

Designing Pure Functions



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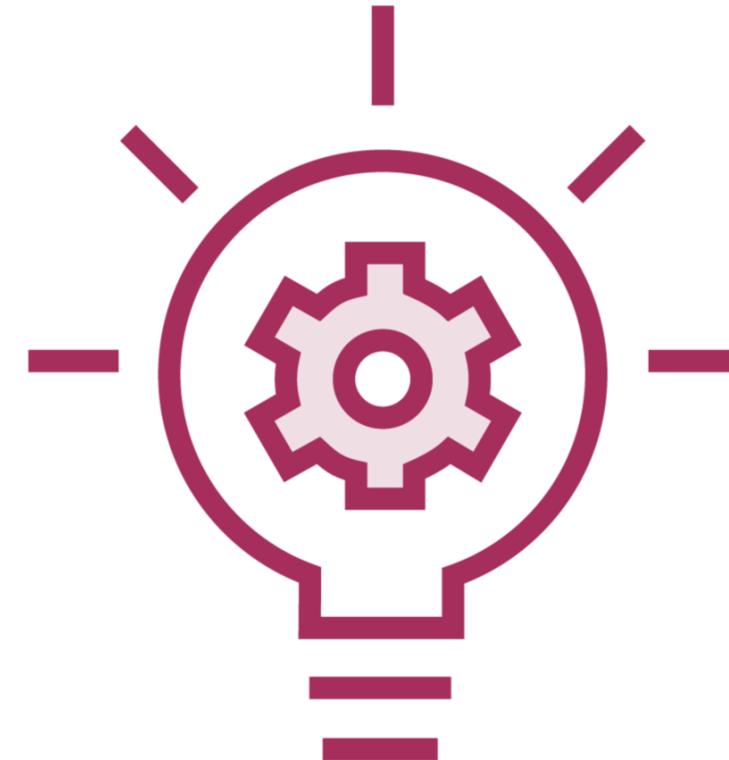


What We Have Done So Far...



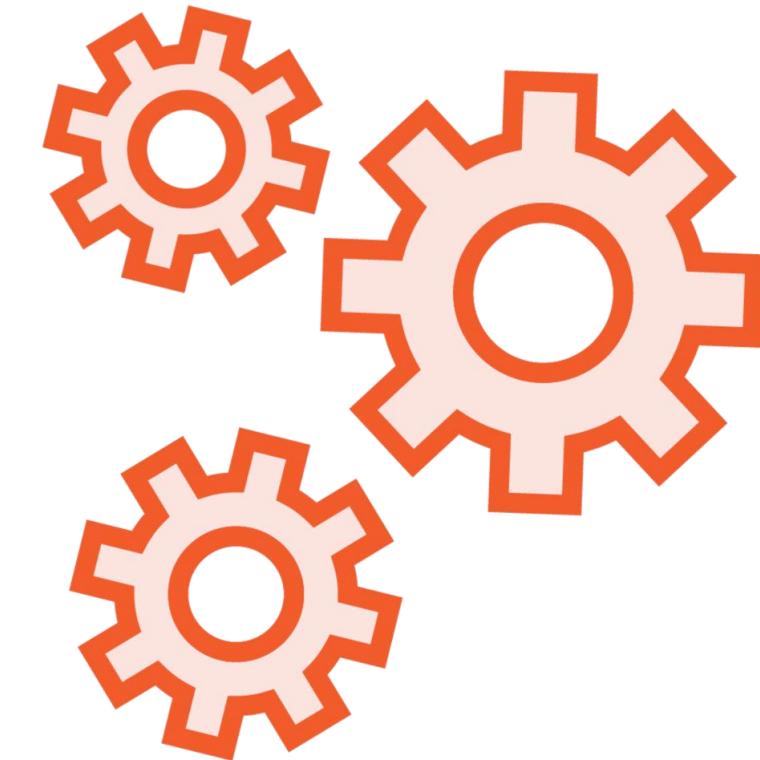
Designed a type system

Used types to model the business domain



Started defining behavior

Learned useful tips about functions



The upcoming steps...

Dive deep into designing behavior



Models > Media > C# BarcodeGeneration.cs > {} Models.Media > Models.Media.BarcodeGeneration

```
1 using Models.Types.Components;
2 using Models.Types.Media;
3
4 namespace Models.Media;
5
6 public static class BarcodeGeneration
7 {
8     public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight) =>
9         new(Array.Empty<byte>(), string.Empty);
10 }
```

Functions

Media

C# BarcodeGeneration.cs

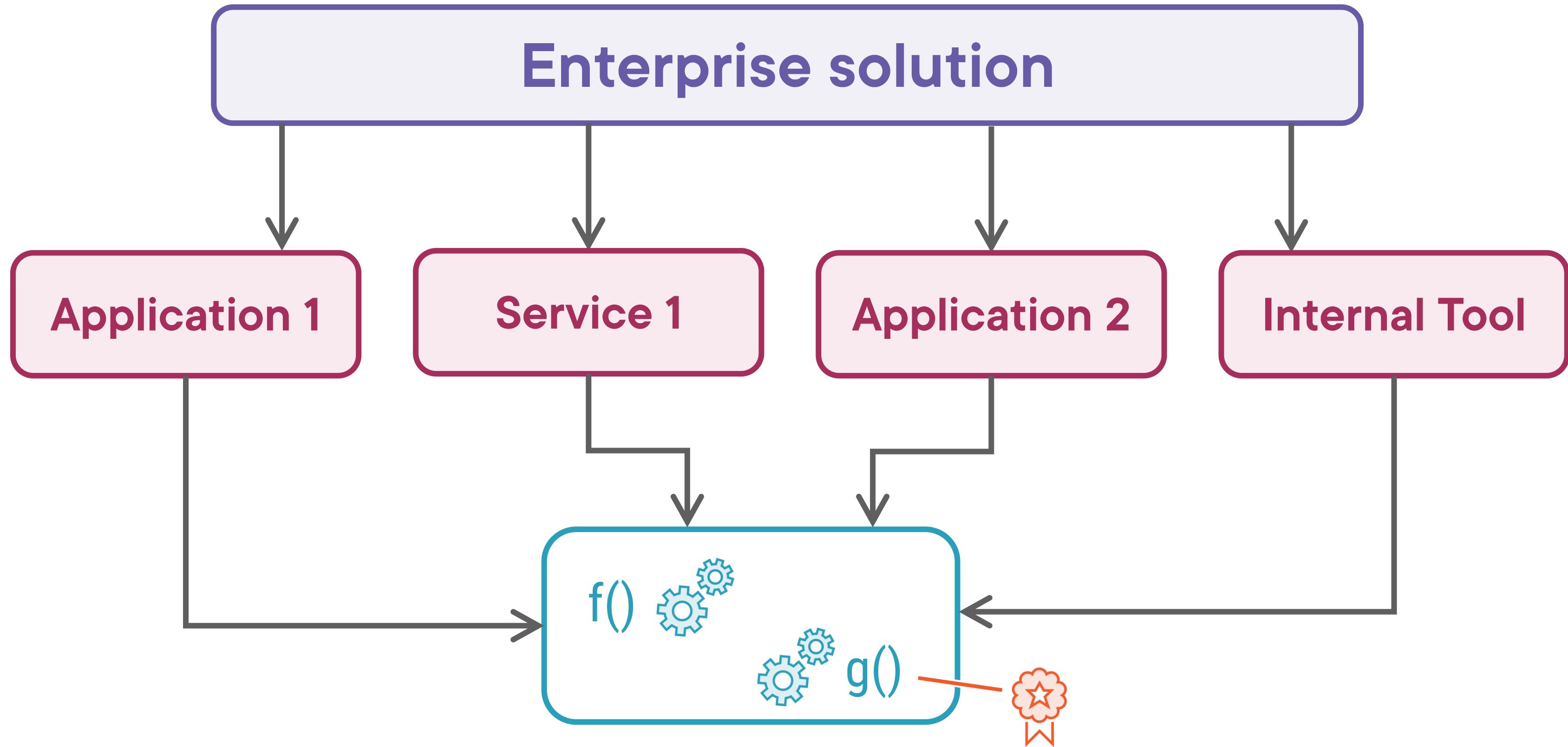
C# StringEncodings.cs

> Time

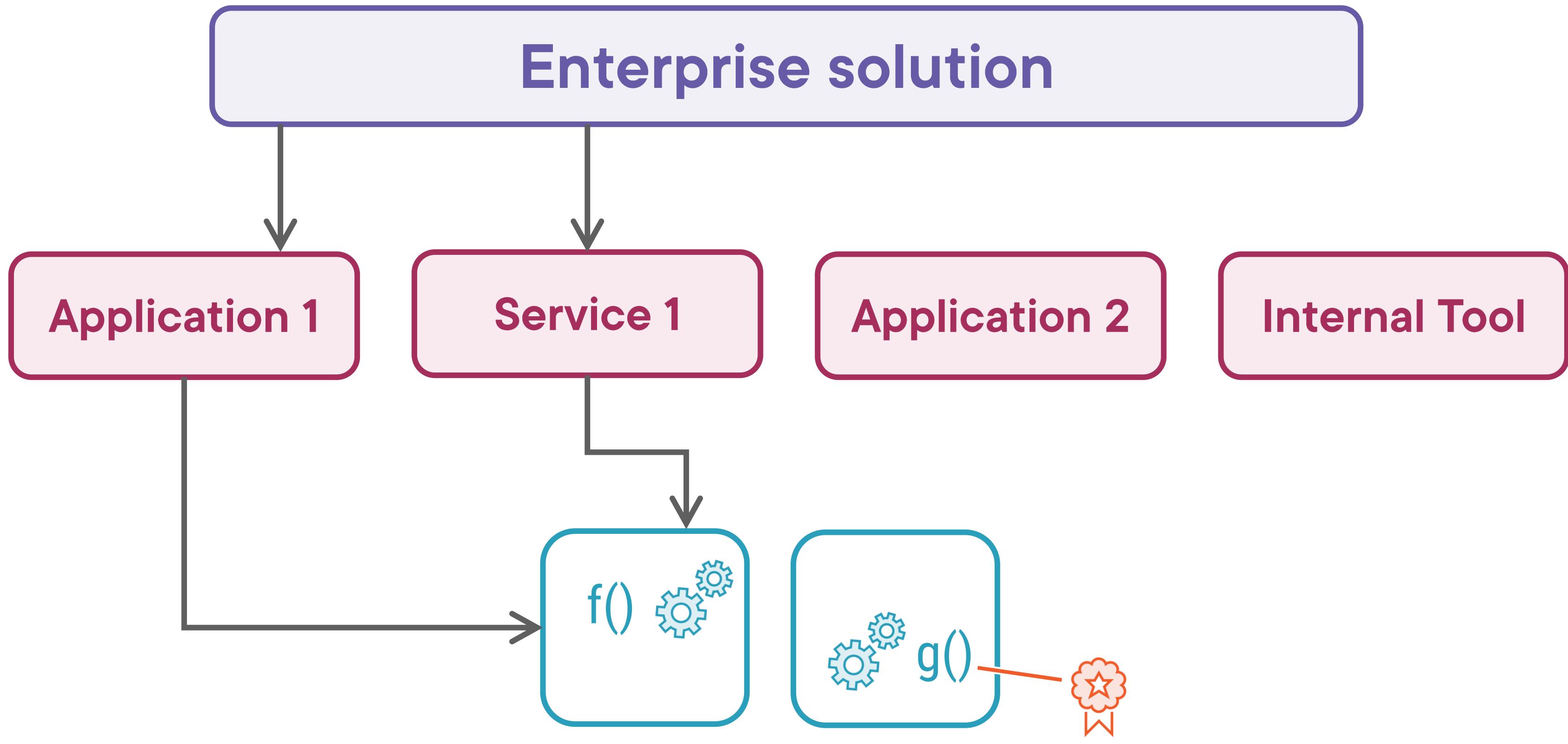
> Types

Types

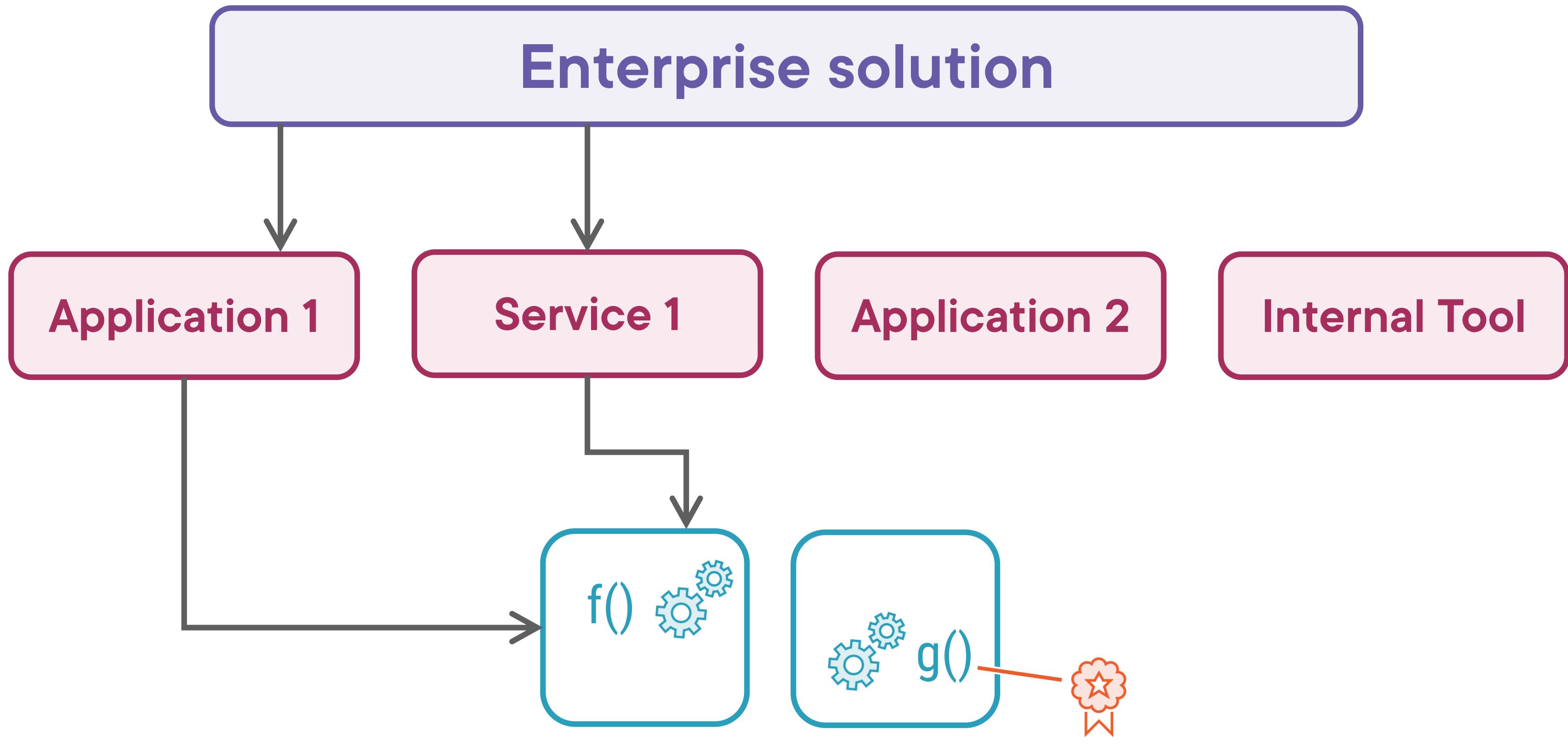
Containing Dependencies



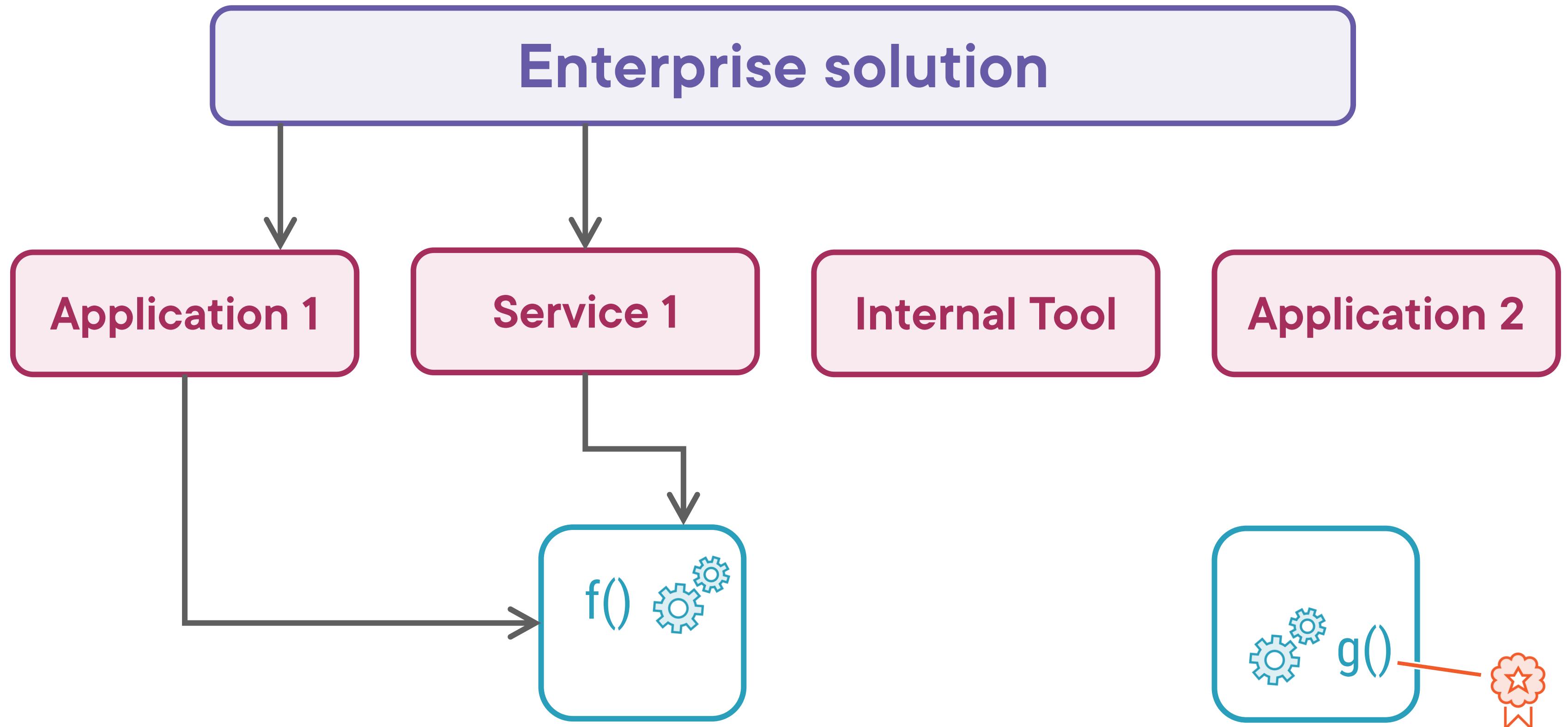
Containing Dependencies



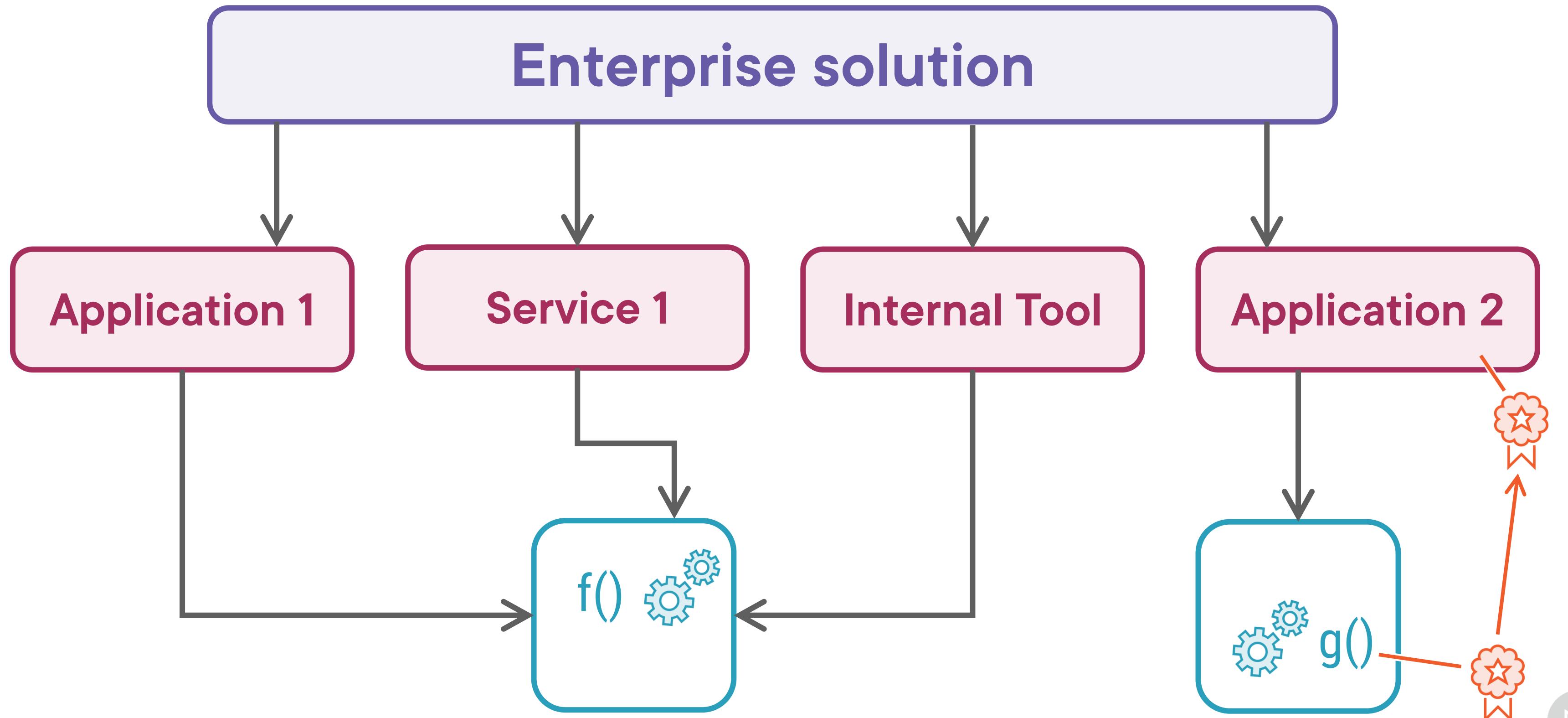
Containing Dependencies



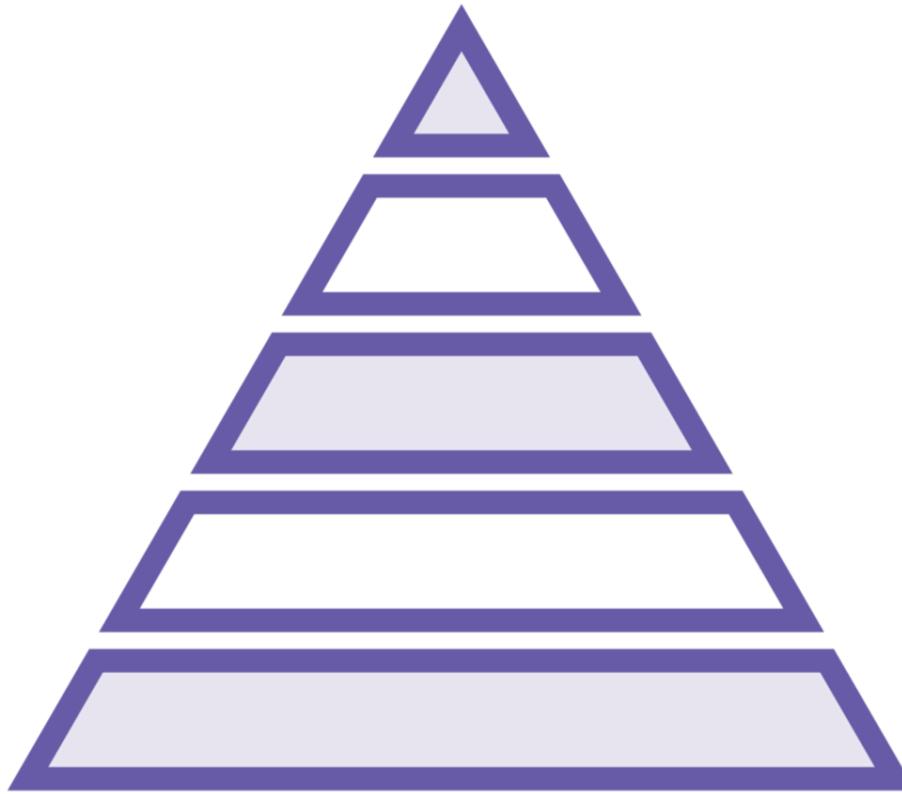
Containing Dependencies



Containing Dependencies



Object-oriented Programming in the Old Days



Methods belong to the class

A class (and those deriving from it)
define all the processes

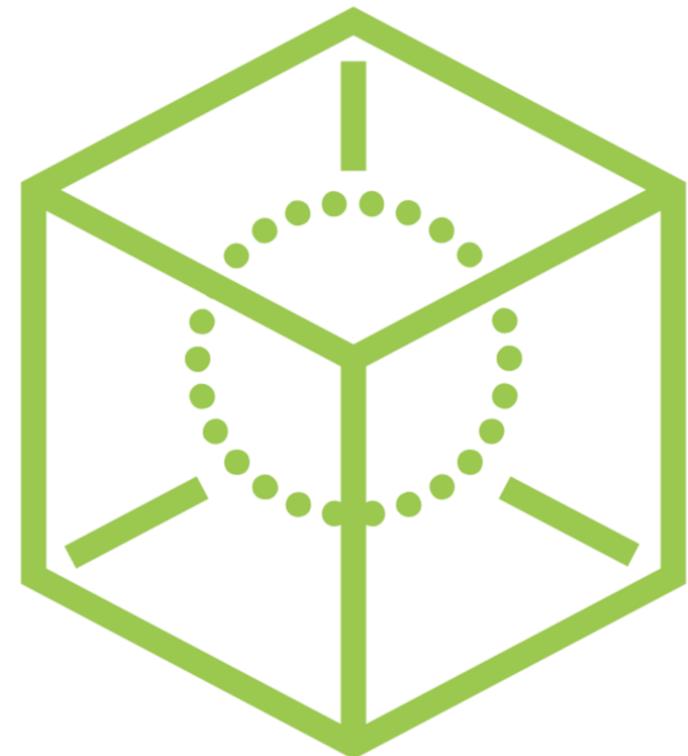


Many unrelated methods

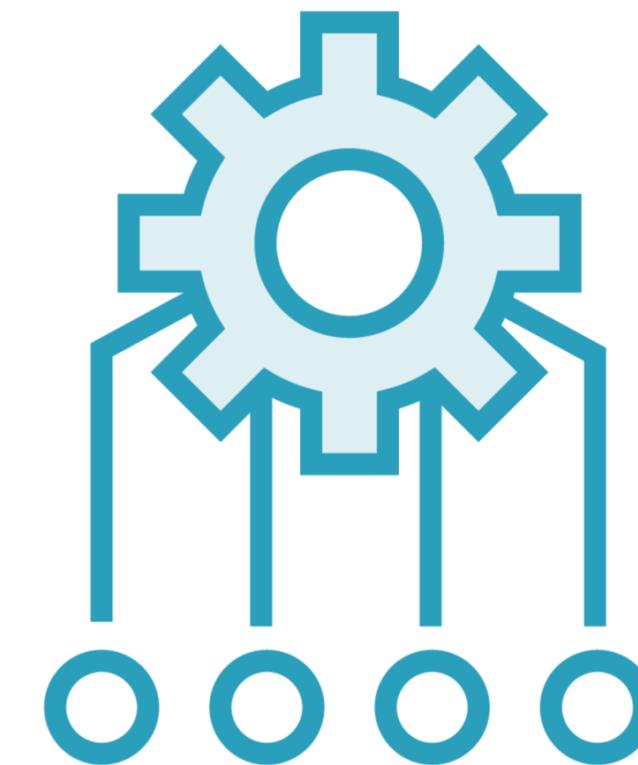
Class's interface would swarm with
largely unrelated business methods



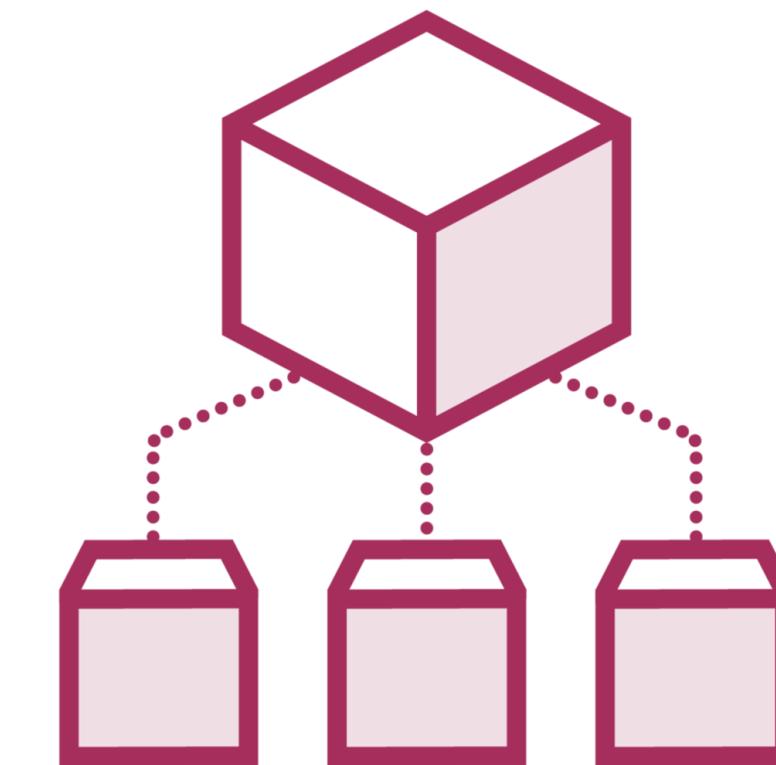
Fighting Bloated Classes in Modern OOP



**Define bare minimum
of functions on class**



**Add some functions
as extension methods**



**Use the class as a
field in other classes**



“Favor object composition
over class inheritance”

Design Patterns, The Gang of Four

*Fully supported in modern C#



EXPLORER

...

C# BarcodeGeneration.cs X

□ ...

Models > Media > C# BarcodeGeneration.cs > {} Models.Media > Models.Media.BarcodeGeneration

```
1 using Models.Types.Components;
2 using Models.Types.Media;
3
4 namespace Models.Media;
5
6 public static class BarcodeGeneration
7 {
8     public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight) =>
9         new(Array.Empty<byte>(), string.Empty);
10 }
```

> TIMELINE

⊗ 0 △ 0 ⚡ Demo.sln

Ln 8, Col 1 Spaces: 4 UTF-8 with BOM CRLF C# ⚡ 🔍

A function (in functional programming)

```
public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight)
```



A function (in functional programming)

```
public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight)
```

- Only operates on its arguments
- Only communicates back via the result
- Must return equal result for equal inputs
(i.e. result only depends on inputs)

A pure function



A function (in functional programming)

```
public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight)
```

- Only operates on its arguments
- Only communicates back via the result
- Must return equal result for equal inputs
(i.e. result only depends on inputs)
- Like a mathematical function (but computable)
- Must not access global properties (time, database...)
- Must not make observable side effects

A pure function



Generating Code 39 Barcode

https://en.wikipedia.org/wiki/Code_39



Generating Code 39 Barcode

Bars	Spaces									
		+0		+10		+20		+30		
	1		1 1		A 10		K 20		U 30	
	2		2 2		B 11		L 21		V 31	
	3		3 3		C 12		M 22		W 32	
	4		4 4		D 13		N 23		X 33	
	5		5 5		E 14		O 24		Y 34	
	6		6 6		F 15		P 25		Z 35	
	7		7 7		G 16		Q 26		- 36	
	8		8 8		H 17		R 27		. 37	
	9		9 9		I 18		S 28		£ 38	
	10		0 0		J 19		T 29		* 42	
			\$ 39		/ 40		+\$ 41		% 42	

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Generating Code 39 Barcode

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EXPLORER

...

C# BarcodeGeneration.cs 2 ●

□ ...

Models > Media > C# BarcodeGeneration.cs > {} Models.Media > Models.Media.BarcodeGeneration

```
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2 using Models.Types.Media;
3
4 namespace Models.Media;
5
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8     public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight) =>
9
10 }
```



> TIMELINE

⊗ 2 △ 0 ⚡ Demo.sln

Ln 9, Col 9 Spaces: 4 UTF-8 with BOM CRLF C# ⚡ 🔍

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```

* H E L L O *



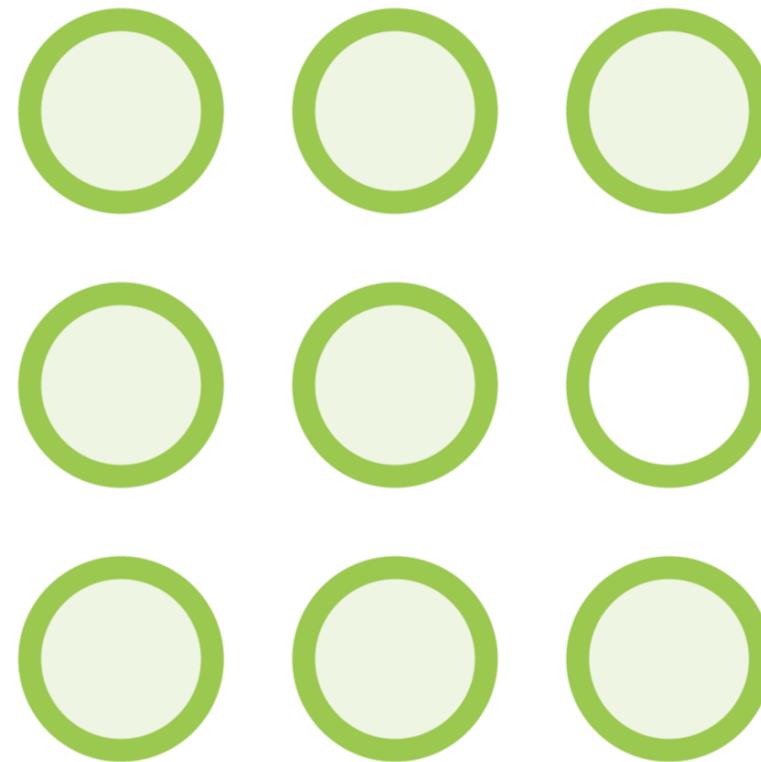
I

> TIMELINE

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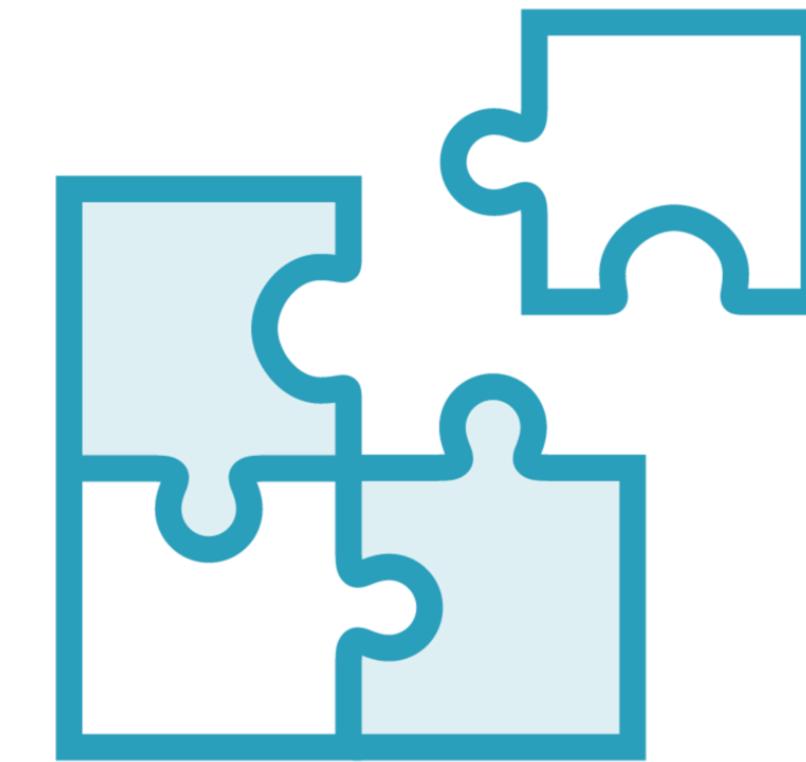
What We Have Achieved So Far



Divided the problem

Address subproblems
in isolation

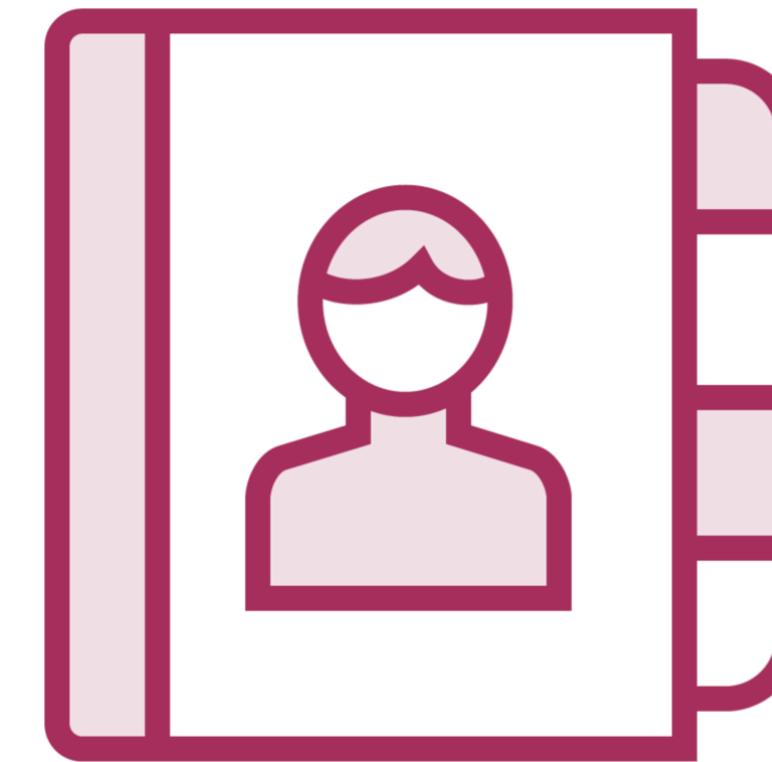
Easier then addressing
the original problem



Composable functions

Functions applicable
in other contexts

Helps reuse code,
reduces duplication



Self-documenting code

There can be no bug
in the function

Function's body reads
the same as the request



Models > Media > C# BarcodeGeneration.cs > {} Models.Media > Models.Media.BarcodeGeneration > ToGraphicalLines(this IEnumerable<int> bars, params SKPaint[] lines)

```
7
8 public static class BarcodeGeneration
9 {
10     public static FileContent ToCode39(this StockKeepingUnit sku, int barHeight) =>
11         sku.Value.ToCode39Bars().ToCode39Bitmap(barHeight).ToPng();
12
13     private static SKBitmap ToCode39Bitmap(this IEnumerable<int> bars, int barHeight) =>
14         bars.ToGraphicalLines().ToBarcodeBitmap(barHeight);
15
16     private static SKPaint[] ToGraphicalLines(this IEnumerable<int> bars) =>
17         bars.ToGraphicalLines(Gap, ThinBar, ThickBar);
18
19     private static SKPaint[] ToGraphicalLines(this IEnumerable<int> bars, params SKPaint[] lines) =>
20         bars.Select(bar => lines[bar]).ToArray();
21
22     private static SKPaint ThickBar => Bar(SKColors.Black, 4.0f);
23     private static SKPaint ThinBar => Bar(SKColors.Black, 1.5f);
24     private static SKPaint Gap => Bar(SKColors.Transparent, 2.0f);
25
26     private static SKPaint Bar(SKColor color, float thickness) => new SKPaint
27     {
28         Color = color,
29         Style = SKPaintStyle.Stroke,
30         StrokeCap = SKStrokeCap.Butt,
31         StrokeWidth = thickness,
```

```
sku.Value.ToCode39Bars().ToCode39Bitmap(barHeight).ToPng();
```

```
bars.ToGraphicalLines().ToBarcodeBitmap(barHeight);
```

```
bars.ToGraphicalLines(Gap, ThinBar, ThickBar);
```

```
bars.Select(bar => lines[bar]).ToArray();
```

```
    ThickBar => Bar(SKColors.Black, 4.0f);
```

```
    ThinBar => Bar(SKColors.Black, 1.5f);
```

```
    Gap => Bar(SKColors.Transparent, 2.0f);
```

```
sku.Value.ToCode39Bars().ToCode39Bitmap(barHeight).ToPng();
```

Take SKU string, convert to Code 39 bars, draw to bitmap, encode to PNG

```
bars.ToGraphicalLines().ToBarcodeBitmap(barHeight);
```

Take bar widths, convert to graphical lines, draw on the bitmap

```
bars.ToGraphicalLines(Gap, ThinBar, ThickBar);
```

Take bar widths, convert them to corresponding graphical lines

```
bars.Select(bar => lines[bar]).ToArray();
```

Take bar widths, select a corresponding graphical line for each

```
ThickBar => Bar(SKColors.Black, 4.0f);
```

```
ThinBar => Bar(SKColors.Black, 1.5f);
```

```
Gap => Bar(SKColors.Transparent, 2.0f);
```

Specify thick, thin bar and a gap according to requirements

Models > Common > C# Code39.cs > {} Models.Common > Models.Common.Code39

```
1 namespace Models.Common;
2
3 public static class Code39
4 {
5     public static IEnumerable<int> ToCode39Bars(this string value) =>
6         ("*" + value + "*").Encode();
7
8     private static IEnumerable<int> Encode(this IEnumerable<char> values) =>
9         values.SelectMany(Encode);
10
11    private static int[] Encode(char value) => Code[value];
12
13    private static IDictionary<char, int[]> Code { get; } = new Dictionary<char, int[]>()
14    {
15        {'1', new[]{2,1,0,1,1,2}}, {'2', new[]{1,2,0,1,1,2}}, {'3', new[]{2,2,0,1,1,1}}, {'4', new[]
16        {'6', new[]{1,2,0,2,1,1}}, {'7', new[]{1,1,0,1,2,2}}, {'8', new[]{2,1,0,1,2,1}}, {'9', new[]
17        {'A', new[]{2,1,1,0,1,2}}, {'B', new[]{1,2,1,0,1,2}}, {'C', new[]{2,2,1,0,1,1}}, {'D', new[]
18        {'F', new[]{1,2,2,0,1,1}}, {'G', new[]{1,1,1,0,2,2}}, {'H', new[]{2,1,1,0,2,1}}, {'I', new[]
19        {'K', new[]{2,1,1,1,0,2}}, {'L', new[]{1,2,1,1,0,2}}, {'M', new[]{2,2,1,1,0,1}}, {'N', new[]
20        {'P', new[]{1,2,2,1,0,1}}, {'Q', new[]{1,1,1,2,0,2}}, {'R', new[]{2,1,1,2,0,1}}, {'S', new[]
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24    };
25 }
```

Models > Common > C# Code39.cs > {} Models.Common > Models.Common.Code39

```
1 namespace Models.Common;
2
3 public static class Code39
4 {
5     public static IEnumerable<int> ToCode39Bars(this string value) =>
6         ("*" + value + "*").Encode();
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8     private static IEnumerable<int> Encode(this IEnumerable<char> values) =>
9         values.SelectMany(Encode);
10
11    private static int[] Encode(char value) => Code[value];
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13    private static IDictionary<char, int[]> Code { get; } = new Dictionary<char, int[]>()
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24    };
25 }
```

Summary



Designing functions that apply to types

- Keeping functions in separate units
- Isolate each function's dependencies
- Isolate a consumer from other functions

Functions operate on shared type system

- Somewhat different from OOD
- Applicable to object-oriented design, too



Summary



Developed functional-style functions

- Communicate back through return value
- Only depend on argument values
- Multiple equal calls return equal results
- Do not produce observable side effects
- These are the traits of a *pure function*



Summary



Applying functional decomposition

- Observe a gap between argument types and the return type
- Use it as a guide in decomposing functions
- Often ends up in trivial solutions



Up Next:

Using Partially Applied Functions
in Modeling

