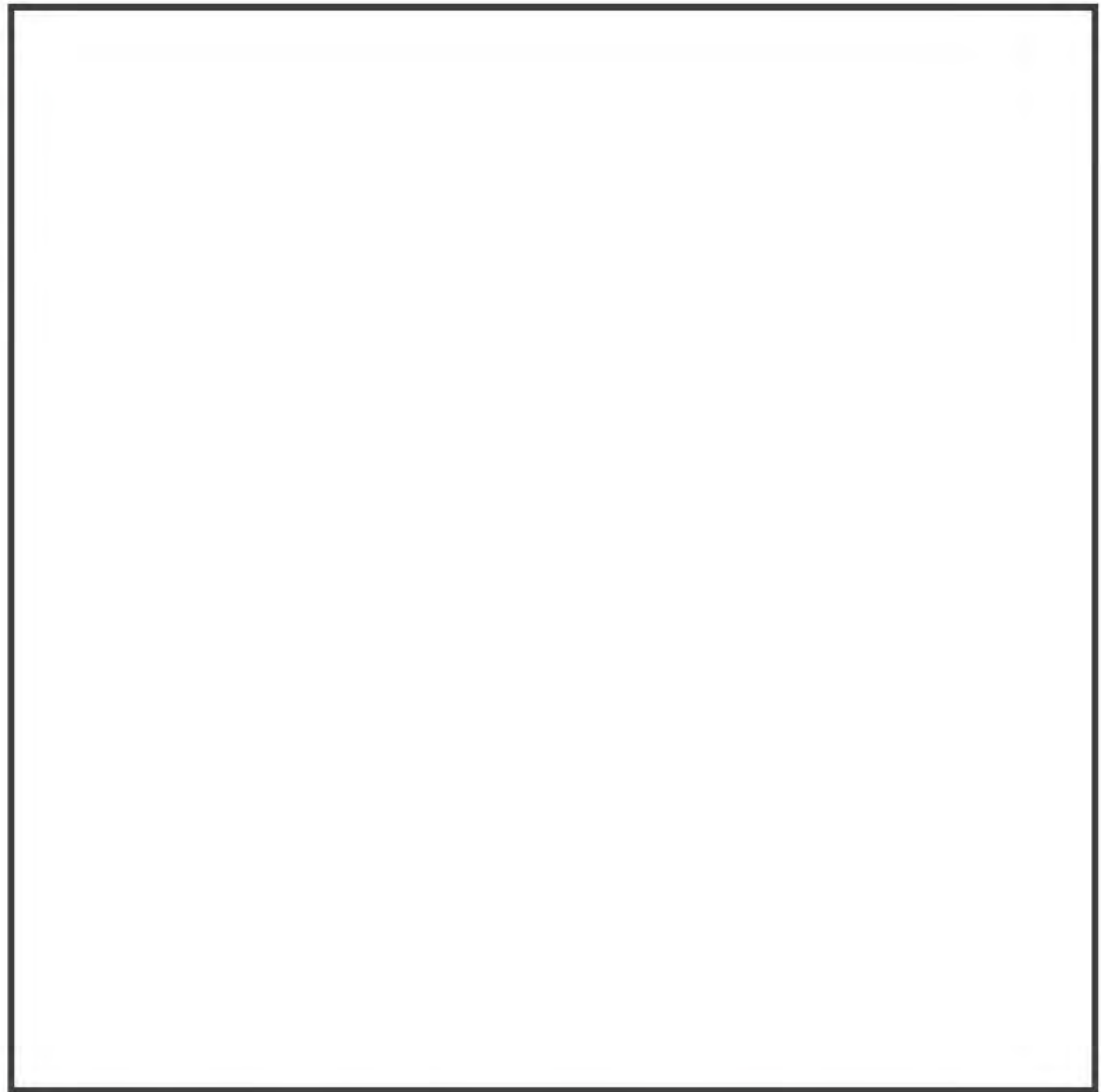
Greenfield development

This box
represents your
application



Beautiful, isn't it?

This box
represents your
application



Beautiful, isn't it?



Greenfield development

Heck, most developers

Me

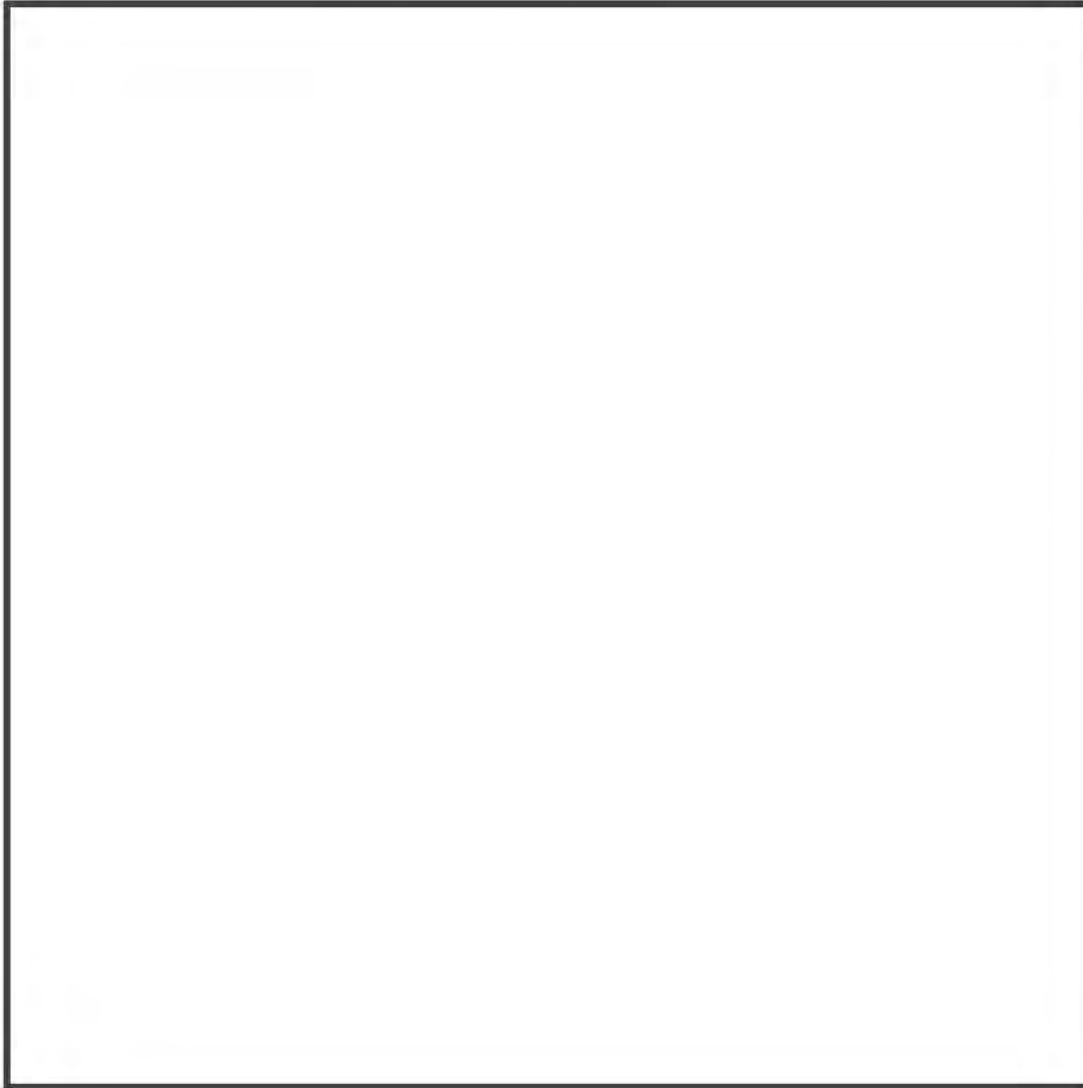


Heck, most developers

Me



Greenfield development



First up: functional requirements

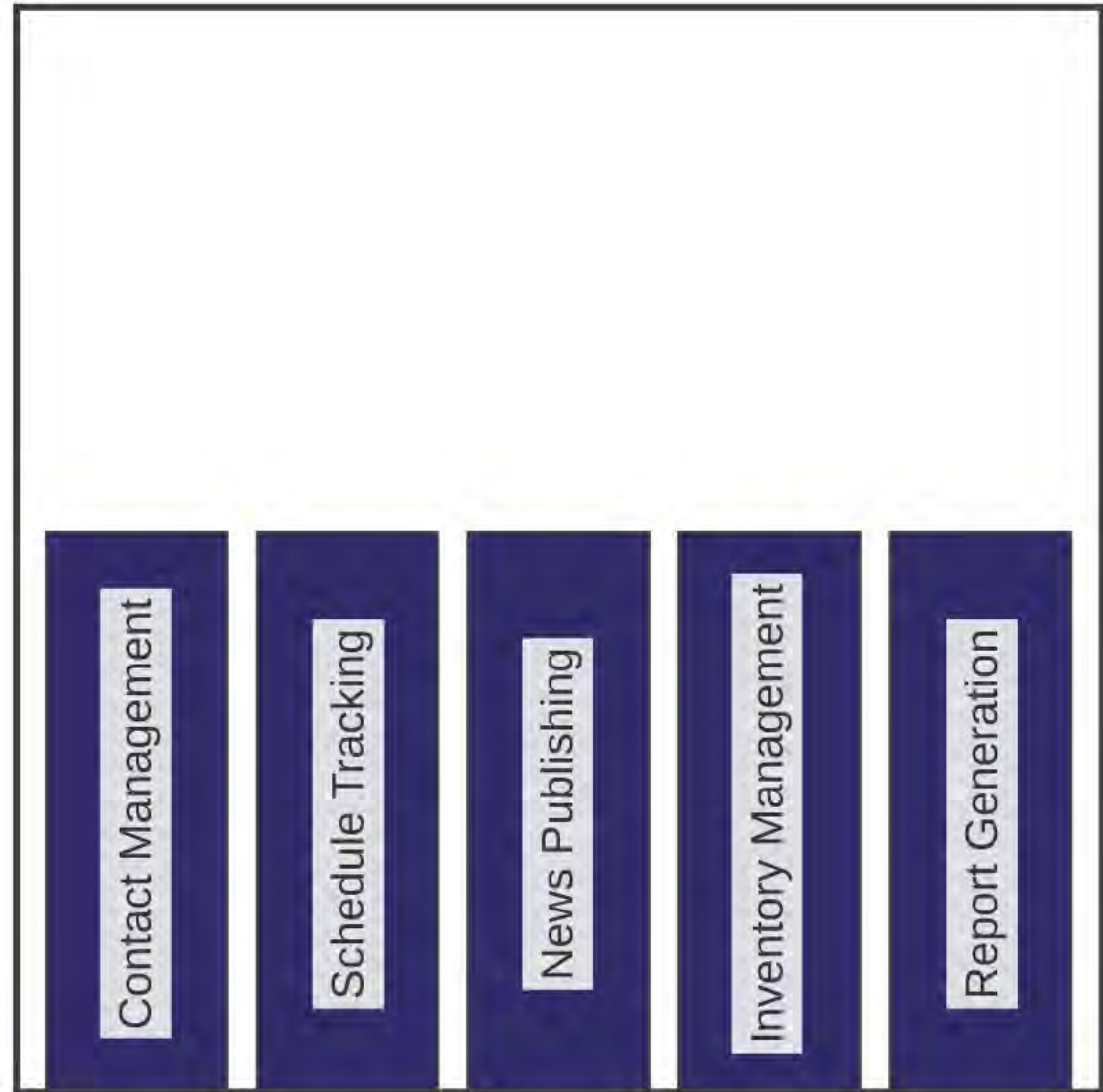
The app needs to do something business-related, so we typically start by adding code based on our solution requirements.



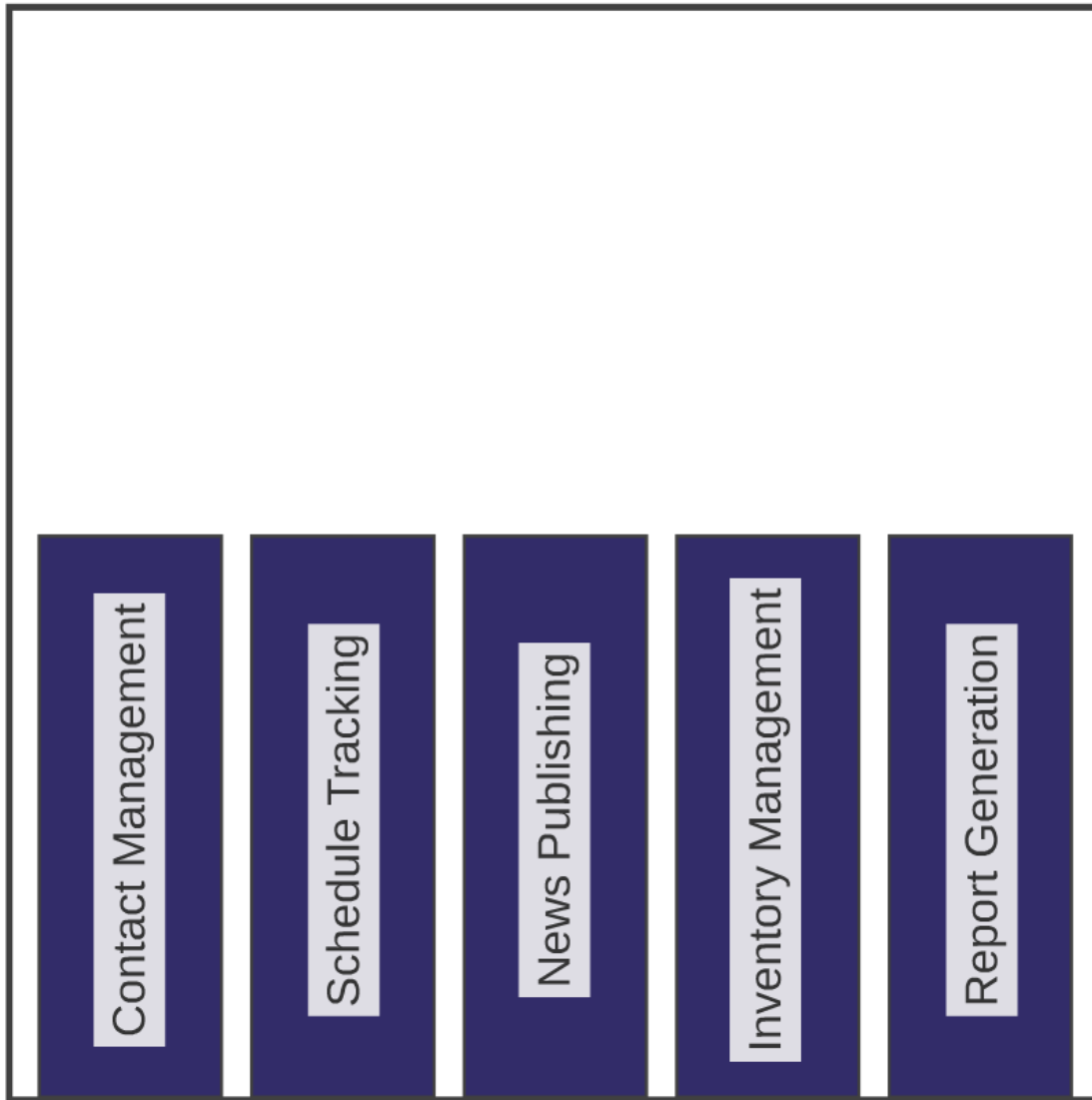
ful, isn't it?

First up: functional requirements

The app needs to do something business-related, so we typically start by adding code based on our solution requirements.



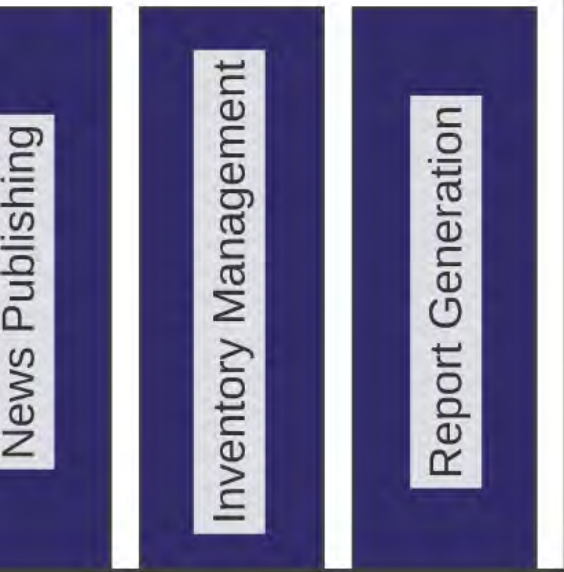
This is the



Chunks of code oriented around delivering desired functionality

- Vertical slices
- When end-users think of apps, this is where their focus usually is
- This code is generally "the fun stuff" to design and write

This is the part of our job



around delivering desired functionality

- Vertical slices
- When end-users think of apps, this is where their focus usually is
- This code is generally "the fun stuff" to design and write



This is the part of our job where we feel like rock stars ...

coding like



This code is generally
"the fun stuff" to design
and write



This is the part of our job where
we feel like rock stars ...

... coding like
crazy, showing
users what we've
done, havin' fun!



and then

... is generally
"fun stuff" to design
write



... part of our job where
rock stars ...



Example #1

and then

we feel like rock stars ...

... coding like
crazy, showing
users what we've
done, havin' fun!



... and then ...

Reality catches up to us.

Business functionality is only part of the puzzle. There's a less glorious side to all of this solution development stuff.



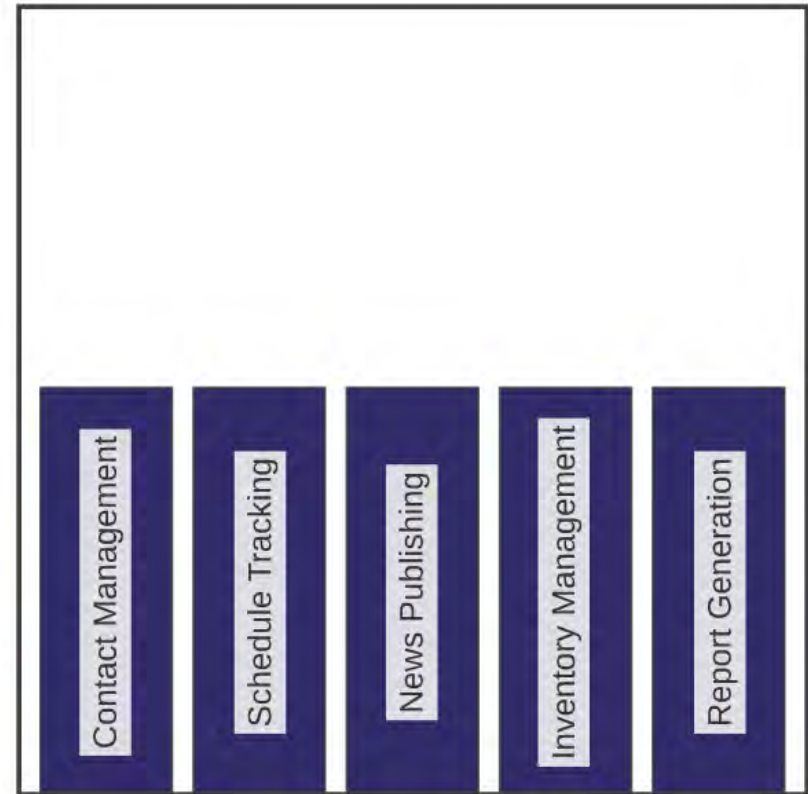
In reality. our

glorious side to all of this
tion development stuff.



The other part: plumbing and
non- functional requirements

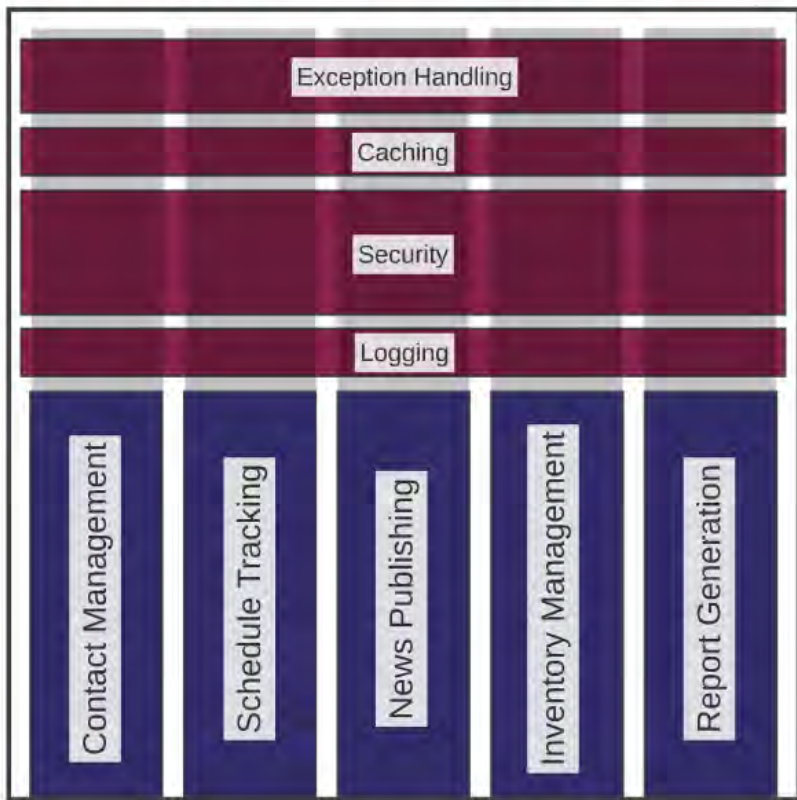
In reality, our
application doesn't
look like this





Cross-cutting concerns

It looks like this



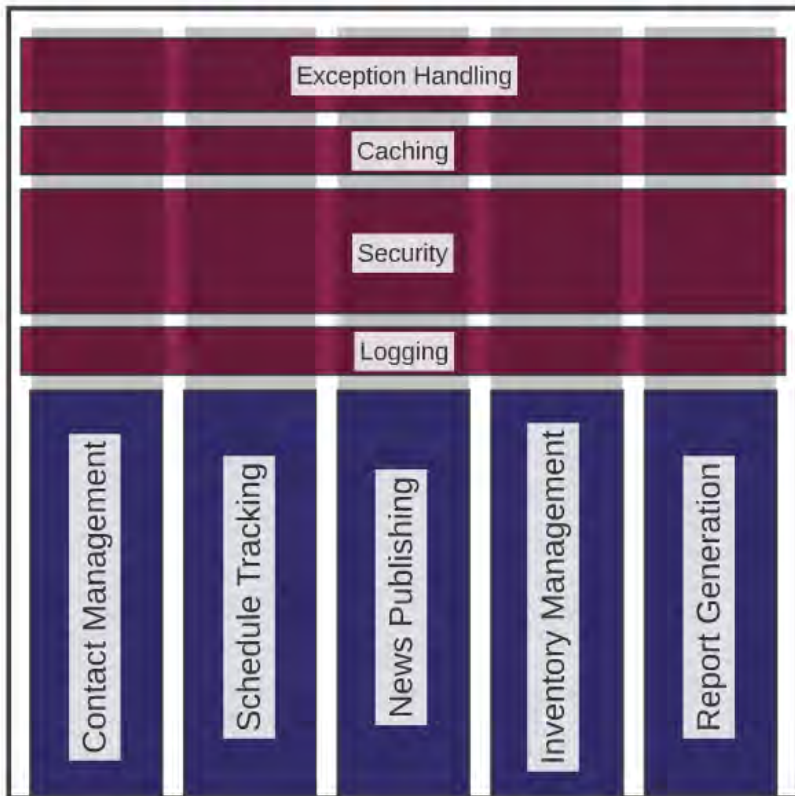
- Needs that "cut across" all of the solution's functional areas
- Plumbing code like security, exception handling, logging, caching, performance monitoring, and more
- Code tends to be highly repetitive in nature

Unfortunately, this tends to lead to a lot of cut-and-paste between classes in the average solution



Cross-cutting concerns

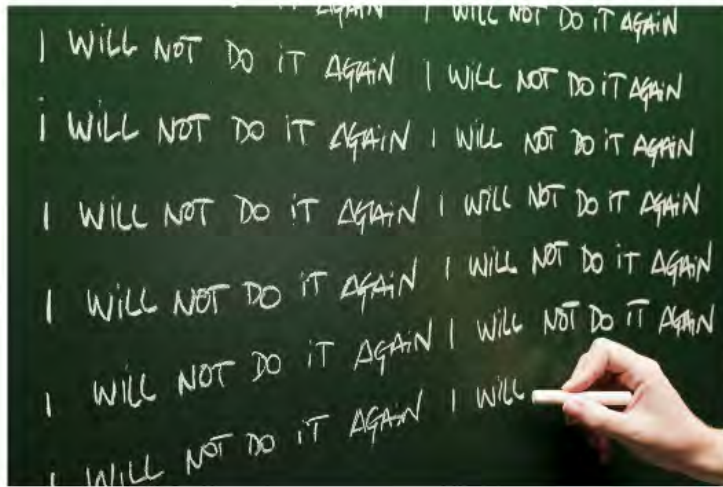
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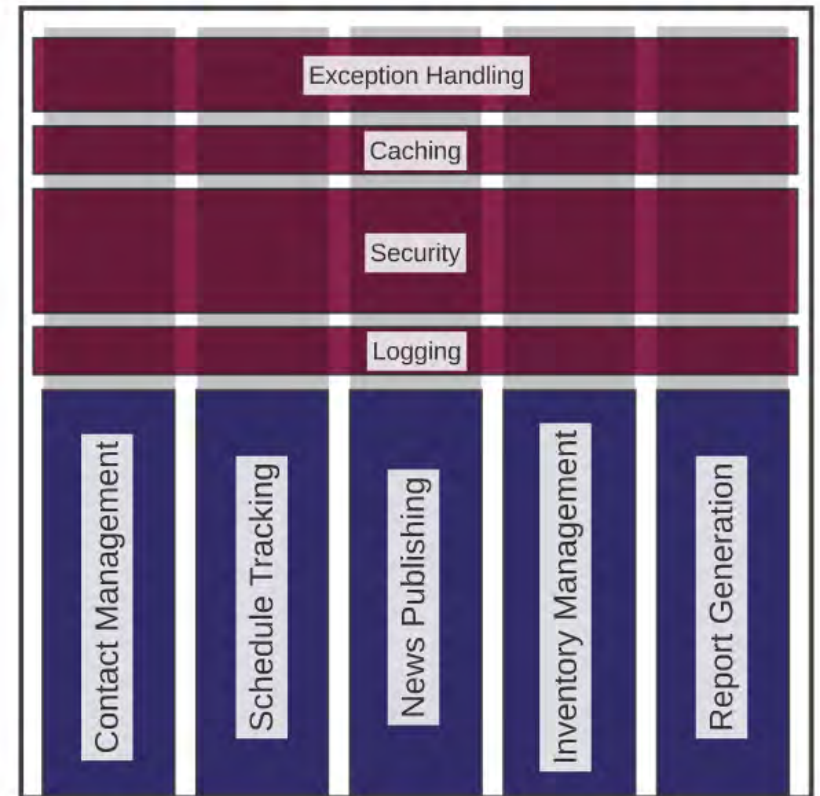
Unfortunately, this tends to lead to a lot of cut-and-paste between classes in the average solution





Example #2

It looks like this



Unfortunately, this tends to
and-paste between classes



Going from this:

1 reference | spmcdonough, 14 hours ago | 3 changes

```
private String GenerateLine1()  
{  
    return "It is by caffeine alone that I set my mind in motion.\n";  
}
```

... to this:

1 reference | spmcdonough, 18 hours ago | 2 changes

```
private String GenerateLine1()
```

Going from this:

1 reference | spmcdonough, 14 hours ago | 3 changes

```
private String GenerateLine1()
{
    return "It is by caffeine alone that I set my mind in motion.\n";
}
```

... to this:

1 reference | spmcdonough, 18 hours ago | 2 changes

```
private String GenerateLine1()
{
    LoggingSupport.WriteToLog("Entering Method GenerateLine1", 2);
    String whatToWrite = "It is by caffeine alone that I set my mind in motion.\n";
    LoggingSupport.WriteToLog("Exiting Method GenerateLine1", 2);
    return whatToWrite;
}
```

... is a substantial code change

Going from this:

1 reference | spmcdonough, 14 hours ago | 3 changes

```
private String GenerateLine1()  
{  
    return "It is by caffeine alone that I set my mind in motion.\n";  
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private String GenerateLine1()  
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    LoggingSupport.WriteToLog("Entering Method GenerateLine1", 2);  
    String whatToWrite = "It is by caffeine alone that I set my mind in motion.\n";  
    LoggingSupport.WriteToLog("Exiting Method GenerateLine1", 2);  
    return whatToWrite;  
}
```

... is a substantial code change

not cool



Going from this:

1 reference | spmcdonough, 14 hours ago | 3 changes


```
private String GenerateLine1()  
{  
    return "It is by caffeine alone that I set my mind on fire";  
}
```

... to this:

1 reference | spmcdonough, 18 hours ago | 2 changes

```
private String GenerateLine1()  
{  
    LoggingSupport.WriteToLog("Entering Method GenerateLine1",  
        String whatToWrite = "It is by caffeine alone that I set my mind on fire");  
    LoggingSupport.WriteToLog("Exiting Method GenerateLine1",  
        return whatToWrite;  
}
```

... is a substantial code change



And it only gets worse with each additional concern we add ...

Let's add in some exception handling

0 references | 0 authors | 0 changes

```
private String GenerateLine1()
{
    LoggingSupport.WriteToLog("Entering Method GenerateLine1", 2);
    String whatToWrite;

    try
    {
        whatToWrite = "It is by caffeine alone that I set my mind in motion.\n";
    }
    catch (Exception ex)
    {
        var newAppException = new Exception("Unexpected problem generating line 1", ex);
        LoggingSupport.WriteToLog(newAppException.ToString(), 3);
        throw newAppException;
    }

    LoggingSupport.WriteToLog("Exiting Method GenerateLine1", 2);
    return whatToWrite;
}
```



exception handling, and caching brought us to this

And some memory-based caching



```
0 references | 0 authors | 0 changes
private String GenerateLine1()
{
    LoggingSupport.WriteToLog("Entering Method GenerateLine1", 2);
    const String lineCacheKey = "TESTAPP_GenerateLine1_KEY";
    String whatToWrite;

    try
    {
        var aspNetCache = HttpContext.Current.Cache;
        Object targetLineObject = aspNetCache[lineCacheKey];
        if (targetLineObject == null)
        {
            targetLineObject = "It is by caffeine alone that I set my mind in motion.\n";
            aspNetCache.Add(lineCacheKey, targetLineObject, null, Cache.NoAbsoluteExpiration,
                TimeSpan.FromMinutes(15), CacheItemPriority.Default, null);
        }
        whatToWrite = targetLineObject.ToString();
    }
    catch (Exception ex)
    {
        var newAppException = new Exception("Unexpected problem generating line 1", ex);
        LoggingSupport.WriteToLog(newAppException.ToString(), 3);
        LoggingSupport.WriteToLog("Exiting Method GenerateLine1 due to exception", 2);
        throw newAppException;
    }

    LoggingSupport.WriteToLog("Exiting Method GenerateLine1", 2);
    return whatToWrite;
}
```



We started with this:

1 reference | spmcdonough, 14 hours ago | 3 changes

```
private String GenerateLine1()
{
    return "It is by caffeine alone that I set my mind in motion.\n";
}
```

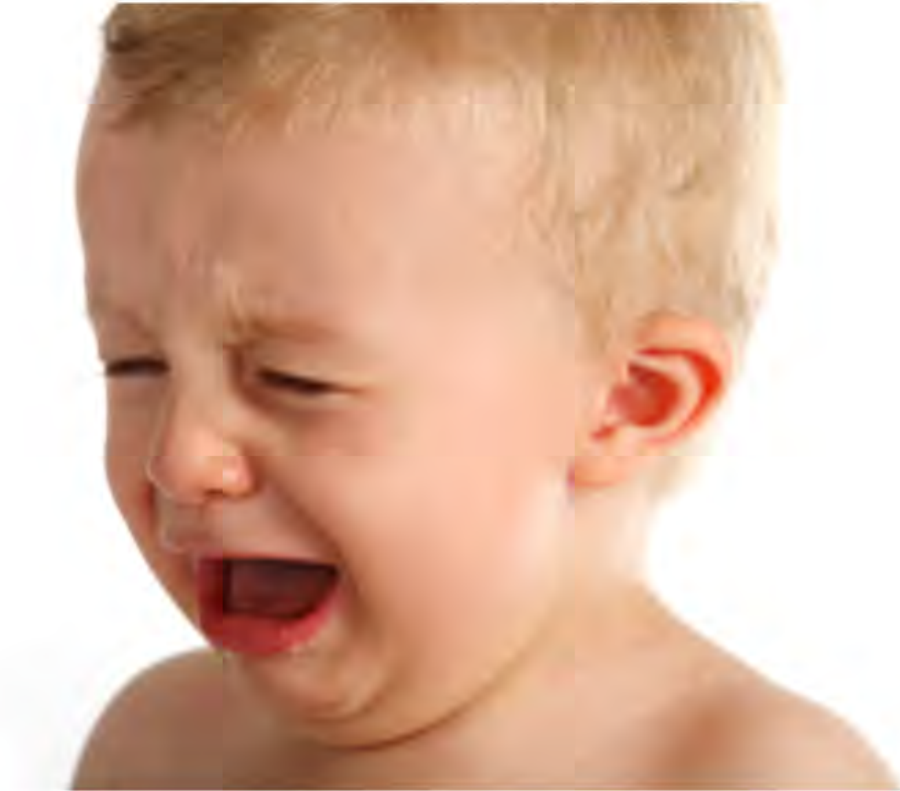
And adding logging, exception handling, and caching brought us to this

0 references | 0 authors | 0 changes

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private String GenerateLine1()
{
    LoggingSupport.WriteToLog("Entering Method GenerateLine1", 2);
    const String lineCacheKey = "TESTAPP_GenerateLine1_KEY";
    String whatToWrite;

    try
    {
        var aspNetCache = HttpContext.Current.Cache;
        Object targetLineObject = aspNetCache[lineCacheKey];
        if (targetLineObject == null)
        {
            targetLineObject = "It is by caffeine alone that I set my mind in motion.\n";
            aspNetCache.Add(lineCacheKey, targetLineObject, null, Cache.NoAbsoluteExpiration,
                TimeSpan.FromMinutes(15), CacheItemPriority.Default, null);
        }
        whatToWrite = targetLineObject.ToString();
    }
    catch (Exception ex)
    {
        var newAppException = new Exception("Unexpected problem generating line 1", ex);
        LoggingSupport.WriteToLog(newAppException.ToString(), 3);
        LoggingSupport.WriteToLog("Exiting Method GenerateLine1 due to exception", 2);
        throw newAppException;
    }

    LoggingSupport.WriteToLog("Exiting Method GenerateLine1", 2);
    return whatToWrite;
}
```



24 lines

And the worst part

We started with this:

1 reference | spmcndonough, 14 hours ago | 3 changes

```
private String GenerateLine1()
{
    return "It is by caffeine alone that I set my mind in motion.\n";
}
```

1 line

And adding logging, exception handling, and caching brought us to this

```
0 references | 0 authors | 0 changes
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        LoggingSupport.WriteToLog(newAppException.ToString(), 3);
        LoggingSupport.WriteToLog("Exiting Method GenerateLine1 due to exception", 2);
        throw newAppException;
    }
    LoggingSupport.WriteToLog("Exiting Method GenerateLine1", 2);
    return whatToWrite;
}
```



24 lines

And the worst part of this ...

We end up doing it for nearly all





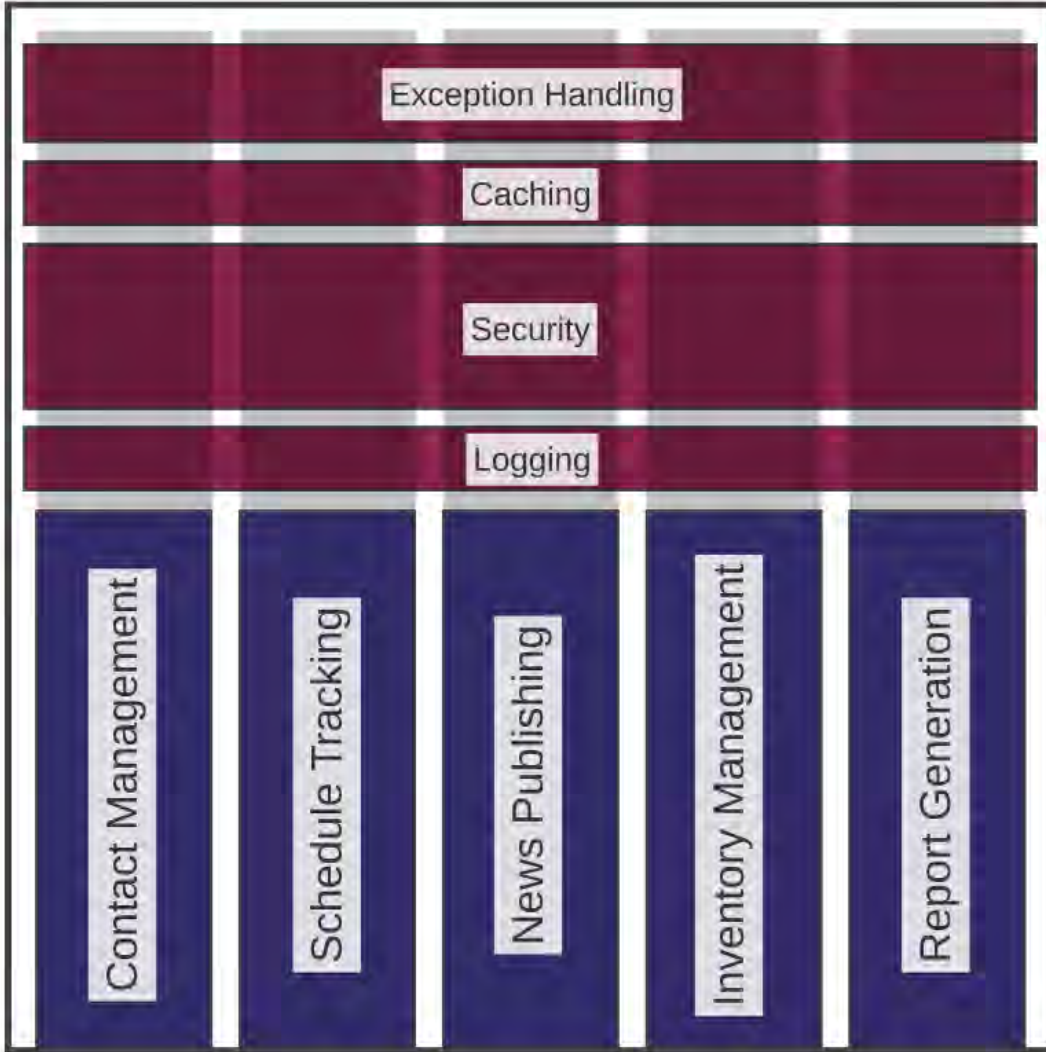
And the worst part of this ...

We end up doing it
for nearly all
methods and
properties



There has to be a better way

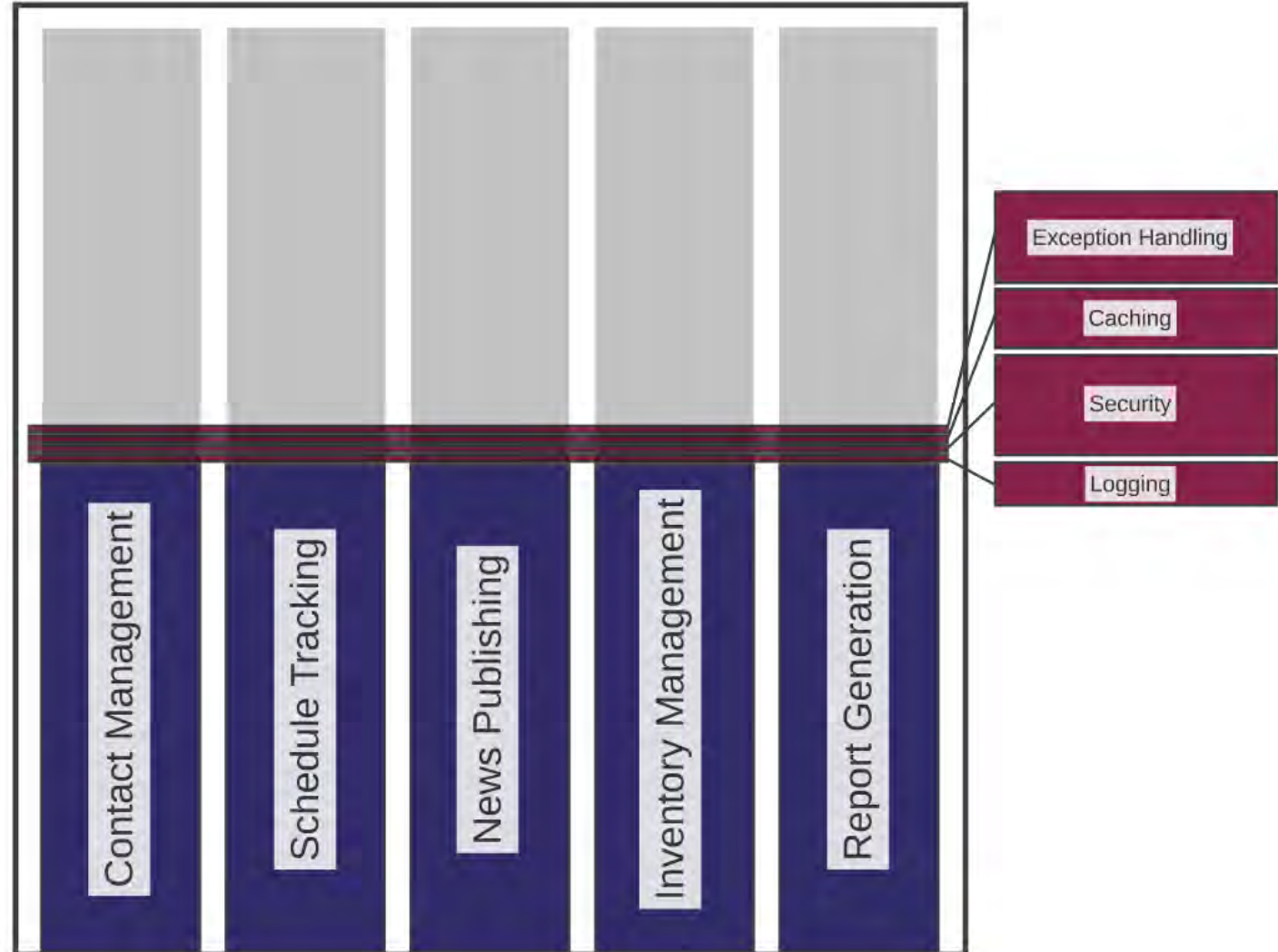




Instead of this

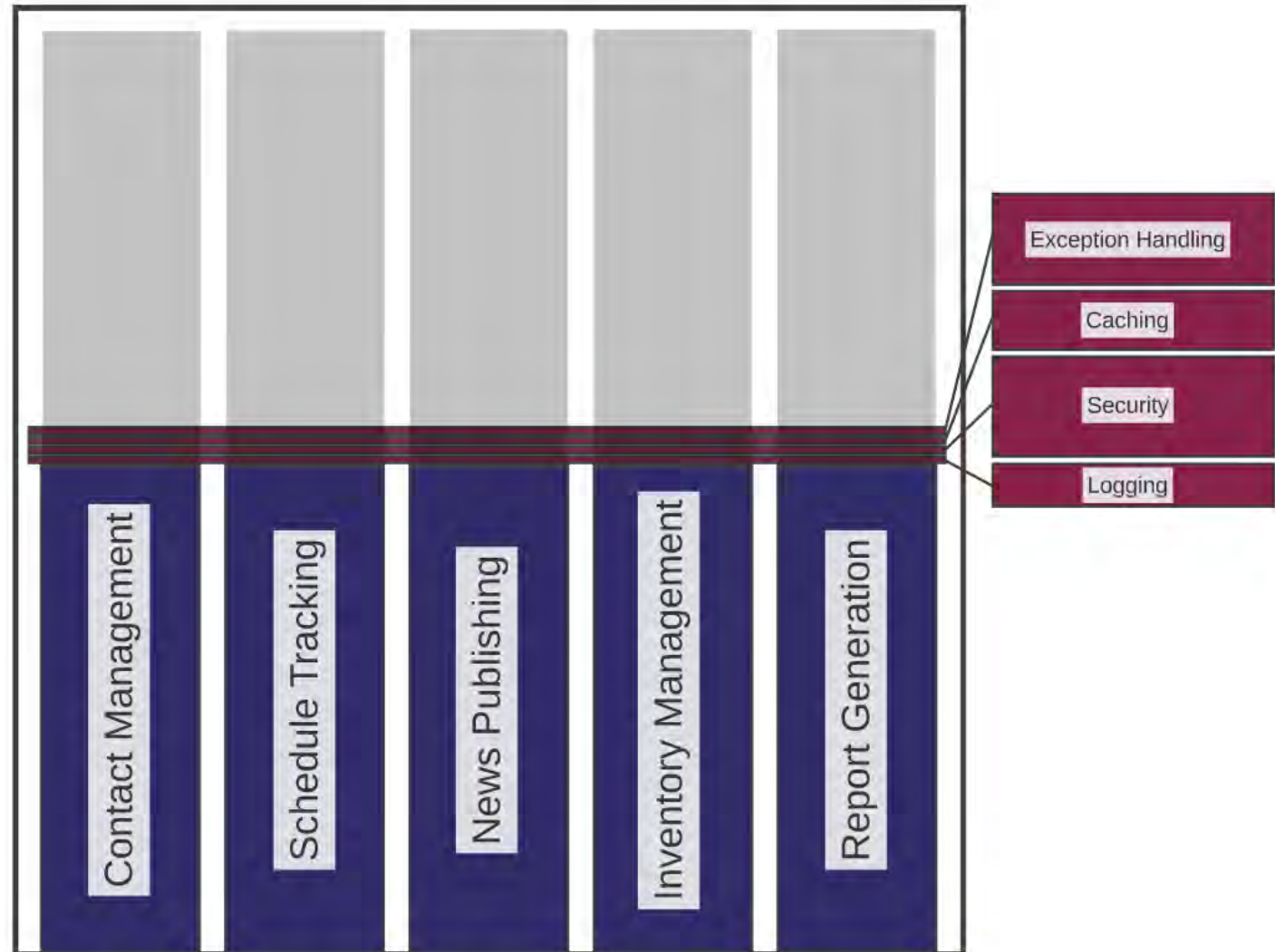
This is exactly what AOP offers

we need
this

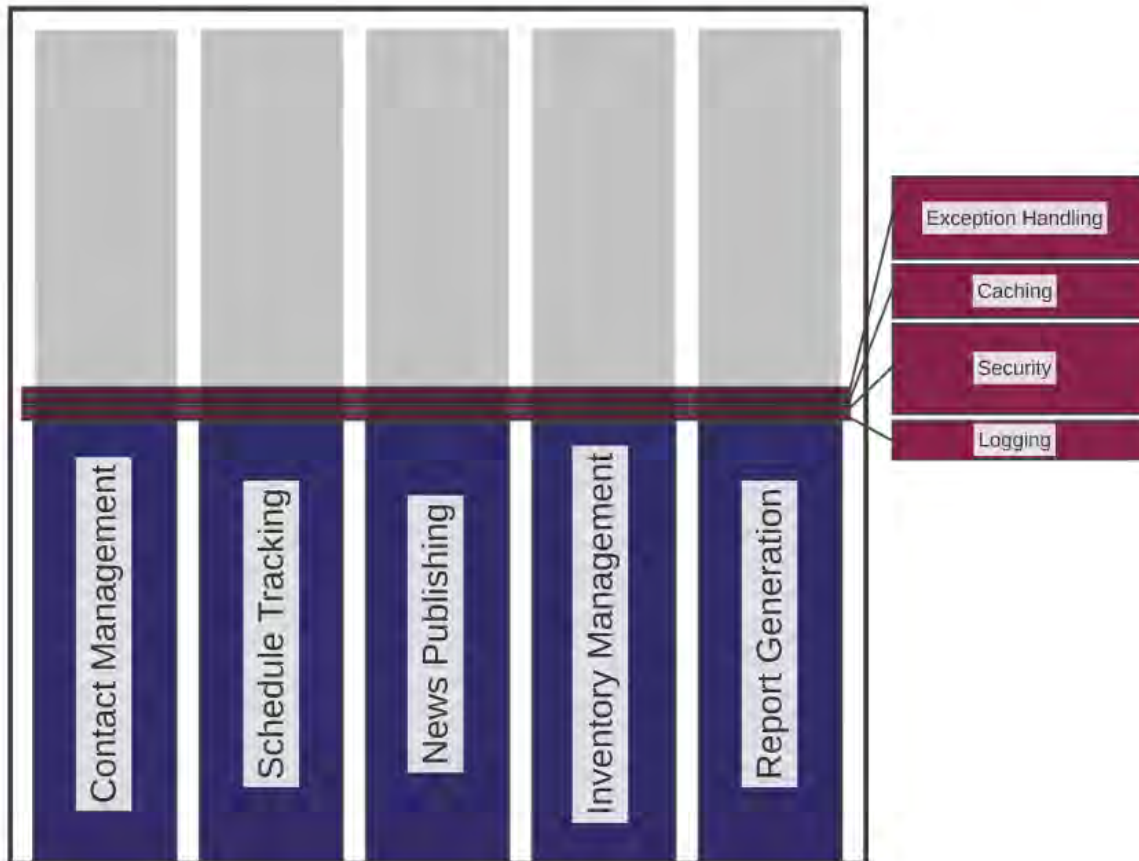


This is exactly what AOP offers

we need
this



Exactly what AOP offers



- Cross-cutting concerns are encapsulated within aspects
- Functional code remains clear of redundant plumbing code
- Reduces clutter and overall line counts
- Simplifies maintenance

- Cross-cutting concerns are encapsulated within aspects
- Functional code remains clear of redundant plumbing code
- Reduces clutter and overall line counts
- Simplifies maintenance



Example #3

- Simplifies maintenance

FREQUENTLY ASKED QUESTION

Seems neat, but if AOP is so useful, how come I haven't seen it "in the wild" by now?





Aspects come in many forms

And if you haven't been looking

And if you haven't been looking,
you may have missed them



HTTP Modules and ASP.NET MVC Action

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▸ HTTP Handlers and HTTP Modules Overview

How to: Register HTTP Handlers

How to: Configure an HTTP Handler Extension in IIS

Walkthrough: Creating a Synchronous HTTP Handler

Walkthrough: Creating an Asynchronous HTTP Handler

Walkthrough: Creating and Registering HTTP Handler Factories

Walkthrough: Creating and Registering a Custom HTTP Module

Walkthrough: Creating and Registering a Custom HTTP Module

.NET Framework 4 | Other Versions ▾ | 15 out of 24 rated this helpful - Rate this topic

This walkthrough illustrates the basic functionality of a custom HTTP module. An HTTP module is called on every request in response to the `BeginRequest` and `EndRequest` events. As a result, the module runs before and after a request is processed.

If the ASP.NET application is running under IIS 6.0, you can use HTTP modules to customize requests for resources that are serviced by ASP.NET. This includes ASP.NET Web pages (.aspx files), Web services (.asmx files), ASP.NET handlers (.ashx files), and any file types that you have mapped to ASP.NET. If the ASP.NET application is running under IIS 7.0, you can use HTTP modules to customize requests for any resources that are served by IIS. This includes not just ASP.NET resources, but HTML files (.htm or .html files), graphics files, and so on. For more information, see [ASP.NET Application Life Cycle Overview for IIS 5.0 and 6.0](#) and [ASP.NET Application Life Cycle Overview for IIS 7.0](#).

The example module in this topic adds a message to the requested ASP.NET Web page at the beginning of any HTTP request. It adds another message after the page has been processed. The module includes code that makes sure that it does not add text to a request for any other file type.

Each event handler is written as a private method of the module. When the registered events are raised, ASP.NET calls the appropriate handler in the module, which writes information to the ASP.NET Web page.

How about an ASP.NET MVC Action Filter?

The screenshot shows the Microsoft ASP.NET website. At the top left is the Microsoft logo. A search bar contains "Search ASP.NET" and a magnifying glass icon. To the right is a "Language" dropdown menu. Further right are "Sign In" and "Join" links. Below the search bar is the "ASP.NET" logo and a navigation menu with items: Home, Get Started, Learn (highlighted), Hosting, Downloads, Community (with a dropdown arrow), Forums, and Help. A secondary menu under "Learn" includes MVC: Overview, Tutorials (highlighted), Videos, Samples, Forum, Books, and Open Source. On the right side, there are social media icons for Twitter and Facebook with the text "Follow us on".

The main content area features the article title "ASP.NET MVC 4 Custom Action Filters" in a large, bold font. Below the title is the author information "By Web Camps Team | February 18, 2013" and a "Print" button. The article text is enclosed in a light blue box and reads: "ASP.NET MVC provides Action Filters for executing filtering logic either before or after an action method is called. Action Filters are custom attributes that provide declarative means to add pre-action and post-action behavior to the controller's action methods." Below this is a paragraph: "In this Hands-on Lab you will create a custom action filter attribute into MvcMusicStore solution to catch controller's requests and log the activity of a site into a database table. You will be able to add your logging filter by injection to any controller or action. Finally, you will see the log view that shows the list of visitors." A "Note" follows: "Note: This Hands-on Lab assumes you have basic knowledge of ASP.NET MVC. If you have not used ASP.NET MVC before, we recommend you to go over ASP.NET MVC 4 Fundamentals Hands-on Lab." Below the article text is the "Objectives" section, which begins with "In this Hands-On Lab, you will learn how to:".

On the left side of the page, there is a sidebar with a list of links: ASP.NET MVC 5, ASP.NET MVC 4, MVC Music Store, Getting Started with EF 6 using MVC 5, Getting Started with EF 5 using MVC 4, and Views.

At the bottom left, there is a small text element: "Waiting for www.microsofttranslator.com..."

you may have missed them



HTTP Modules and ASP.NET MVC Action Filters are just two examples of AOP at work

There are other tools, but this
the best implemented and supported

My AOP Tool of Choice:

PostSharp Ultimate



There are other tools, but this is (in my opinion)
the best implemented and supported

PostSharp Ultimate

- Free version available
- Cleanest separation of concerns (no spaghetti code)
- Employs compile-time weaving

Um ...



spagnetti code)

- Employs compile-time weaving



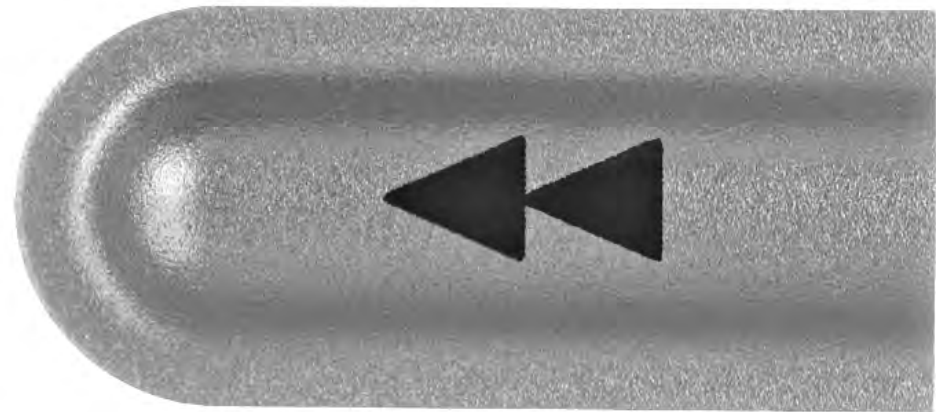
Um ...

compile-time what?



Okay, let's pause
for a second

And rewind
to cover
some basics



A code snippet from the LoggingToTextboxAspect

```
/// <summary>
/// This method boundary aspect (created with PostSharp) is responsible
/// for handling logging activities for each of the methods with which
/// it is associated.
/// </summary>
[Serializable]
1 reference | spmcidonough, 3 days ago | 1 change
internal class LoggingToTextboxAspect : OnMethodBoundaryAspect
{
    #region Overrides: OnMethodBoundaryAspect

    /// <summary>
    /// The OnEntry method fires on the join point that occurs just before
    /// a method is entered and its first lines of code are executed.
    /// </summary>
    0 references | spmcidonough, 3 days ago | 1 change
    public override void OnEntry(MethodExecutionArgs args)
    {
        | CreateLogEntry(args, "Entering Method");
    }

    /// <summary>
    /// The OnExit method fires on the join point that occurs just after
    /// a method is exited and its execution is complete.
    /// </summary>
    0 references | spmcidonough, 3 days ago | 1 change
    public override void OnExit(MethodExecutionArgs args)
    {
        | CreateLogEntry(args, "Exiting Method");
    }

    #endregion Overrides: OnMethodBoundaryAspect
}
```



Let's establish some

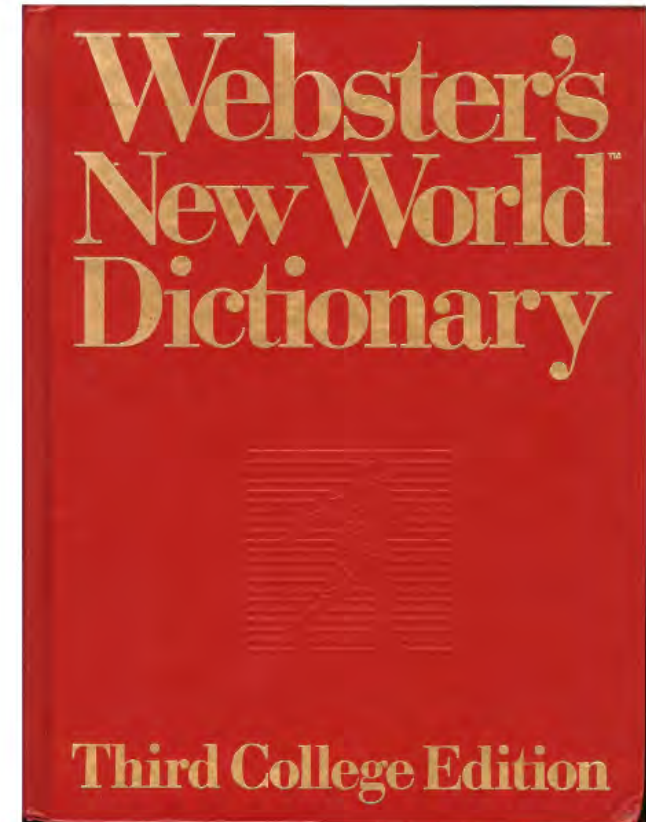
Get from the LoggingToTextboxAspect

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    {
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    }

    #endregion Overrides: OnMethodBoundaryAspect
}
```



Let's establish some definitions

A code snippet from the LoggingToTe

The aspect
code itself
is called ..



```
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}
```

Let's establish

/// <summary>

The arrows represent

1 reference | sprmcDonough, 14 hours ago | 3 changes

```
private String GenerateLine1()
{
    return "It is by caffeine alone that I set my mind in motion.\n";
}
```

```
/// <summary>
/// This method boundary aspect (created with PostSharp) is responsible
/// for handling logging activities for each of the methods with which
/// it is associated.
/// </summary>
[Serializable]
1 reference | sprmcDonough, 3 days ago | 1 change
internal class LoggingToTextboxAspect : OnMethodBoundaryAspect
{

    #region Overrides: OnMethodBoundaryAspect

    /// <summary>
    /// The OnEntry method fires on the join point that occurs just before
    /// a method is entered and its first lines of code are executed.
    /// </summary>
    0 references | sprmcDonough, 3 days ago | 1 change
    public override void OnEntry(MethodExecutionArgs args)
    {
        CreateLogEntry(args, "Entering Method");
    }

    /// <summary>
    /// The OnExit method fires on the join point that occurs just after
    /// a method is exited and its execution is complete.
    /// </summary>
    0 references | sprmcDonough, 3 days ago | 1 change
    public override void OnExit(MethodExecutionArgs args)
    {
        CreateLogEntry(args, "Exiting Method");
    }

    #endregion Overrides: OnMethodBoundaryAspect
}
```

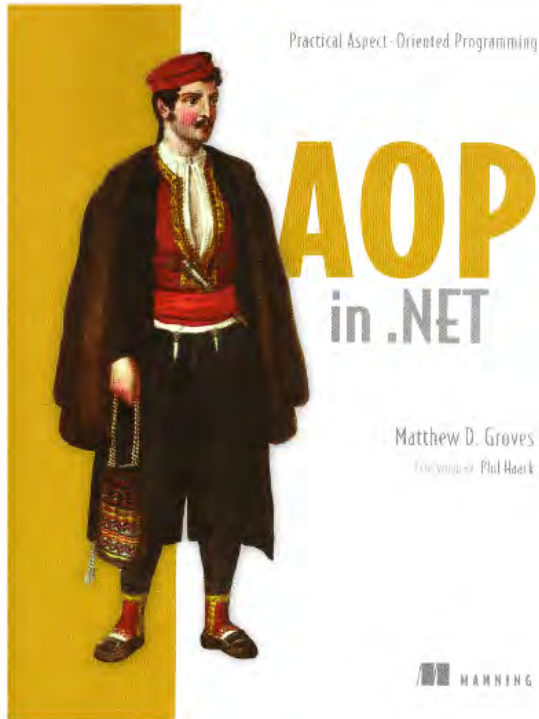
Join Points



"A join point is a place that can be defined between logical steps"

AOP targets

Join Points

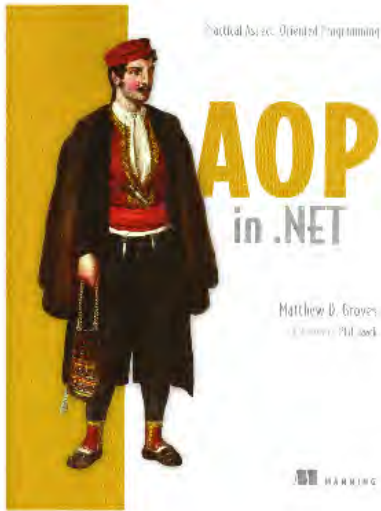


"A join point is a place that can be defined between logical steps of the execution of your program."

- Matthew D. Groves

Join Points

```
/// </summary>  
0 references | spmcndonough, 3 days ago |  
public override void OnExit  
{  
    CreateLogEntry(args, "  
}  
  
#endregion Overrides: OnMe
```



"A join point is a place that can be defined between logical steps of the execution of your program."

- Matthew D. Groves

AOP
targets
these

A set of join points is known as a **pointcut**

roves



pointcut

brings us to

weaving

The process by which
aspects (advice) are

us to

weaving

The process by which aspects (advice) are applied to pointcuts for use by and with your code

Compile-Time



Run-Time

Compile-Time

Weaving
Options

ols

est

mpile
ct IL
de




Run-Time

- Typically relies on reflection
- Doesn't require special tools
- Easier to (unit) test
- Acts similarly to a proxy or decorator

Example: Castle DynamicProxy



Compile-Time

- Requires tools
 - Hard to (unit) test
 - Involves a post-compile step to weave aspect IL with main solution code
 - Allows for optimizations
- 

Example:
PostSharp



We've covered key AOP concepts:

- Advice
- Join Points
- Pointcuts
- Weaving



these apply to aspects

Aspects



We've covered

- Advice
- Join Points
- Pointcuts
- Weaving

And we've talked about how these apply to aspects

Let's look at some of the common
aspect types and how they work



Aspects

Aspect Types We're Going To Examine

How It Works Potential Uses Considerations

Method
Boundary
Method
Interception
Location
Interception



Well-suited to repetitive tasks

- (ULS) Logging
- Tracing
- Performance profiling
- Exception handling*



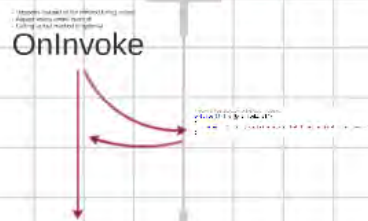
Aspect methods are statically scoped

- Only one instance of each method services all requests from implementing types
- Sidestep this with either the `MethodExecutionTag` or by implementing `IInstanceScopeAspect`

IL can be optimized by PostSharp*

- Arguments selectively copied boxed/unboxed

Multiple methods = great flexibility



Perfect for tasks that involve selective execution

- Caching
- Retry support
- Multi-threading



Shared state benefits

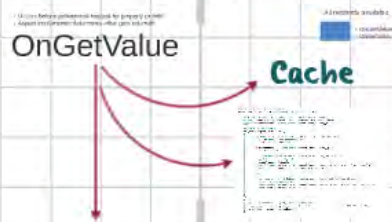
- All activity happens in `OnInvoke`, so state is easy to track outside of intercepted method
- No need for `MethodExecutionTags` and what-not

Somewhat reduced clarity

- Downside of everything in one method

IL cannot be optimized

- All arguments are boxed/unboxed per invocation



Similar to method interception, but more granular

- Validation
- Filtering
- Change tracking & notification
- Lazy loading/initialization

Same basic set of considerations as method interception aspects

- Again, similar in operation - just narrower scope

Works for properties and fields

- Including auto-properties

Method
Boundary
Method

OnEntry

- Occurs before method begins executing
- Provides access to parameters and method info

All methods available



- OnEntry
- OnException
- OnExit
- OnResume
- OnSuccess
- OnYield

1 reference | spmcndonough, 14 hours ago | 3 changes

```
private String GenerateLine1()  
{  
    return "It is by caffeine alone that I set my mind in motion.\n";  
}
```

- Method execution has completed
- Ability to alter return value

OnExit

- Happens instead of the method being called
- Aspect wraps entire method
- Calling actual method is optional

OnEntry



- Occurs before method begins executing
- Provides access to parameters and method info

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OnExit

All methods available



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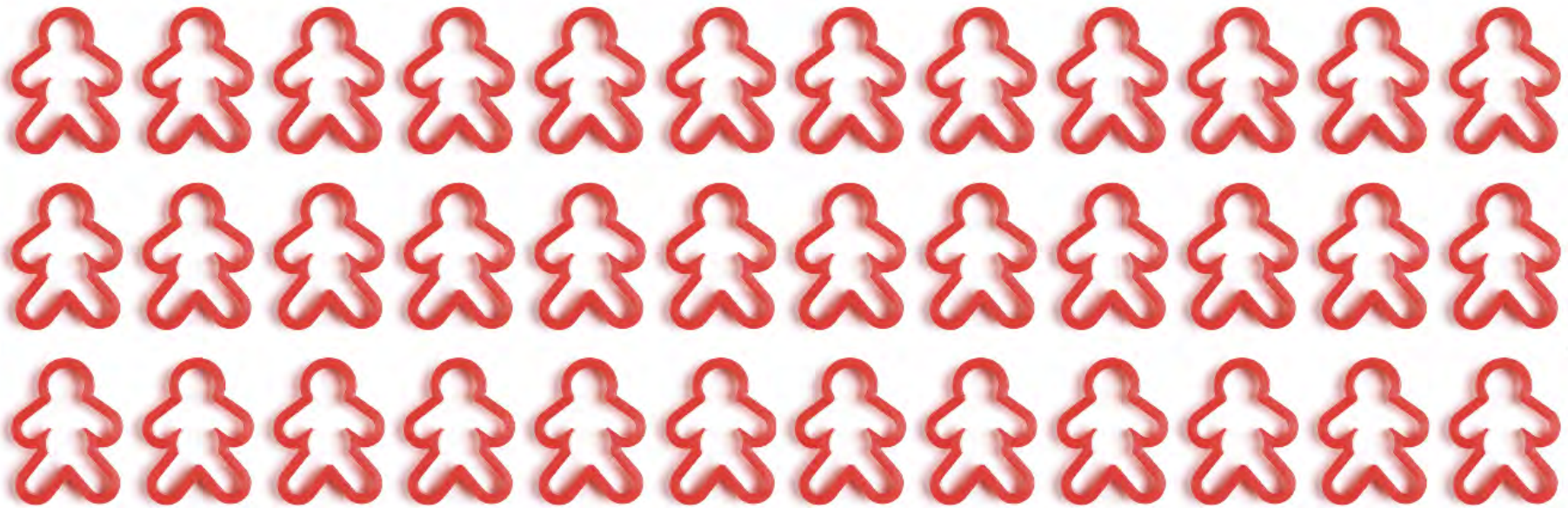
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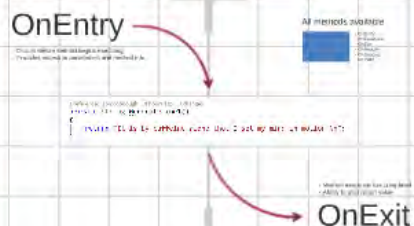
Example #4



Aspect Types We're Going To Examine

How It Works Potential Uses Considerations

Method
Boundary
Method
Interception
Location
Interception



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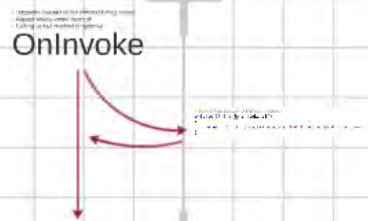
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- Multi-threading



Shared state benefits

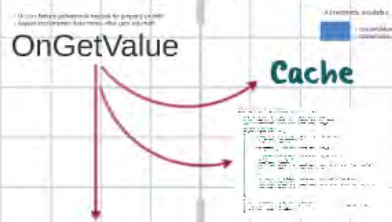
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Boundary

Method

Interception

Location

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OnInvoke

1 reference | spmcodonough, 14 hours ago | 3 changes

```
private String GenerateLine1()  
{  
    return "It is by caffeine alone that I set my mind in motion.\n";  
}
```

- Occurs before get/retrieval request for property or field
- Aspect implementer determines what gets returned

- Happens instead of the method being called
- Aspect wraps entire method
- Calling actual method is optional

OnInvoke



- Happens instead of the method being called
- Aspect wraps entire method
- Calling actual method is optional

OnInvoke

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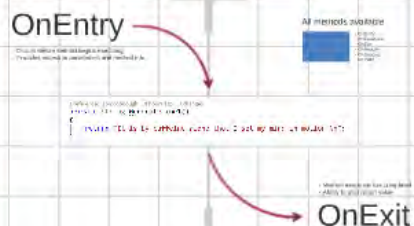
Example #5



Aspect Types We're Going To Examine

How It Works Potential Uses Considerations

Method
Boundary
Method
Interception
Location
Interception



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- Performance profiling
- Exception handling*



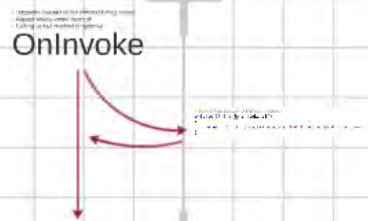
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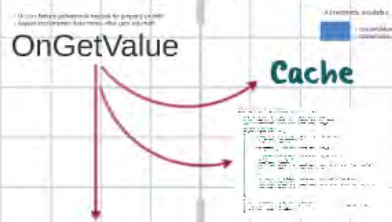
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Interception

Location

Interception

- Occurs before get/retrieval request for property or field
- Aspect implemter determines what gets returned

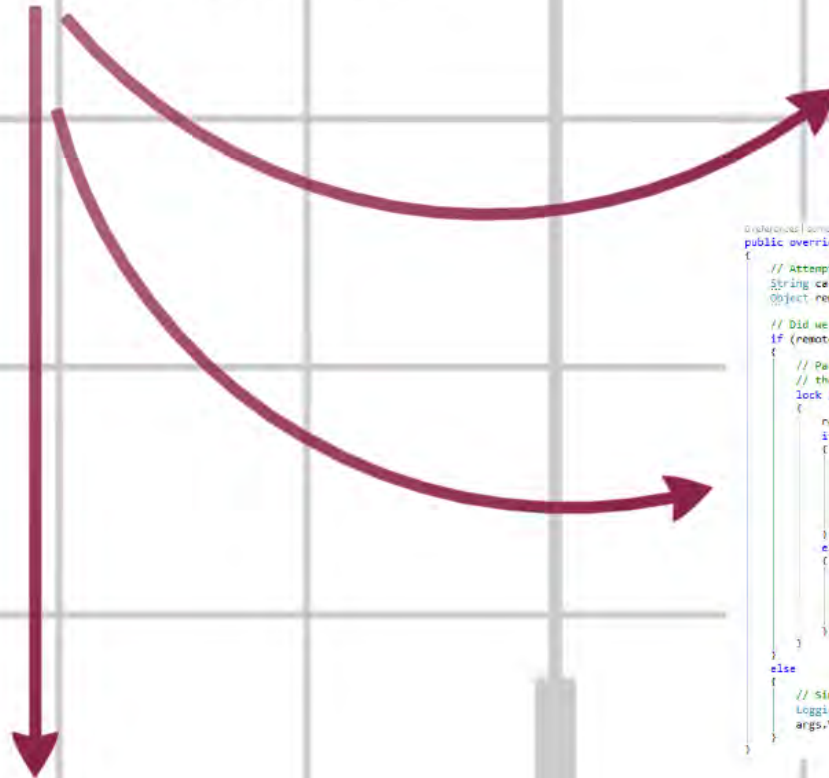
OnGetValue

All methods available



- OnGetValue
- OnSetValue

Cache

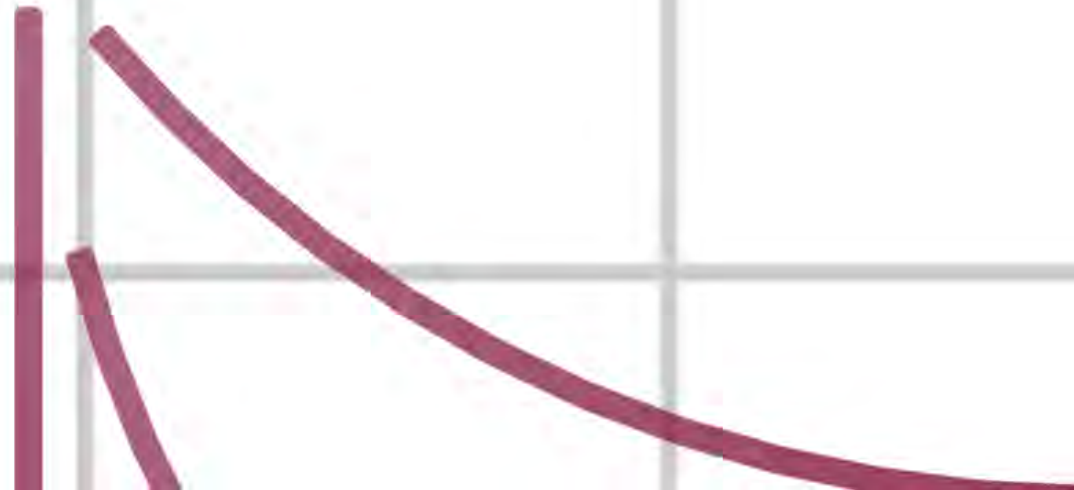


```
public override void OnGetValue(LocationInterceptionArgs args)
{
    // Attempt to fetch the desired property from the ASP.NET Cache.
    String cacheKey = String.Format(CACHE_KEY_TEMPLATE, args.LocationName);
    Object remotePropertyValue = HttpContext.Current.Cache[cacheKey];

    // Did we get anything back?
    if (remotePropertyValue == null)
    {
        // Pause here by locking to ensure that only one caller actually makes
        // the call to retrieve the property value.
        lock (_remotePropertyLockObject)
        {
            remotePropertyValue = HttpContext.Current.Cache[cacheKey];
            if (remotePropertyValue == null)
            {
                // The property value isn't available in the Cache, so we need to
                // fetch it, store it, and pass it back.
                args.ProceedGetValue();
                LoggingSupport.WriteToLog(args.LocationName + " property value fetched from source.");
                HttpContext.Current.Cache.Insert(cacheKey, args.Value);
            }
            else
            {
                // Property wasn't initially in cache, but another thread (in ahead of the
                // current one) populated it.
                LoggingSupport.WriteToLog(args.LocationName + " property value fetched from ASP.NET Cache.");
                args.Value = remotePropertyValue;
            }
        }
    }
    else
    {
        // Simply assign the property value from the Cache.
        LoggingSupport.WriteToLog(args.LocationName + " property value fetched from ASP.NET Cache.");
        args.Value = remotePropertyValue;
    }
}
```

- Occurs before get/retrieval request for property or field
- Aspect implementer determines what gets returned

OnGetValue



All methods available



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- OnSetValue

- Occurs before get/retrieval request for property or field
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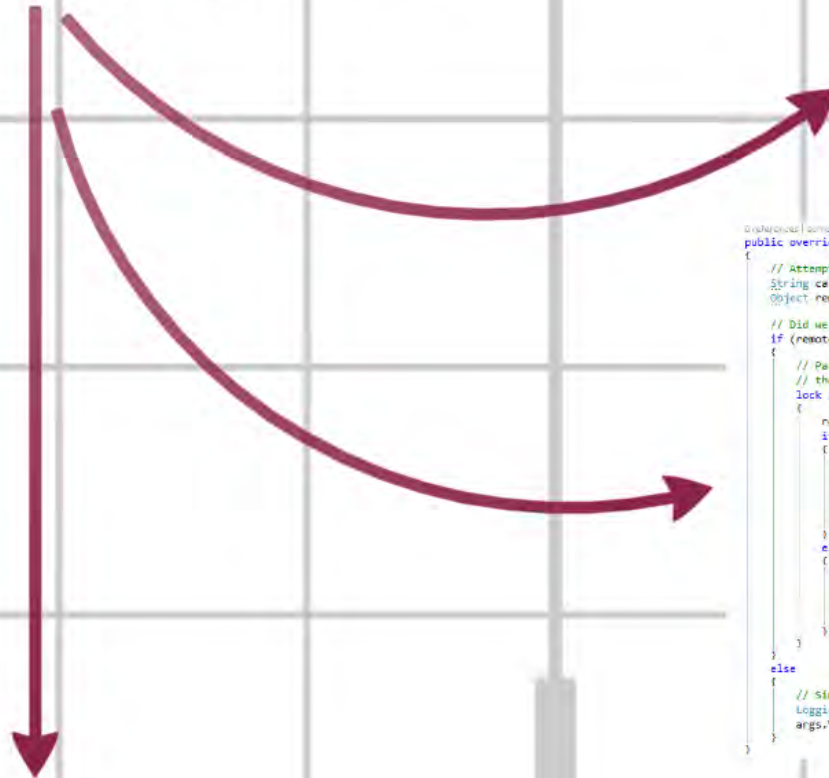
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Cache



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- Multi-threading

Similar to method interception, but more granular

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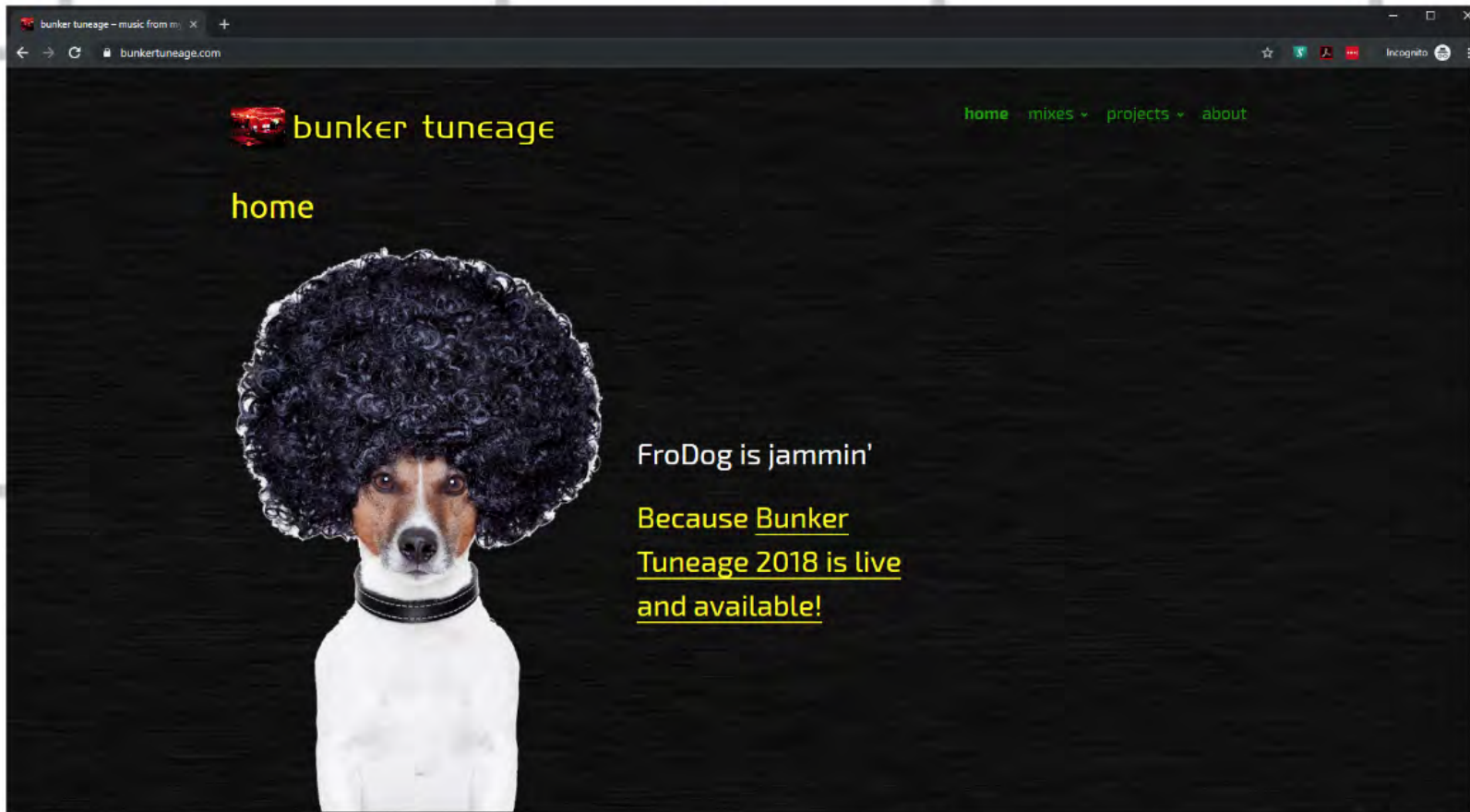
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Example #6



Aspect Types We're Going To Examine

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Method
Interception
Location
Interception



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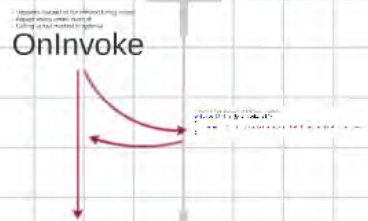
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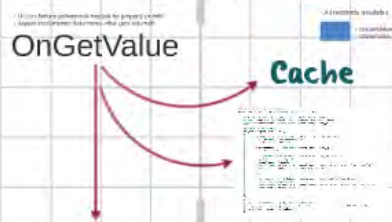
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Walkthrough: Creating and Registering a Custom HTTP Module

[http://msdn.microsoft.com/en-us/library/ms227673\(v=vs.110\).aspx](http://msdn.microsoft.com/en-us/library/ms227673(v=vs.110).aspx)

ASP.NET MVC 4 Custom Action Filters

<https://docs.microsoft.com/en-us/aspnet/mvc/overview/older-versions/hands-on-labs/aspnet-mvc-4-custom-action-filters>

PostSharp

<http://www.postsharp.net>

AOP in .NET

<http://tinyurl.com/AOPinDotNet>

Castle Project DynamicProxy

<http://www.castleproject.org/projects/dynamicproxy/>

Bunker Tuneage

<https://bunkertuneage.com/>

References





Sean P. McDonough

sean@sharepointinterface.com

sean@bitstreamfoundry.com

SharePoint Gearhead,
Developer, and Consultant

*not necessarily
in that order*

My company:



Twitter:

@spmcdonough

Blog:

<http://SharePointInterface.com>

About:

<http://about.me/spmcdonough>