Creation Patterns

- Replace the use of new for more loosely coupled alternatives
    - Factory patterns
    - Builder
    - Prototype

- Use of new keyword implies tight coupling
- What if
  - You want to test a component that needs to create another component
  - The choice of which type to create is complex
  - The type you need to create hasn't been written yet
    - Extension points, Plugins

```
public void MakeAnimalNoise(string type) {
    Animal animal = null;

    switch (type.ToLower()) {
        case "dog": animal = new Dog(); break;
        case "chicken": animal = new Chicken(); break;
        case "cow": animal = new Cow(); break;
        case "sheep": animal = new Sheep(); break;
    }
    animal.Speak();
}
```

- Is this the factory pattern ?

```
public void MakeAnimalNoise(string type) {
    Animal animal = AnimalCreator.Create(type);

    animal.Speak();
}
```

```
public static class AnimalCreator {
    public static Animal Create(string type)  {
        Animal animal = null; ;
        switch (type.ToLower()) {
            case "dog": animal = new Dog(); break;
            case "chicken": animal = new Chicken(); break;
            case "cow": animal = new Cow(); break;
            case "sheep": animal = new Sheep(); break;
        }
        return animal;
    }
}
```
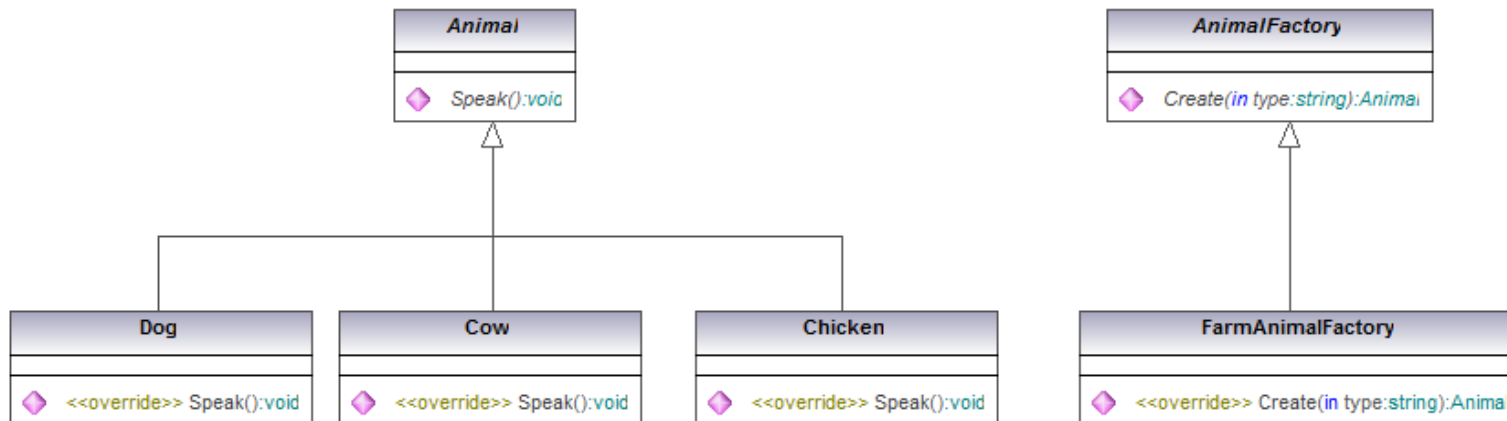
Creation Method

- Simplified the caller, encapsulated creation logic but still
  - Tightly coupled to the AnimalCreator class
  - Hard to test
- Sometimes known as "Creation Method" pattern
- To produce a true factory pattern solution
  - The creation logic needs to be able to vary

Factory Method Pattern

- "Encapsulate what varies and separate from code that's constant"
- Creation abstraction is constant
  - Create(string type)
- Implementation varies
  - Create real Animals or perhaps fake ones for testing

- Method is now loosely coupled from implementation of animal creation logic
- Animal creation logic can now therefore vary

```
public static void MakeAnimalNoise(string type,
                                   AnimalFactory factory)
{
 Animal animal = factory.Create(type);

 animal.Speak();
}
```

- Abstract class provides abstraction for creation
- Derived classes provide implementation of creation logic

```
public abstract class AnimalFactory{
   public abstract Animal Create(string type);
}

public class FarmAnimalFactory : AnimalFactory{
 public override Animal Create(string type) {
  Animal animal = null;

  switch (type.ToLower()){
    case "dog": animal = new Dog(); break;
    case "chicken": animal = new Chicken(); break;
    case "cow": animal = new Cow(); break;
    case "sheep": animal = new Sheep(); break;
  }
 return animal;
 }
}
```

- Base factory class provides base implementation providing common point of interception
- Delegates to derived class for specific creation logic
- Can layer in caching, singleton behaviour, lazy creation

```
public abstract class AnimalFactory{
   public virtual Animal Create(string type) {
    // Do something before creation
    Animal animal = InternalCreate(type);
    // Do something after creation
    return animal;
   }

   protected abstract Animal InternalCreate(string type);
 }

}
```

- Define an interface for creating an object, but let subclasses decide which class to instantiate.

- Factory Method lets a class defer instantiation to subclasses
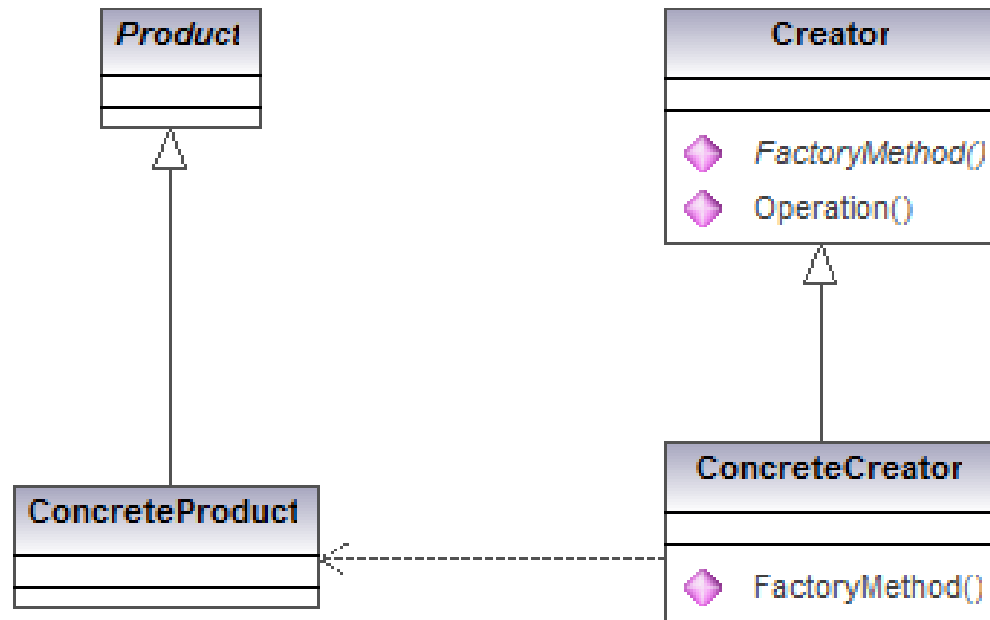
- Replacing New offers flexibility
- Utilise reflection to create types unknown at compile time

```csharp
public class AnimalAttribute : Attribute {
  public string Type {get;set;}
}
```

```csharp
[AnimalAttribute(Type="cow")]
public class Cow:Animal {
 }
```

```csharp
public class ReflectionAnimalFactory : AnimalFactory   {
 private readonly Dictionary<string, Type> animals;
 public ReflectionAnimalFactory(){
  animals =
  (from type in this.GetType().Assembly.GetTypes()
    let animalAttrs = type
        .GetCustomAttributes(typeof(AnimalAttribute), false)
        .OfType<AnimalAttribute>()
    where animalAttrs.Count() > 0
    select new { Type = type, Kind = animalAttrs.First().Type }
  ).ToDictionary(e => e.Kind, e => e.Type);
 }
 public override Animal Create(string type){
   return (Animal) Activator.CreateInstance(animals[type.ToLower()]);
 }
}
```

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- Suppose we want to create a number of related objects
  - Database connection, command, parameter, permission
  - Would want a single factory to create all products
  - One 'create' method would not be enough
- Factory type contains many create methods
- Objects from same factory are compatible

```
public abstract class DbProviderFactory  {
   public virtual DbCommand CreateCommand();
   public virtual DbConnection CreateConnection();
   . . .
}
```

```
DbProviderFactory factory =  DbProviderFactories
                              .GetFactory("System.Data.SqlClient");
DbConnection connection = factory.CreateConnection();
DbCommand cmd = factory.CreateCommand();
cmd.Connection = connection;
```
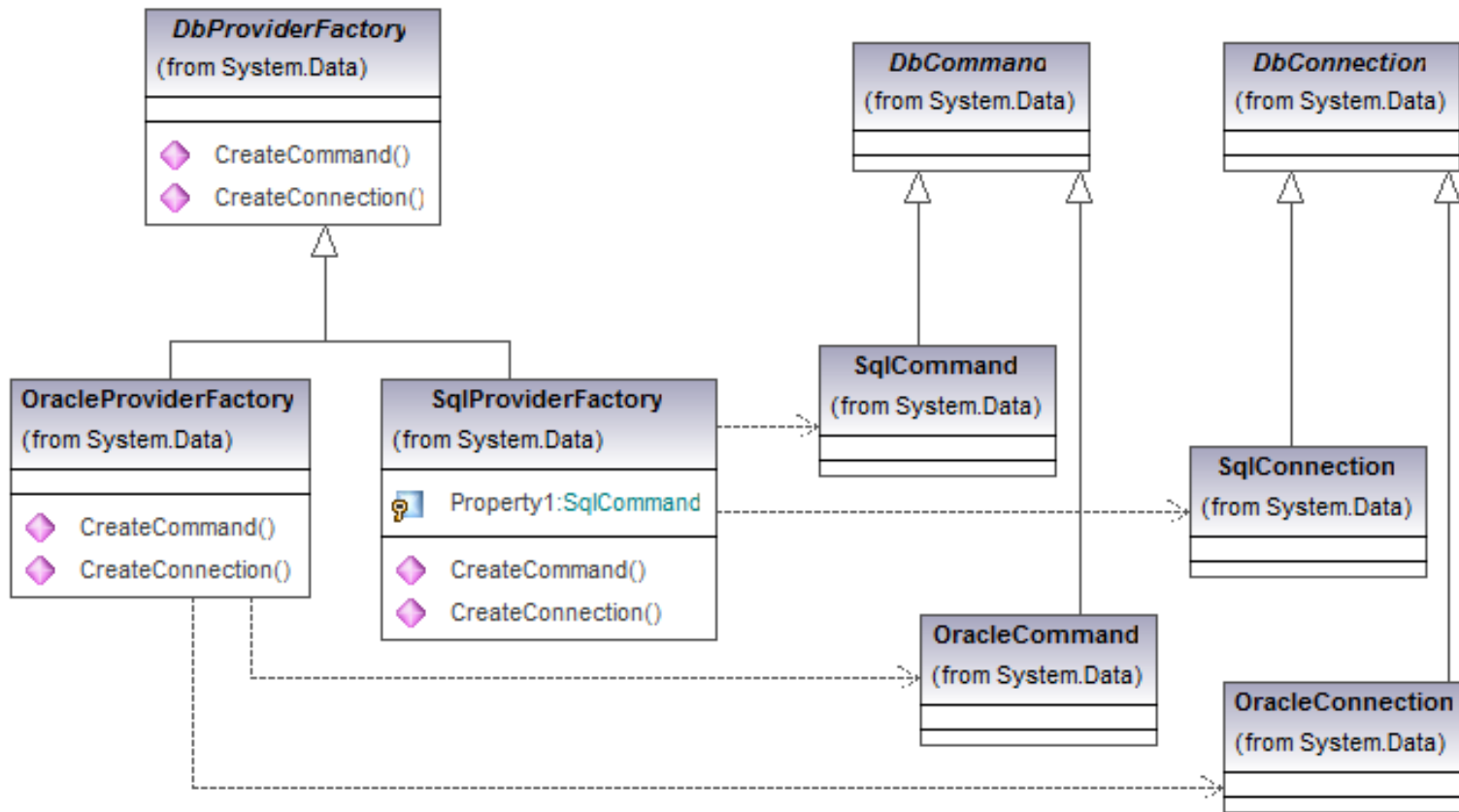
- Often as the number of concrete objects increases the number of factories increases too
  - As we add new document types we may need to add additional factories
  - XPSDocument, XPSDocumentFactory
- What if the concrete objects had knowledge of cloning themselves, we could do away with factories
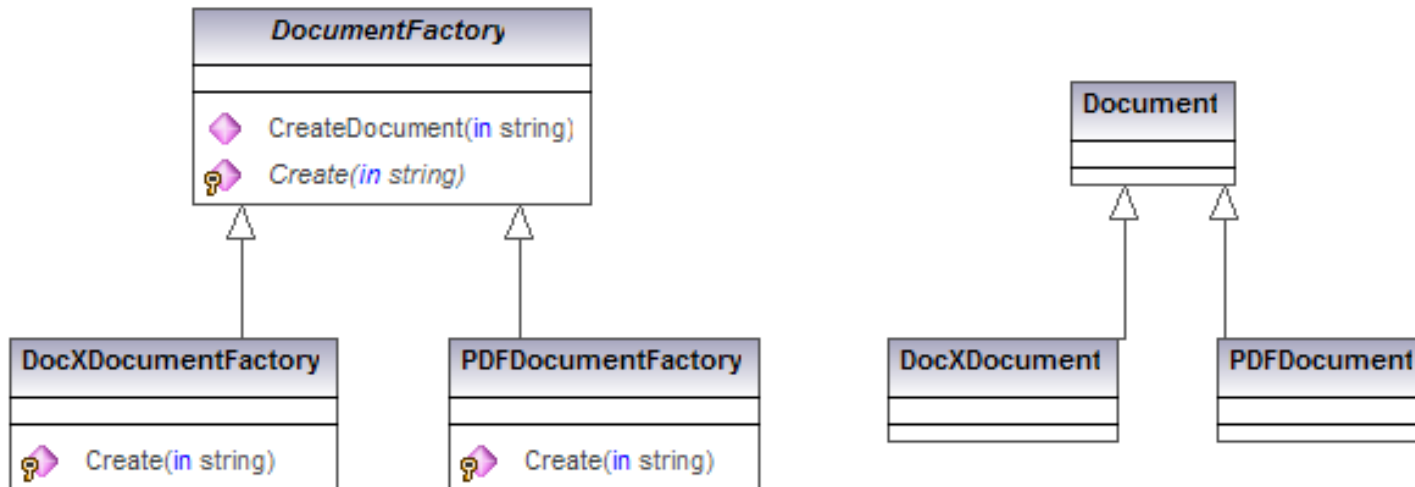
- Objects know how to clone themselves
- Application creates prototype object
  - Configures object for initial settings
- Client utilises New method rather than relying on a factory
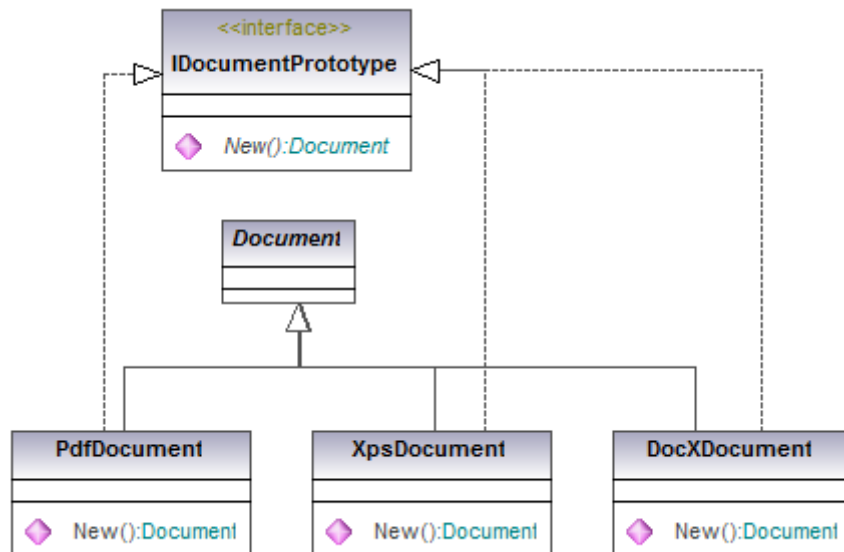
- Prototype objects can sometimes be used instead of creating additional classes
- Creates the illusion of new types at runtime
  - Instantiate from prototype rather than by class

Multi step construction
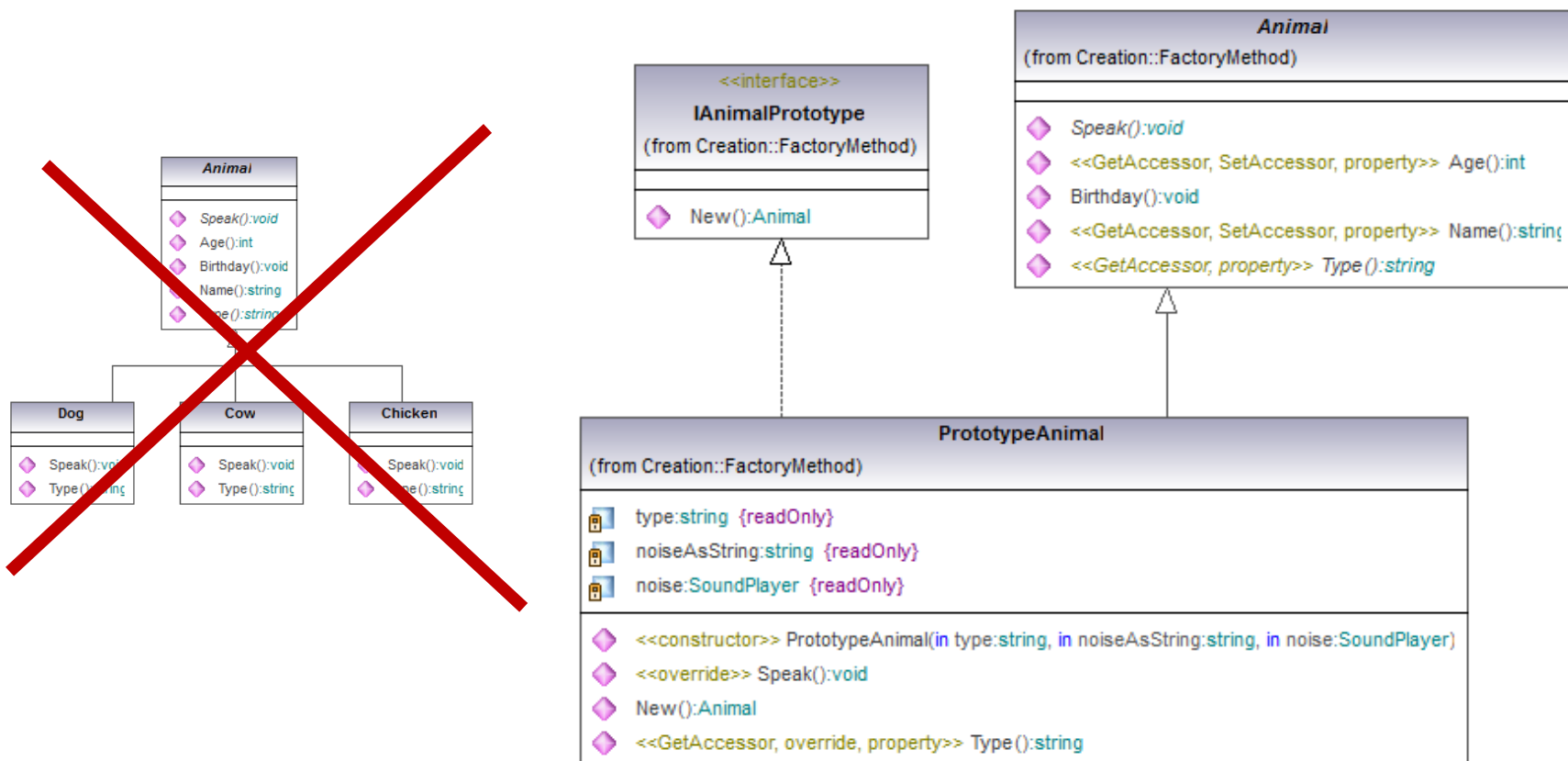
- Factories are great at single step construction
- What if constructing complex object that requires many parts
  - Factory methods start to grow
  - Providing every permutation not practical

```
public abstract class Mail {
 public abstract void Send();
}

public abstract class MailFactory {
 public abstract Mail Create(string from, string to, string subject,
                             string body);
 public abstract Mail Create(string from, string to, string subject,
                             string body, string[] attachments);
 public abstract Mail Create(string from , string to , string cc,
                             string subject , string body )
 . . .
}
```

- Builders allow the construction of a complex object over a series of steps
  - Builder hides the complexity of the construction
  - Complex object representation is independent of method of construction
- Construction methods typically return self to allow natural method chaining
- Build method returns complex object

```
public abstract class MailBuilder  {
    public abstract MailBuilder SetFrom(string name);
    public abstract MailBuilder SetBody(string body);
    public abstract MailBuilder SetSubject(string subject);
    public abstract MailBuilder AddTo(string name);
    public abstract MailBuilder AddCC(string name);
    public abstract MailBuilder AddAttachment(string filename);

    public abstract Mail Build();
}
```

- Client
    - creates new builder for each construction
    - Calls construction methods
    - When construction complete, calls Build to return complex object

```
MailBuilder builder = new SmtpMailBuilder();

builder
   .SetFrom("aclymer@develop.com")
   .SetSubject("Patterns are cool")
   .SetBody("...")
   .AddTo("rich@develop.com")
   .AddCC("kev@develop.com")
   .AddAttachment("uml.png")
   .Build()
   .Send();
```

- StringBuilder
- SqlConnectionStringBuilder
- UriBuilder
  - Define Scheme,Host,Port,Path,Query variables and it builds Uri

```
var connectionStringBuilder = new SqlConnectionStringBuilder()
 {
    DataSource = @".\SQL2008",
    InitialCatalog = "pubs",
    IntegratedSecurity = true
 };

Console.WriteLine(connectionStringBuilder.ConnectionString);
```

- Replacing the direct use of new creates flexible designs
- Creation Method
  - Commonly used to encapsulate creation logic, often wrongly thought of as factory pattern
- Factory Method
  - Replaces the new keyword with a virtual method for creation, allowing creation logic to vary
- Abstract Factory
  - Creates families of related products
- Prototype
  - Used to prevent factory and product type explosion
- Builder
  - Used instead of factories for complex object creation
  - Separates complex object representation from construction