Introduction – Part II

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Outline

WebAPI with Carter

- Carter : open source layer over ASP.NET
- Opinion : ASP.NET as it should have been created form start
- More functional style, fluent validation, etc
- Name : Sinatra, Nancy, Carter (Jay-Z); cf. Node.js express
- Github : `https://github.com/CarterCommunity/Carter`
- Intro : `https://www.hanselman.com/blog/TheOpenSourceCarterCommunityProjectAddsOpinionatedElega aspx`
- Docs required : `https://dotnet.microsoft.com/apps/aspnet/apis` `https://docs.microsoft.com/en-us/aspnet/web-api/`

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Carter from scratch

- Once : install the template

```
dotnet new -i CarterTemplate
```

- Create skeleton project

```
dotnet new Carter -n MyCarterApp
```

- Build and run the created skeleton

```
dotnet run -p MyCarterApp.csproj
```

- Skeleton offers a GET function “Hello ...”

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Carter testing

- Default ASP.NET ports: http 5000, https 5001
- Test: Postman (gui convenience)
- Test: curl (cmd automated)

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> curl -s -S -X GET http://localhost:5000/
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Carter testing

- Test: httprepl (cmd ASP.NET) `https://docs.microsoft.com/en-us/aspnet/core/web-api/http-repl?view=aspnetcore-3.1&tabs=windows`

```
> httprepl
get http://localhost:5000
get https://localhost:5001
```

- Install (once) httprepl

```
dotnet tool install -g Microsoft.dotnet-httprepl
```

Carter testing

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Carter files – can be merged

- .....csproj : compiles all extant .cs files
- Program.cs : main entry point – can change urls here
  e.g. ports 5000 $\rightarrow$ 8000
- Startup.cs : ASP.NET configuration
- ....Module.cs : actual custom code (GET, PUT, POST, etc)

Carter – custom url configuratiion

- Program.cs : original (default ports 5000, 5001)
  note expression lambda

```
1 var host = Host.CreateDefaultBuilder(args)
2     .ConfigureWebHostDefaults(webBuilder =>
3         webBuilder.UseStartup<Startup>())
4     .Build();
```

- Program.cs : change default urls – note statement lambda

```
1 var host = Host.CreateDefaultBuilder(args)
2     .ConfigureWebHostDefaults(webBuilder => {
3         webBuilder.UseStartup<Startup>();
4         webBuilder.UseUrls(
5             "http://localhost:8081",
6             "https://localhost:8082"); })
7     .Build();
```

Carter – skeleton module code

- HomeModule.cs

```
1 public class HomeModule : CarterModule {
2     public HomeModule () {
3         Get("/", async (req, res) =>
4             await res.WriteAsync ("Hello ..."));
5 }}
```

- Get registers a GET method (lambda) for the base URLs
- Complex routing: urls extensions, query string parameters, ...
- Other methods: Post for POST, Put for PUT, ...
  – conventions
- Conversions: req.Bind<X>(), res.AsJson (x)
  – also fluent validations
- Self describing : OpenAPI / Swagger

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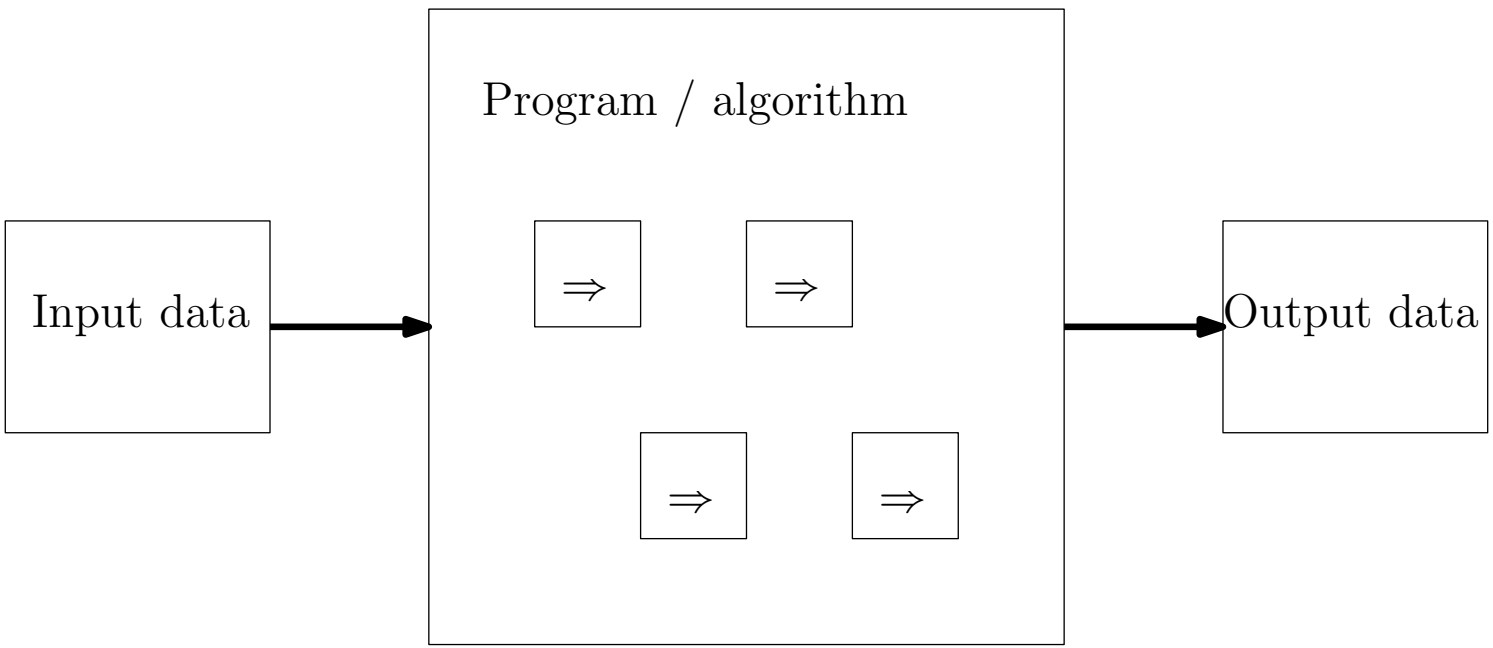
Outline

Basic functional morphisms (transformations)

- obj $\rightsquigarrow$ obj : n $\Rightarrow$ n + 1
- obj seq $\rightsquigarrow$ obj seq : map (n $\Rightarrow$ n+1), filter (...)
- obj seq $\rightsquigarrow$ obj : sum (), fold (...), reduce (...)
- obj $\rightsquigarrow$ obj seq : unfold (...)
- recursion – no explicit loops



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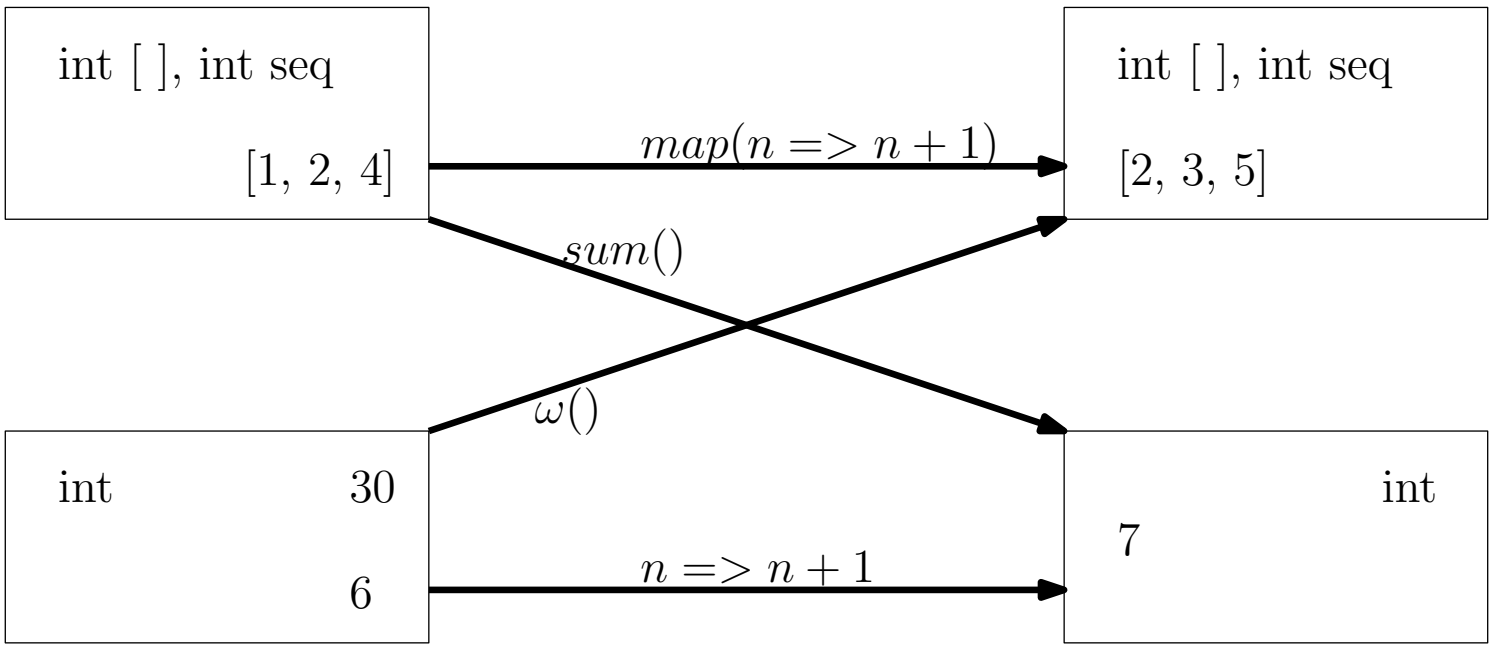

- hylomorphisms : map (n ⇒ n+1), filter (...), ...
- catamorphisms : sum (), fold (...), reduce (...), ...
- anamorphisms : ω (), ...

Outline

Nested functions

- Functions nested in other functions – a FP feature

```
1  int Outer () {
2      int s = 0;
3      void Inner (int i) {
4          if (i > 0) {
5              s += i;
6              Inner (i-1);
7          }
8      }
9      Inner (4);
10     return s;
11 }
```

- Result: 10

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- Result: 10

ReadAllLines with nested functions

```
1  string[] ReadAllLines (TextReader inp) {
2      var s = new List<string> ();
3      void Inner () {
4          var line = inp.ReadLine ();
5          if (line != null) {
6              s.Add (line);
7              Inner ();
8          }
9      }
10     Inner ();
11     return s.ToArray ();
12 }
```

Outline

Type dynamic

- Dynamic types transgress the usual OO class and interface hierarchy
- Only the actual object capabilities count, not its type credentials
- This is also known as "duck typing"

  "When I see a bird that walks like a duck and swims like a duck and quacks like a duck, I call that bird a duck."

  `en.wikipedia.org/wiki/Duck_typing`
- `https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/keywords/dynamic`

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Type dynamic

- For example, consider two totally unrelated types which implement a method Talk (same name and signature)

```
1 class Cat { public void Talk() { meow } }
2
3 class Duck { public void Talk() { quack } }
```

- And method Test that looks like almost applicable to instances of both classes

```
1 void Test(??? pet) {
2     pet.Talk();
3 }
```

- Problem: what should we declare for the type of pet ???, to keep the compiler happy?

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- We declare pet **dynamic**!

```
1 void Test(dynamic pet) {
2     pet.Talk();
3 }
```

- Then this will work!

```
1     var moggy = new Cat();
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4     var donald = new Duck();
5     Test(donald);
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- The capability checks are now the responsibility of the runtime

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The expando object

- An object with dynamically increasing capabilities (at runtime)!
- `http://www.c-sharpcorner.com/Blogs/9439/expandoobject-in-C-Sharp-4-0.aspx`
  `https://msdn.microsoft.com/en-us/library/system.dynamic.expandoobject(v=vs.110).aspx`
- This creates an empty expando object (no visible properties or methods) – must be typed as dynamic

```
1 dynamic p = new System.Dynamic.ExpandoObject();
```

- This dynamically expands it with two properties, X and Y

```
1 p.X = 10;
2 p.Y = 20;
3 Console.WriteLine("X={0}, Y={1}", p.X, p.Y);
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The expando object

- This dynamically expands it with one method, MoveX

```
1 p.MoveX = (Action<int>)
2     ((int deltax) => { p.X += deltax; });
```

- We'll talk later about such inline functions (don't worry for now)
- Just keep in mind that this works!

```
1 p.MoveX(100);
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- Note: an expando object is implemented as a dynamic dictionary...

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Named and default parameters

- Consider this method

```
1 void F(int x, int y=20, string z="abc") { ... }
```

- Parameter x is mandatory
- Parameter y is optional: if not given, the default value 20 is assumed
- Parameter z is optional: if not given, the default value "abc" is assumed
- Parameters can be given by position (as traditionally) and/or by name

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Named and default parameters

- Consider this method

```
1 void F(int x, int y=20, string z="abc") { ... }
```

- Possible calls

```
1     F(10, 15, "xyz");
2     F(y:25, z:"xyz", x:10);
3
4     F(100);
5     F(100, z:"klm");
```

- Named and default parameters are frequently used in some framework, e.g. MVC

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Try ...

- Consider this frequently used coding pattern, which avoids exception handling

```
1   int r;
2   bool b;
3
4   b = int.TryParse("123", out r);
5   if (b) // use r
6   else   // ...
7
8   b = int.TryParse("abc", out r);
9   if (b) // ...
10  else   // r is useless, 0
```

- The API contains quite a few similar **bool** TryX(..., **out** r) methods

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Hashtable based collections

Hashtables are data structures based on hash functions, which are often more efficient than other structures (such as arrays or trees), in the sense that, on average, elementary operations (retrievals, insertions, deletions) take constant time, $O(1)$.

The following hashtable based structures will be often used in our topics (please make yourself familiar with these):

- HashSet<T>
- Dictionary<TKey, TValue>
- Lookup<TKey, TValue>

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HashSet – cf. LINQ Distinct ()

HashSet<T> class provides a high performance set of elements of type T.

A set is a collection that contains no duplicate elements, and whose elements are in no particular order (although you can list them in some order).

$$\{elem_0, elem_1, elem_2, \ \ldots\}$$

HashSet<T> methods:

```
1 bool Add(T elem)
2 bool Contains(T elem)
3 bool Remove(T elem)
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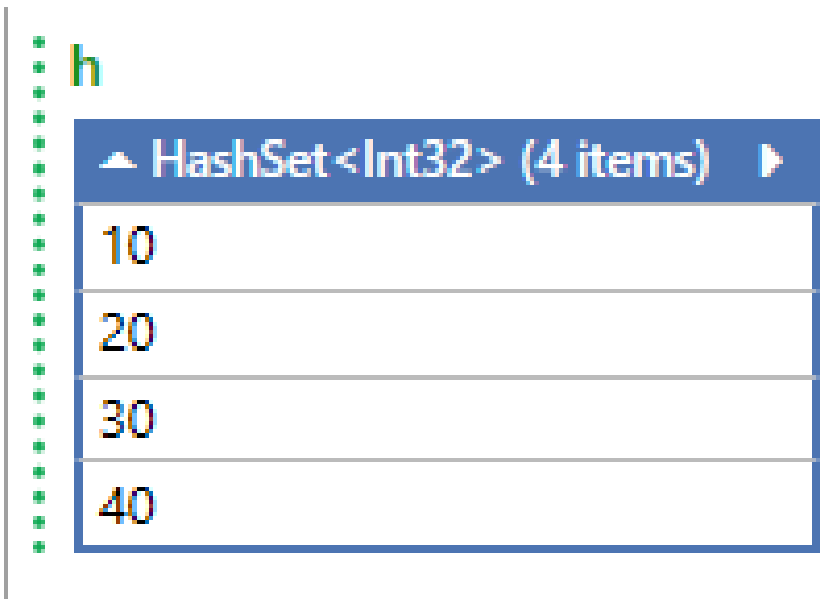
HashSet Example

```
1 var h = new HashSet<int> (new[]   {
2             10, 20, 30, 40, 30, 20, 10, });
```



Dictionary – cf. LINQ ToDictionary ()

Dictionary<TKey, TValue> class provides a mapping from a set of keys to a set of values (TKey $\rightarrow$ TValue).

Each addition to the dictionary consists of a pair (key, value), where keys are unique.

$$\{k_0 \rightarrow v_0, k_1 \rightarrow v_1, k_2 \rightarrow v_2, \ \ldots\}$$

Dictionary<TKey, TValue> methods:

```
1  void Add(TKey key, TValue value) // exception if key exists
2
3  TValue this[TKey key] { get; set; }  // set can replace
4                                       // get exception if key does not exist
5
6  bool TryGetValue(TKey key, out TValue value)   // !
7  bool Remove(TKey key)
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Dictionary Example

d

Dictionary<String,String> (4 items)

Key	Value
txt	notepad.exe
bmp	paint.exe
dib	paint.exe
rtf	wordpad.exe

Lookup – cf. LINQ ToLookup ()

Lookup<TKey, TValue> resembles a Dictionary<TKey, TValue>.

The difference is that a dictionary maps keys to single values, whereas a lookup maps keys to enumerable collections of values. Also, lookups are immutable, i.e. once created, cannot be changed.

$$\{k_0 \to \{v_{00}, v_{01}, \dots\}, k_1 \to \{v_{10}, v_{11}, \dots\}, k_2 \to \{v_{20}, v_{21}, \dots\}, \ \dots\}$$

Lookup<TKey, TValue> indexer (read-only):

```
1 IEnumerable<TValue> this[TKey key] { get; }
2                     // Item in VB, ...
3
4 // example
5 IEnumerable<Student> students = lookup["335"];
```

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4  // example
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Lookup Example

```
1 var t = new[] { ("mano", 335), ("radu", 335),
2                 ("radu", 711),   ("xinfeng", 711),};
3 var x = t.ToLookup (p => p.Item2);
```

x

Lookup<Int32,ValueTuple<String,Int32>> (2 items)

Key= 335

Grouping<Int32,ValueTuple<String,Int32>> (2 items)

Item1	Item2
mano	335
radu	335
	670

Key= 711

Grouping<Int32,ValueTuple<String,Int32>> (2 items)

Item1	Item2
radu	711
xinfeng	711
	1422

Outline

Nullable types—Overview

- SQL `x int null` : **null** $\neq$ 0!
- C#'s nullable types provide complete and integrated support for nullable forms of all **struct** types (technically, this includes all *numeric* types).
- useful for smooth SQL data integration
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Nullable types

```
1 int? x = 7;
2 int? y = null;
3 int i = 3;
4 if (x.HasValue) { i = x.Value; }
5 if (y.HasValue) { i = y.Value; }
6 //      .HasValue can be replaced by != null,
7 //      unless this operator is overridden
```

```
1 int i = 7;
2 int? x = i;                  //  int → int?
3 double? y = x;               //  int? → double?
4 int? z = (int?)y;            //  double? → int?
5 int j = (int)z;              //  int? → int
6                              //  exception if z==null
```

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Nullable types

```
1 int? z = x ?? y;
2 int i = y ?? -1;
3 int? w = x + y;
```

The result of x??y is x, if x is non-**null**; otherwise is y.

The result of x+y is **null**, if any of the operands is **null**.

Note: Nullable<**int**> offers coherent extensions for all arithmetic operations available on **int**.

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Outline

Extra null operators

Meet the following operators:

- ?? : null coalescing operator (similar to Elvis operator ?: used eg in Kotlin)
- ?. : null conditional operator aka safe navigation operator – for properties and methods
- ?[ ] : null conditional operator aka safe navigation operator – for arrays

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Safe navigation – scenario

Consider the following class:

```
1 class Person {
2     public string Name { get; set; }
3     public Person Father { get; set; }
4 }
```

Problem: get the name of the grandfather of a given Person x

You write:

```
1 string Grand (Person x) {
2     return x.Father.Father.Name;
3 }
```

What's wrong? The Father pointer may be **null** (and also the Name) – possible exceptions

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Safe navigation – quick and dirty solution

Instead of:

```
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You write:

```
1       if (x != null && x.Father != null
2                     && x.Father.Father != null) {
3           return x.Father.Father.Name;
4       } else {
5           return null;
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```

What's now wrong? Possible repeated computations of Fasther and possibly some side-effects!

.Father could be a method call like .GetFather()

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Safe navigation – Pyramide of doom "solution"

You may want to write:

```
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3       if (f != null) {
4           var g = f.Father;   // called once only
5           if (g != null) {
6               return g.Name;
7           } else {
8               return null;
9           }
10      } else {
11          return null;
12      }
13  } else {
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Would you do this? Better solution?

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You can write ☺:

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Note: this is the default semantics in Objective-C!

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Safe navigation and null coalescing!

Problem: write "Unspecified" if either p is null or its name is null:

```
1  Person p = new Person { Name = "Dr Evil" };
2           new Person();  // Name == null
3           // null
4
5  var n1 = p == null? "Unspecified":
6           (p.Name == null? "Unspecified": p.Name);
7
8  var n2 = p?.Name ?? "Unspecified";
9
10 WriteLine ($"{n1} {n2}");
```

Outline

Properties

Structured accessors, i.e. (getter, setter) pair

You write (inside a class definition):

```
1     private int a;                  // private backing field
2
3     public int A {                  // public property
4         get { return a; };          // getter
5         set { a = value; }          // setter
6      }
```

Conceptually equivalent code:

```
1     private int a;
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Usage (right-hand vs left-hand side):

```
1 x = t.A;   // x = t.getA();
2 t.A = y;   // t.setA(y);
```

Increment A/a as a property

```
1 t.A = t.A + 1;
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Compare to incrementation via accessors

```
1 t.setA (t.getA() + 1);
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Many frameworks require public properties instead of public fields.

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Automatically generated accessors

Most simple – no filters, no side effects

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1    public int B { get; private set; }
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Truly read-only – initialised in constructor

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1    public int C { get; }
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This style can also be used for methods

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using static

WriteLine is a static method of class System.Console

Traditional:

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1 using System;
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4     Console.WriteLine("This is the Console!");
```

New – use static methods as top-level functions:

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string interpolation

Note the $ sign before the format string:

```
1 var greet1 = "Hello";
2 var greet2 = "Goodbye";
3
4 WriteLine ("{0}, {1}!", greet1, greet2); // traditional
5
6 WriteLine ($"{greet1}, {greet2}!"); // new
```