Winter Semester 17/18

Software Engineering Design & Construction

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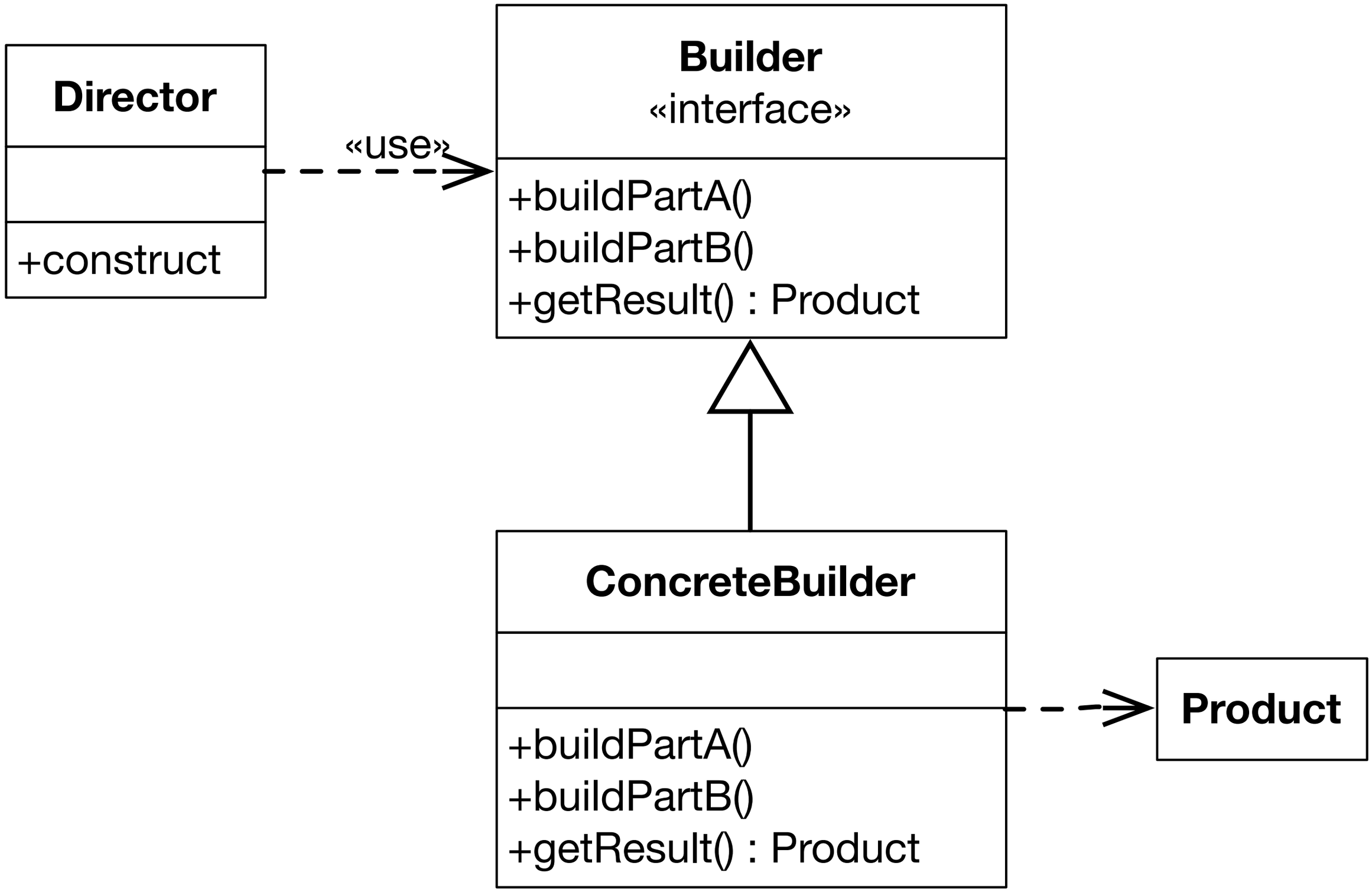
Builder Pattern

The Builder Pattern

Divide the construction of multi-part objects in different steps, so that different implementations of these steps can construct different representations of object

Builder - Structure

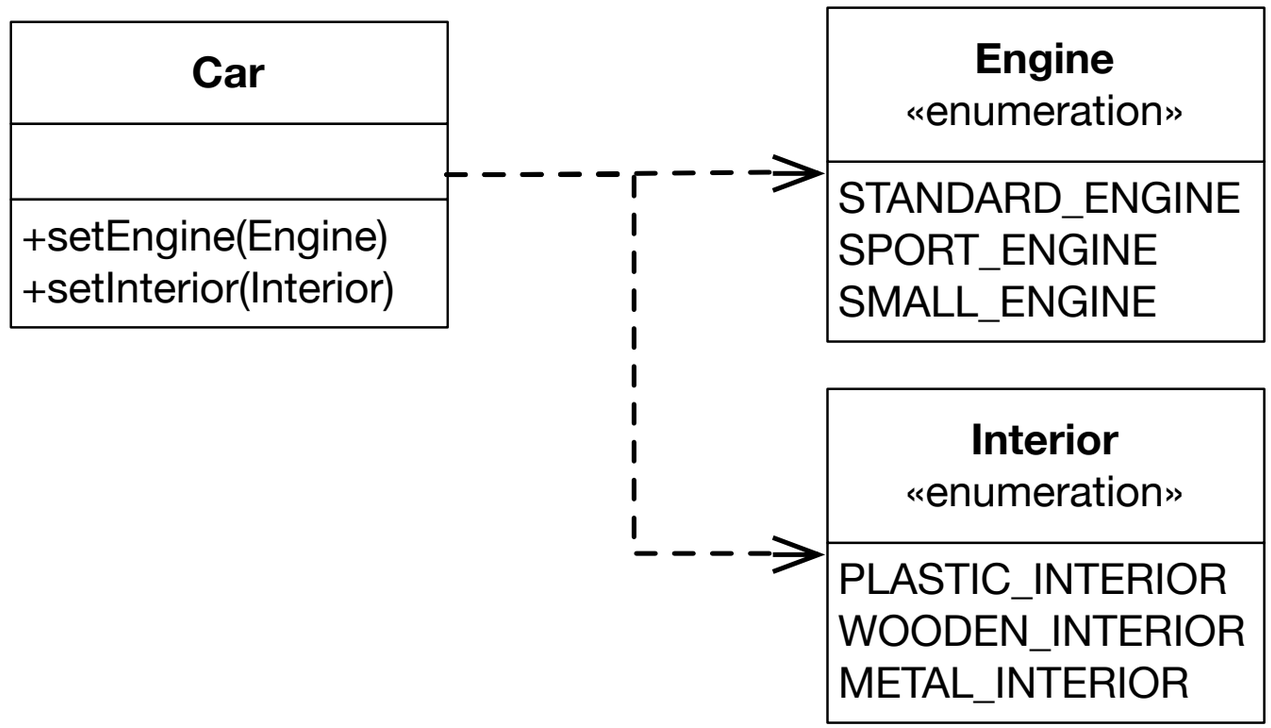


Example

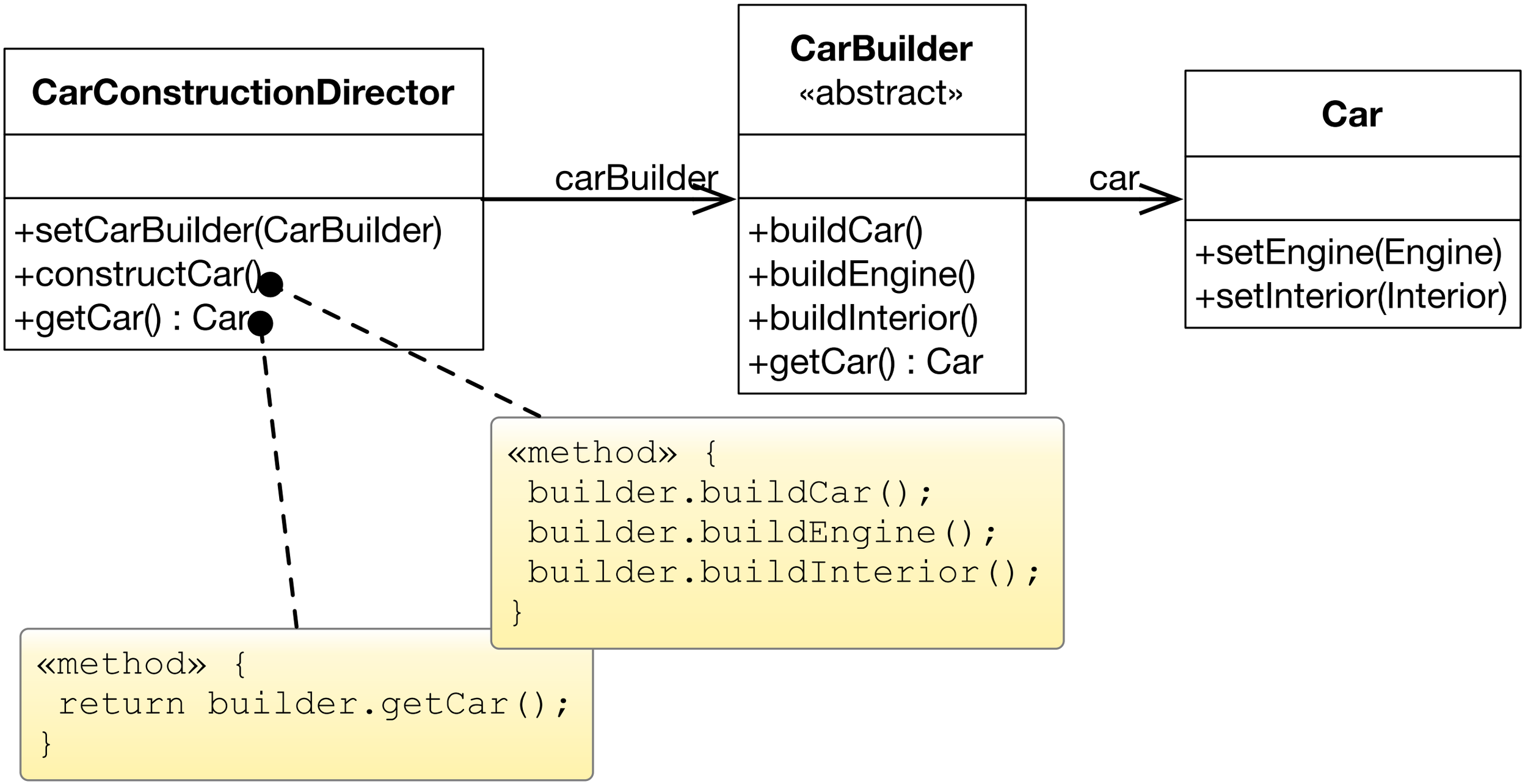
Car Builder

Builder - A Car Builder

- We want to construct different types of cars.
- In this example, cars have an engine and an interior.



Builder - A Car Builder



Two Possible Car Builders

```
class CheapCarBuilder extends CarBuilder {
  void buildEngine() {
    car.setEngine(Engine.SMALL_ENGINE);
  }

  void buildInterior() {
    car.setInterior(Interior.PLASTIC_INTERIOR);
  }
}

class LuxuryCarBuilder extends CarBuilder {

  void buildEngine() {
    car.setEngine(Engine.SPORT_ENGINE);
  }

  void buildInterior() {
    car.setInterior(Interior.WOODEN_INTERIOR);
  }
}
```

Example Collections

The map operation

- Takes the elements of a collection and applies a given function `f` to create the elements of the target collection.

```
Collection[E]{
   def map[T](f: E=>T):Collection[T] = {…}
}
```

- Let's assume that we want/have to transform the elements and the type of the collection at the same time.
  E.g., we want to map from a `List` of `Strings` to an `Array` of type `Array[SHA256]` in one step as shown in the following example:

```
val hashes : Array[SHA256] =
   List("a","b","c") map {e => SHA256(e)}
```

1. Apply the Builder Pattern

```
trait Builder[T,C[T]] {
    def add(t : T) : Unit
    def build : C[T]
}

class ListBuilder[T] extends Builder[T,List] {
    private var l : List[T] = List.empty
    def add(t : T) : Unit = l ::= t
    def build : List[T] = l
}

case class Singleton[T](t : T) {
    def map[X,C[X]](f : T => X) (builder : Builder[X,C]) : C[X] = {
        builder.add(f(t))
        builder.build
    }
}

Singleton(100).map(_.toString)(new ListBuilder)
```

2. Automatic “Selection” of the Builder (Using `implicit` Factories for Builders)

```
// The existing Builders are kept

trait BuilderFactory[C[_]] {
    def create[T]() : Builder[T,C]
}

implicit val lbf = new BuilderFactory[List] {
    def create[T]() = new ListBuilder[T]
}

case class Singleton[T](t : T) {
    def map[X,C[X]](f : T => X) (implicit bf : BuilderFactory[C]) : C[X] = {
        val builder = bf.create[X]()
        builder.add(f(t))
        builder.build
    }
}

Singleton(100).map(_.toString) // the (only) builder is automatically selected
```

Final Solution

```
trait Builder[T,C[T]] {
  def add(t : T) : Unit
  def build : C[T]
}
class ListBuilder[T] extends Builder[T,List] {
  private var l : List[T] = List.empty
  def add(t : T) : Unit = l ::= t
  def build : List[T] = l
}
class SetBuilder[T] extends Builder[T,Set] {
  private var l : Set[T] = Set.empty
  def add(t : T) : Unit = l += t
  def build : Set[T] = l
}

trait BuilderFactory[C[_]] { def create[T]() : Builder[T,C] }

val lbf = new BuilderFactory[List] {
  def create[T]() = new ListBuilder[T]
}

case class Singleton[T](t : T) {
  def map[X,C[X]](
          f : T => X
      ) (   implicit bf : BuilderFactory[C]) : C[X] = {
      val builder = bf.create[X]()
      builder.add(f(t))
      builder.build
  }
}
```

```
class SingletonBuilder[T] extends Builder[T,Singleton] {
  private var l : Singleton[T] = null
  def add(t : T) : Unit = if (l != null) throw new
IllegalStateException else l = Singleton(t)
  def build : Singleton[T] = l
}

trait LowPriorityImports {
  implicit val lbf = new BuilderFactory[List] {
    def create[T]() = new ListBuilder[T]
  }
  implicit val sbf = new BuilderFactory[Set] {
    def create[T]() = new SetBuilder[T]
  }
}
object HighPriorityImports extends LowPriorityImports{
  implicit val singletonbf = new BuilderFactory[Singleton] {
    def create[T]() = new SingletonBuilder[T]
  }
}
import HighPriorityImports._

Singleton(100).map[String,List](_.toString)

Singleton(100).map(_.toString) // =>  : Singleton[String]
```

Takeaway

- Use **Abstract Factory** for creating objects depending on finite numbers of factors you know in advance.
  E.g. if there are only three kinds of cars.

- Use **Builder** for creating complex objects depending on unbound number of factors that are decided at runtime.
  E.g. if cars can be configured with multiple different parts.