Writing Purely Functional Code in C#

UNDERSTANDING THE NEED FOR DISCRIMINATED UNIONS

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Functional Concepts in C#

Func delegates

```
delegate int AddTo(int x);

class BusinessModel
{
  void Recalculate(AddTo adder) { ... }
}
```

Functional Concepts in C#

Func delegates

```
delegate int AddTo(int x);

class BusinessModel
{
  void Recalculate(AddTo adder) { ... }
}

class BusinessModel
{
  void Recalculate(Func<int, int> adder) { ... }
}
```

Functional Concepts in C#

Func delegates

Lambdas

```
class BusinessModel
{
  public void Recalculate(Func<int, int> adder);
}
```

Functional Concepts in C#

Func delegates

Lambdas

```
class BusinessModel
{
  public void Recalculate(Func<int, int> adder);
}

class Worker
{
  int Adder(int x) { return x + 2; }

  void DoStuff()
  {
    ...
    model.Recalculate(this.Adder);
  }
}
```

Functional Concepts in C#

Func delegates

Lambdas

```
class BusinessModel
{
  public void Recalculate(Func<int, int> adder);
}

class Worker
{


  void DoStuff()
  {
    ...
    model.Recalculate(x => x + 2);
  }
}
```

Functional Concepts in C#

Func delegates

Lambdas

LINQ

```
List<Car> favoriteCars = new List<Car>();
foreach (Vehicle v in city.RegisteredVehicles)
{
  Car aCar = v as Car;
  if (aCar != null && aCar.Color == Colors.Red)
  {
    favoriteCars.Add(aCar);
  }
}
return favoriteCars;
```

Functional Concepts in C#

Func delegates

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LINQ

```
List<Car> favoriteCars = new List<Car>();
foreach (Vehicle v in city.RegisteredVehicles)
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  Car aCar = v as Car;
  if (aCar != null && aCar.Color == Colors.Red)
  {
    favoriteCars.Add(aCar);
  }
}
return favoriteCars;

Car goodOne = city.RegisteredVehicles
  .OfType<Car>()
  .Where(car => car.Color == Colors.Red)
  .First();
```

Functional Concepts in C#

Func delegates

Lambdas

LINQ

Extension methods

```
static class CarObsessionBehavior
{
    public Car GetBestCar(this City from)
    {
        ...
    }
}
```

Functional Concepts in C#

Func delegates

Lambdas

LINQ

Extension methods

Anonymous types

```
var x = new
{
    Vehicle = redCar,
    Owner = "Joe"
};
```

Functional Concepts in C#

Func delegates
Lambdas
LINQ
Extension methods
Anonymous types
Tuple literals

```
var tuple = (redCar, "Joe");
(Car vehicle, string owner) = (redCar, "Joe");
var (vehicle, owner) = (redCar, "Joe");

Tuple<Car, string> tuple =
  Tuple.Create(redCar, "Joe");
```

Functional Concepts in C#

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var tuple = (redCar, "Joe");
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var (vehicle, owner) = (redCar, "Joe");

Tuple<Car, string> tuple =
  Tuple.Create(redCar, "Joe");
```

Functional Concepts in C#

Func delegates
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Tuple literals
Pattern matching

```
if (vehicle is Car car && car.DoorsCount == 5) ...

vehicle is Car car && car.DoorsCount == 5
  ? car.Color
  : Colors.Grey;

switch (vehicle)
{
  case Car car:
    return car.DoorsCount;
  case Truck truck:
    return truck.Cabin.Doors.Count();
  case Boat _: return 1;
  default: return 0;
}
```

Functional Concepts in C#

Func delegates
Lambdas
LINQ
Extension methods
Anonymous types
Tuple literals
Pattern matching
Type inference

```
city.Vehicles
  .Select<Vehicle, Person>(v => v.OwnedBy)
  .Select<Person, Color>(p => p.FavoriteColor)
  .Select<Color, double>(c => c.DistanceFrom(red))
  .Average();
```

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Functional Concepts in C#

Func delegates
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Pattern matching
Type inference

```
class Treadmill
{
  public TRes CountMeIn<TSub, TMsr, TRes>
    (TSub subject, TMsr bodyMeasure) { ... }
}

treadmill.CountMeIn<_, _, DateTime>(name, weight);
```

won't compile

Functional Concepts in C#

Func delegates
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}

treadmill.CountMeIn<_, _, DateTime>(name, weight);

treadmill.CountMeIn<string, float, DateTime>
  (name, weight);
```

compiles

Functional Concepts in C#

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}

treadmill.CountMeIn<_, _, DateTime>(name, weight);

treadmill.CountMeIn<string, float, DateTime>
  (name, weight);

DateTime when = treadmill.CountMeIn(name, weight);
```

won't compile

Functional Concepts in C#

- Func delegates
- Lambdas
- LINQ
- Extension methods
- Anonymous types
- Tuple literals
- Pattern matching
- Type inference

```
class Treadmill
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DateTime when = treadmill.CountMeIn(name, weight);

DateTime when =
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    (name, weight);
```

compiles

Functional Concepts in C#

Func delegates
Lambdas
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Extension methods
Anonymous types
Tuple literals
Pattern matching
Type inference

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```

Functional Concepts in C#

Func delegates
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Generics

```
public T FindFittest<T>(IEnumerable<T> seq)
  where T : IComparable<T> =>
  seq.Aggregate((best, cur) =>
    cur.CompareTo(best) > 0 ? cur : best);

public T FindBeautiest<T>(IEnumerable<T> seq)
  where T : IEquatable<Color> =>
  seq.First(x => x.Equals(Colors.Red));
```

Writing Purely Functional Code

Function *evaluates*,
it does not *execute*

Result depends on *arguments*,
not on *state*

Values do *not change*, etc.

Why in C#?

Compare to F#

Writing Purely Functional Code

Previous course:

Making Your C# Code More Functional

Transforming an object model
to accommodate functional elements

Writing Purely Functional Code

Previous course:

Making Your C# Code More Functional

Transforming an object model
to accommodate functional elements

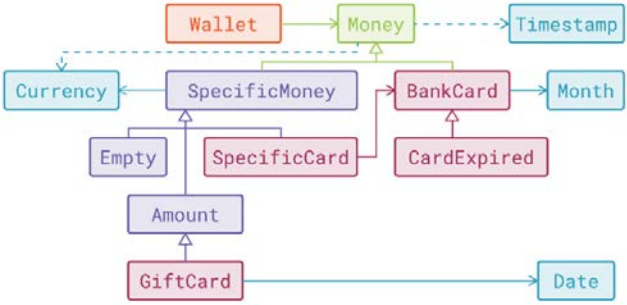
This course:

Writing Purely Functional Code in C#

Design a functional model from scratch

Making Your C# More Functional

OO falling short



Making Your C# More Functional

OO falling short

Object filters

```
this.Content
  .On(Timestamp.Now)
  .Of(expense.Currency)
  .Take(expense.Value)
  .ToList();
```

Making Your C# More Functional

OO falling short

Object filters

FP theory

Pure functions,

Referential transparency,

Memoization, etc.

Making Your C# More Functional

OO falling short

Object filters

FP theory

Pattern matching

```
switch (money)
{
  case Amount amount
    when amount.Currency == expense.Currency:
    return amount.Value >= expense.Value;
  case GiftCard gift
    when gift.ValidBefore.CompareTo(now) >= 0 &&
         gift.Currency == expense.Currency:
    return gift.Value >= expense.Value;
  case BankCard card
    when card.ValidBefore.CompareTo(now) >= 0:
    return true;
  default:
    return false;
}
```

Making Your C# More Functional

OO falling short

Object filters

FP theory

Pattern matching

```
switch (money)
{
  case Amount amount
    when amount.Currency == expense.Currency:
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  case GiftCard gift
    when gift.ValidBefore.CompareTo(now) >= 0 &&
         gift.Currency == expense.Currency:
    return gift.Value >= expense.Value;

  case BankCard card
    when card.ValidBefore.CompareTo(now) >= 0:
    return true;

  default:
    return false;
}
```

Making Your C# More Functional

- OO falling short
- Object filters
- FP theory
- Pattern matching
- Function composition

$$(g \circ f)(x) = g(f(x))$$

$$z = p.f(x).g();$$

$$z = x.f().g();$$

Making Your C# More Functional

OO falling short

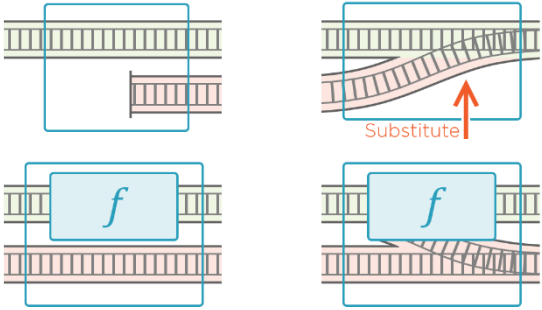
Object filters

FP theory

Pattern matching

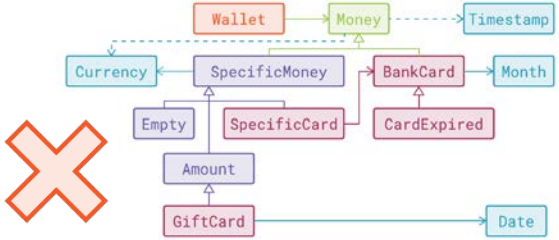
Function composition

Railway-oriented programming



What Follows in This Course

Types vs. classes



No class hierarchies

No member functions

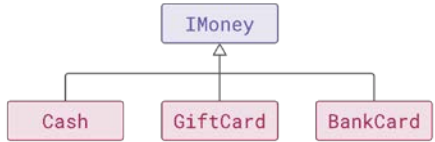
No polymorphism

What Follows in This Course

Types vs. classes

Discriminated unions

```
type Money =
  Cash | GiftCard | BankCard;
```



What Follows in This Course

Types vs. classes

Discriminated unions

Functional functions

What is the function in FP?

Function vs. object method

Function composition

Higher-order functions

Partial function application, etc.

Applying functions to C#

What Follows in This Course

Types vs. classes

Discriminated unions

Functional functions

Value -typed semantic

Custom value types

Tuples

Record types

Upcoming support in C#

What Follows in This Course

Types vs. classes

Discriminated unions

Functional functions

Value -typed semantic

Control flow

Pattern matching

The only method of controlling execution flow in functional programming

Looping implemented via LINQ

What Follows in This Course

Types vs. classes

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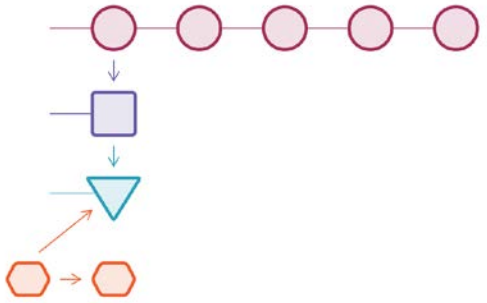
Control flow

Sequences

Functional sequence processing with LINQ



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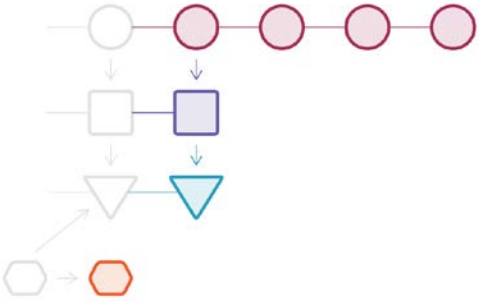

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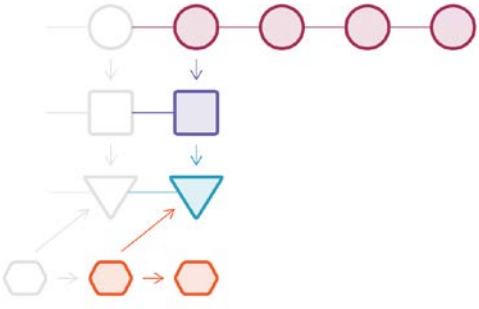

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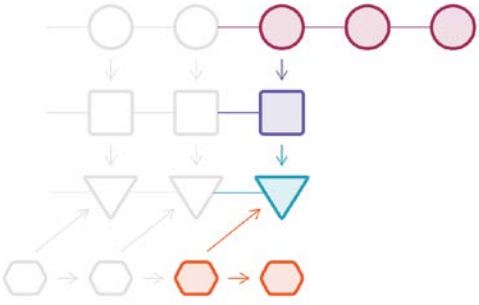

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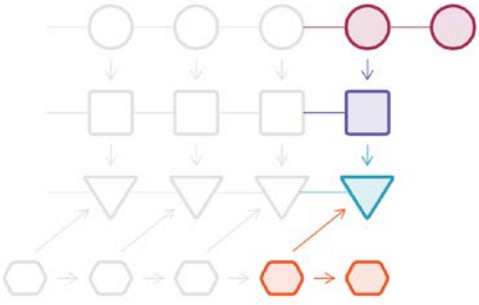

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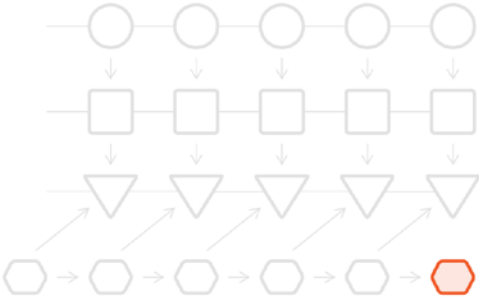

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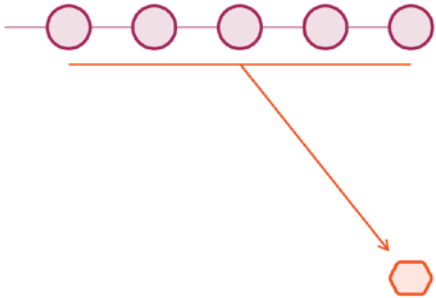
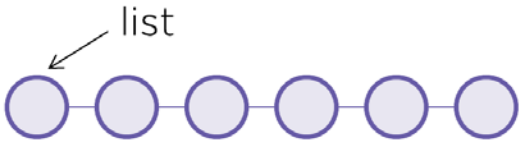


What Follows in This Course

- Types vs. classes
- Discriminated unions
- Functional functions
- Value -typed semantic
- Control flow
- Sequences
- Immutable collections



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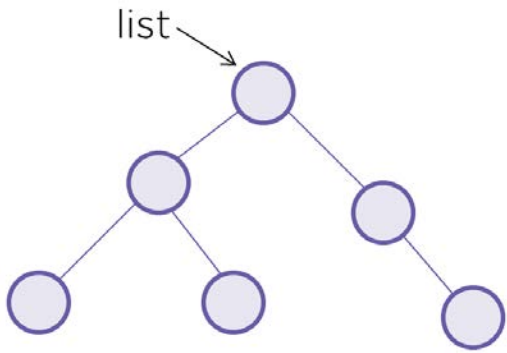

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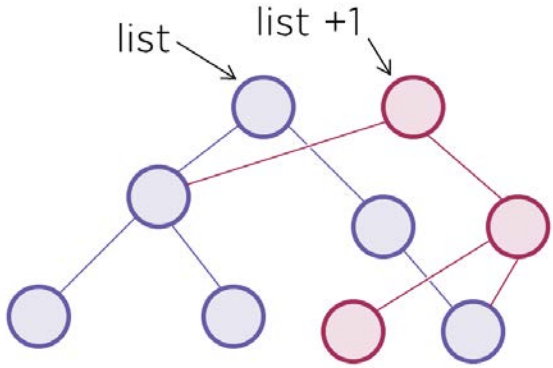

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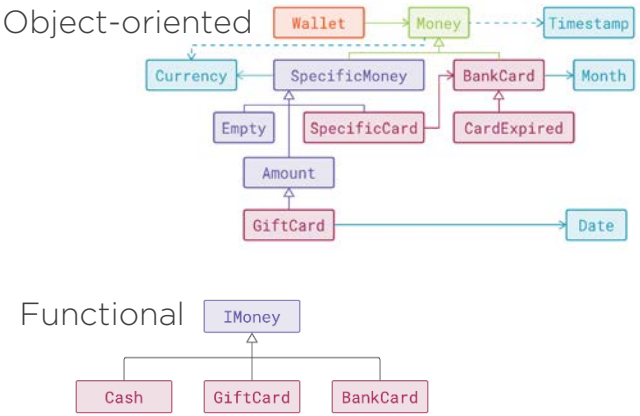
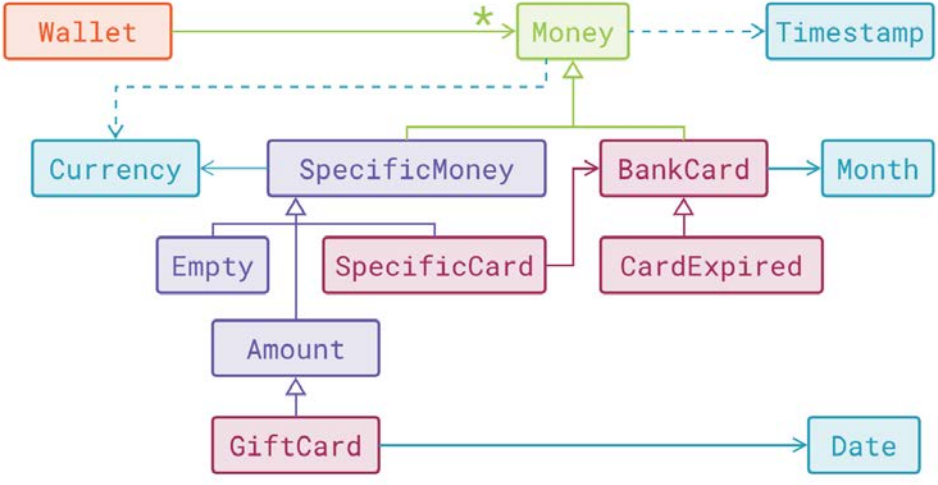


Example Domain



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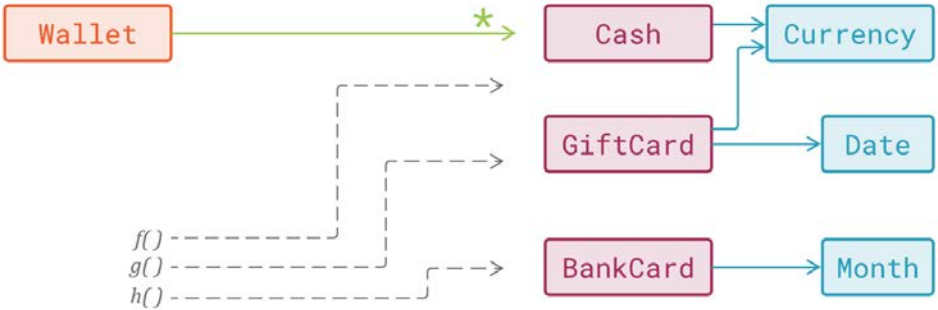
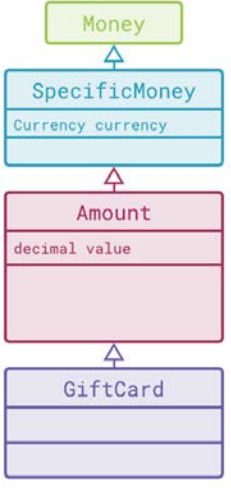


Understanding Class Inheritance



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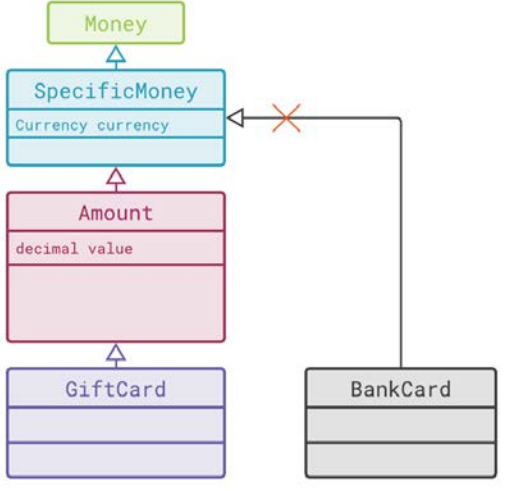
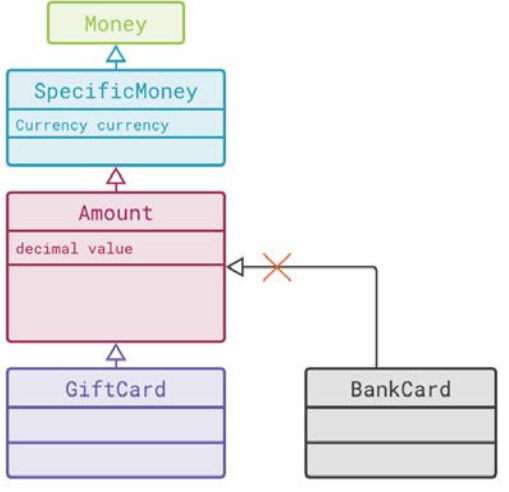


Understanding Class Inheritance



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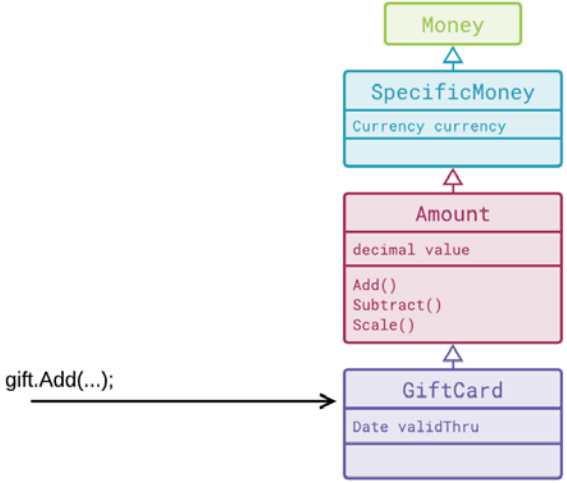

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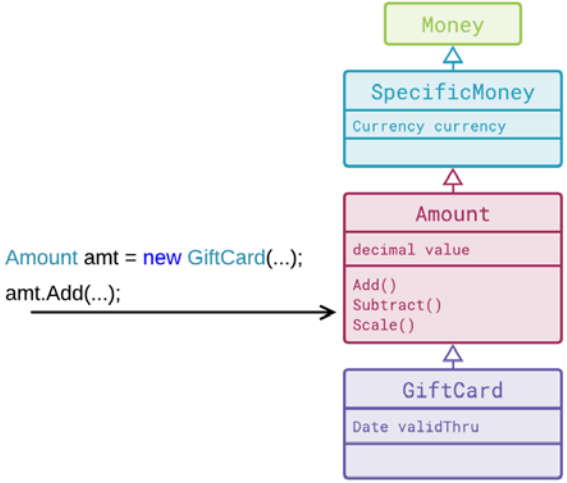

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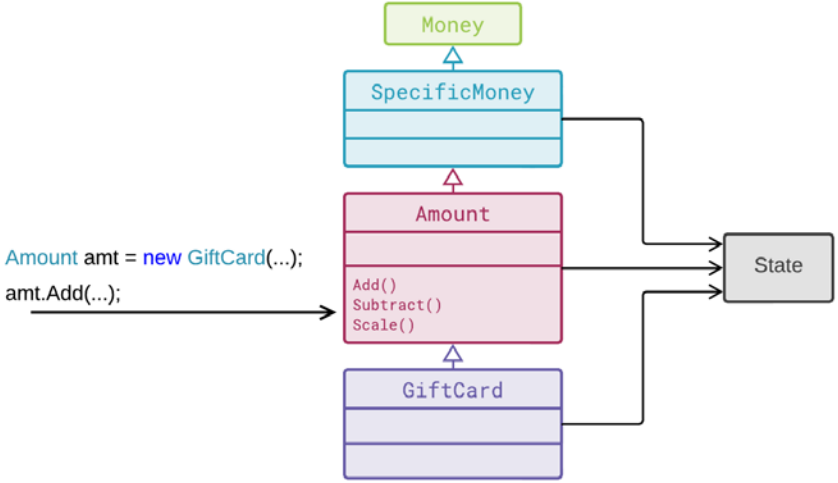

Summary

Discriminated unions

- Constraining a set of types
- Function defined on all of them
- Completeness verified by compiler

Interface inheritance in C#

- Still no discriminated unions in C#

In the rest of the course

- Applying functional programming concepts directly to C#
- Leverage latest C# syntax
- Start off with lambdas

Next module:
Functions as objects, big time