Factory Method Design Pattern

Topics

1) How can we prevent instantiation coupling when we **must instantiate new objects**?

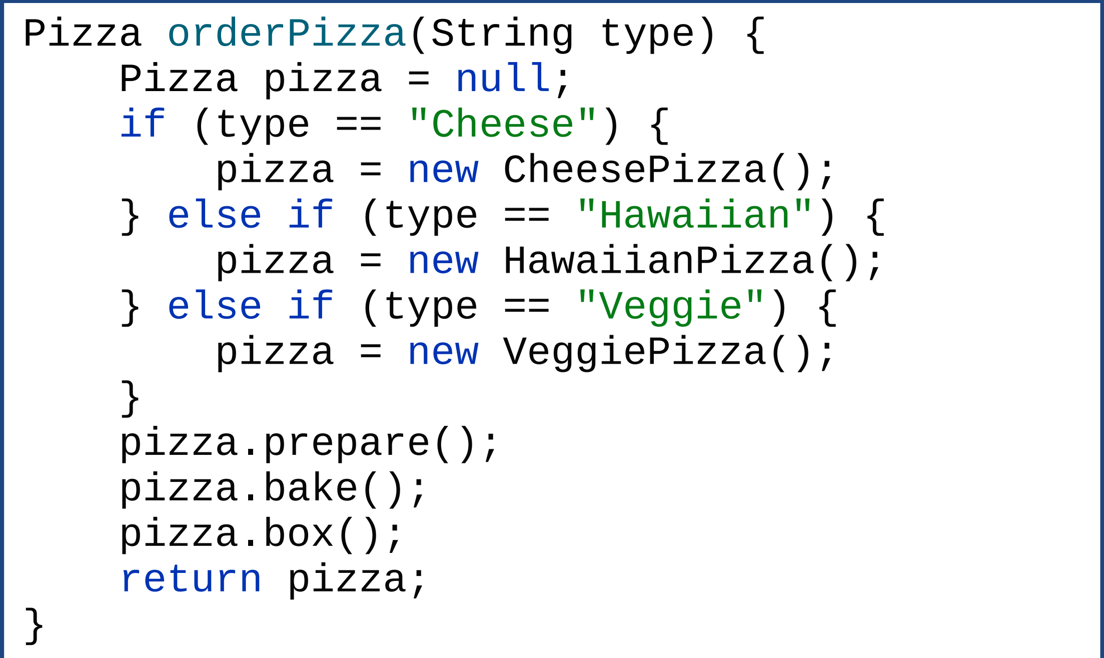
Let’s make Pizzas!

- We are opening a Pizza restaurant chain!
  - Pizza types (Cheese, Veggie, Hawaiian, ...)
  - Pizza styles (New York = thin; Chicago = deep dish)
- And, you know:
  the requirements are going to change!

We have `new` Problems

- The problem with new:
  - new creates an object of a concrete type
  - new couples our code to a specific concrete class
- We want to depend on general types (“interfaces”), not concrete types.
- Solutions
  - If we need an object so we can do our job, use..
  - If our job is **creating new objects**, we can’t use DI: we can..

`new` Problem: Code

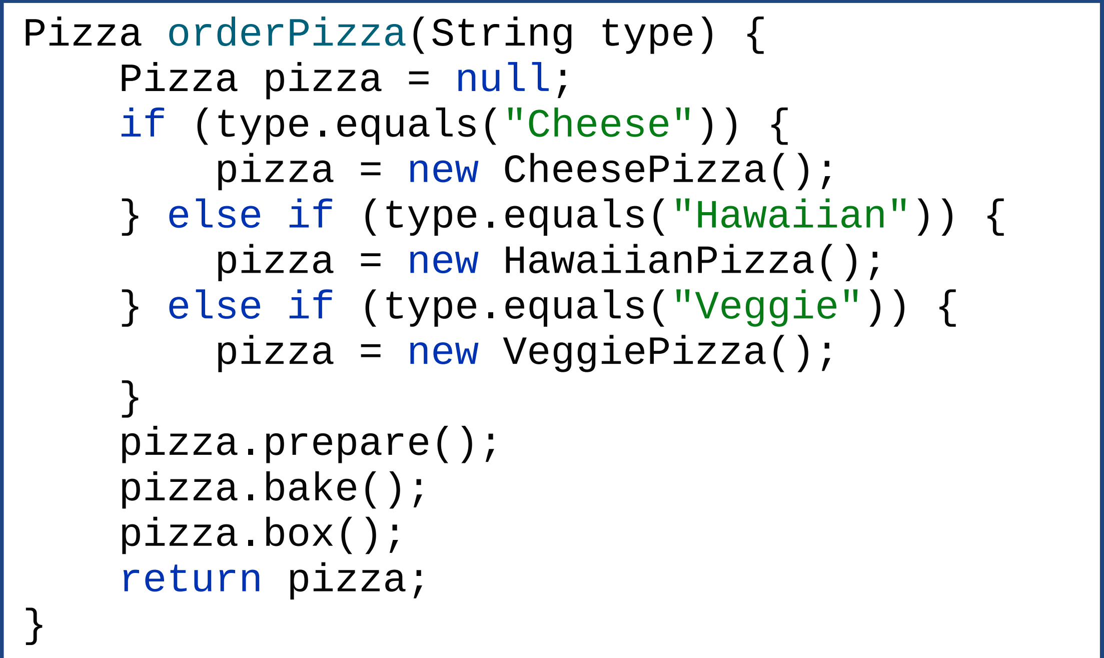


```
Pizza orderPizza(String type) {
    Pizza pizza = null;
    if (type == "Cheese") {
        pizza = new CheesePizza();
    } else if (type == "Hawaiian") {
        pizza = new HawaiianPizza();
    } else if (type == "Veggie") {
        pizza = new VeggiePizza();
    }
    pizza.prepare();
    pizza.bake();
    pizza.box();
    return pizza;
}
```

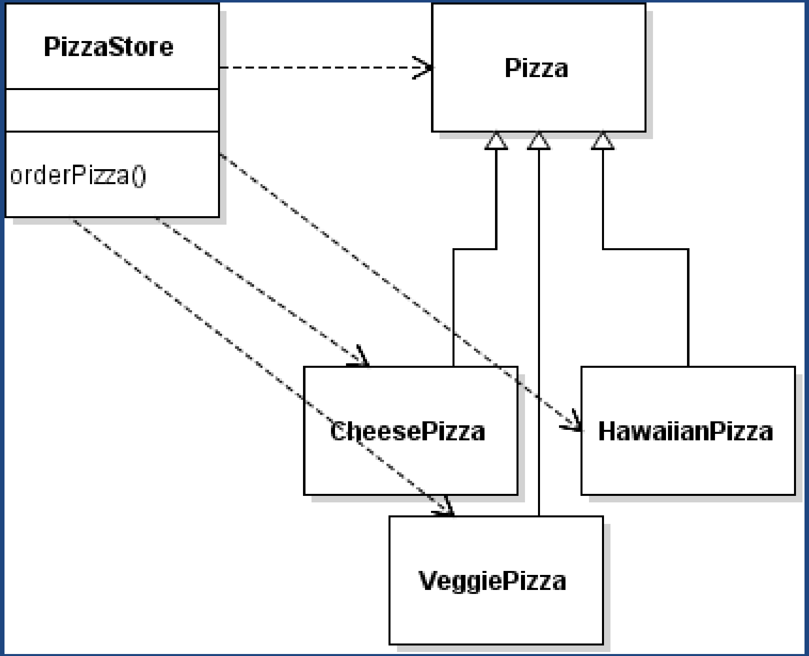
- What changes when adding a new pizza type?
  - Which design principle does this violate?
- What type of coupling?
  - Couples high-level (pizza order)
     to low level classes (Cheese, ...)

Coupling

- ..



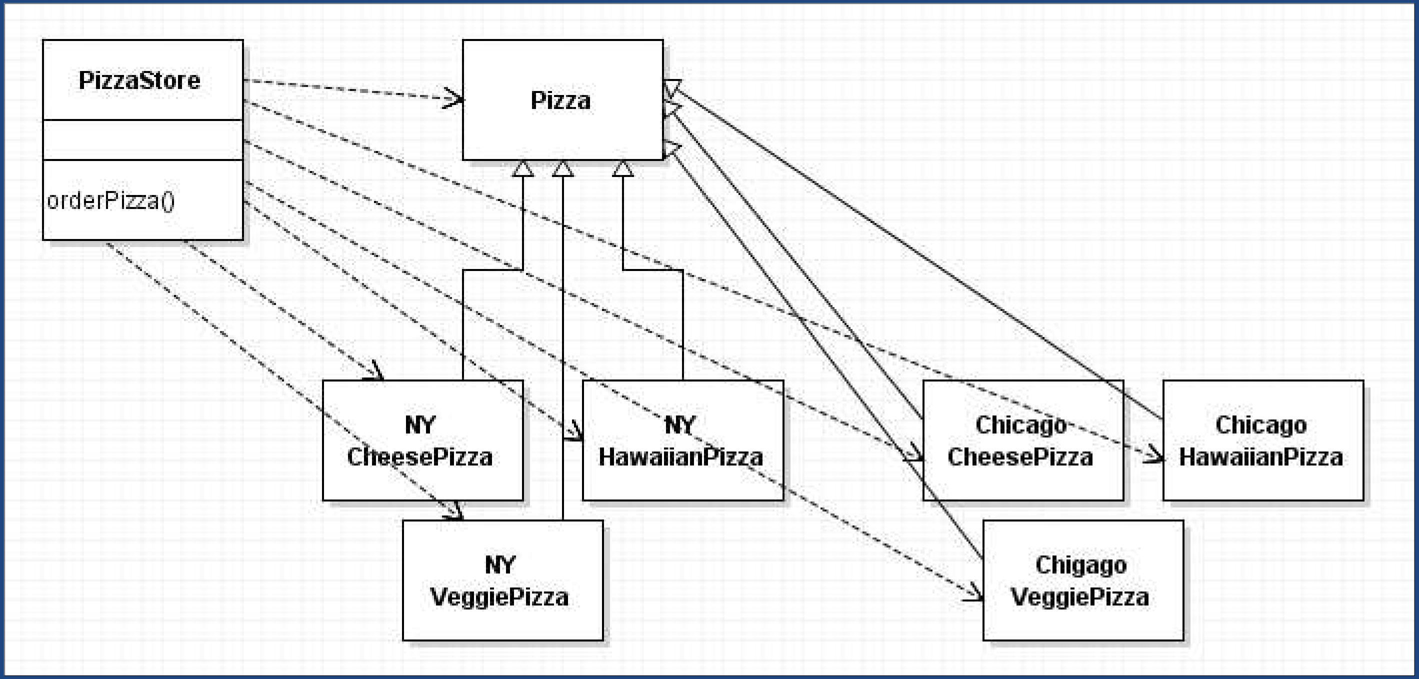
```
Pizza orderPizza(String type) {
    Pizza pizza = null;
    if (type.equals("Cheese")) {
        pizza = new CheesePizza();
    } else if (type.equals("Hawaiian")) {
        pizza = new HawaiianPizza();
    } else if (type.equals("Veggie")) {
        pizza = new VeggiePizza();
    }
    pizza.prepare();
    pizza.bake();
    pizza.box();
    return pizza;
}
```



Factory Method

Creating families of objects

- What if we want to support creating NY or Chicago pizzas?
  - Ex: Want a NY Cheese, and a Chicago Cheese



Creating families of objects (code)

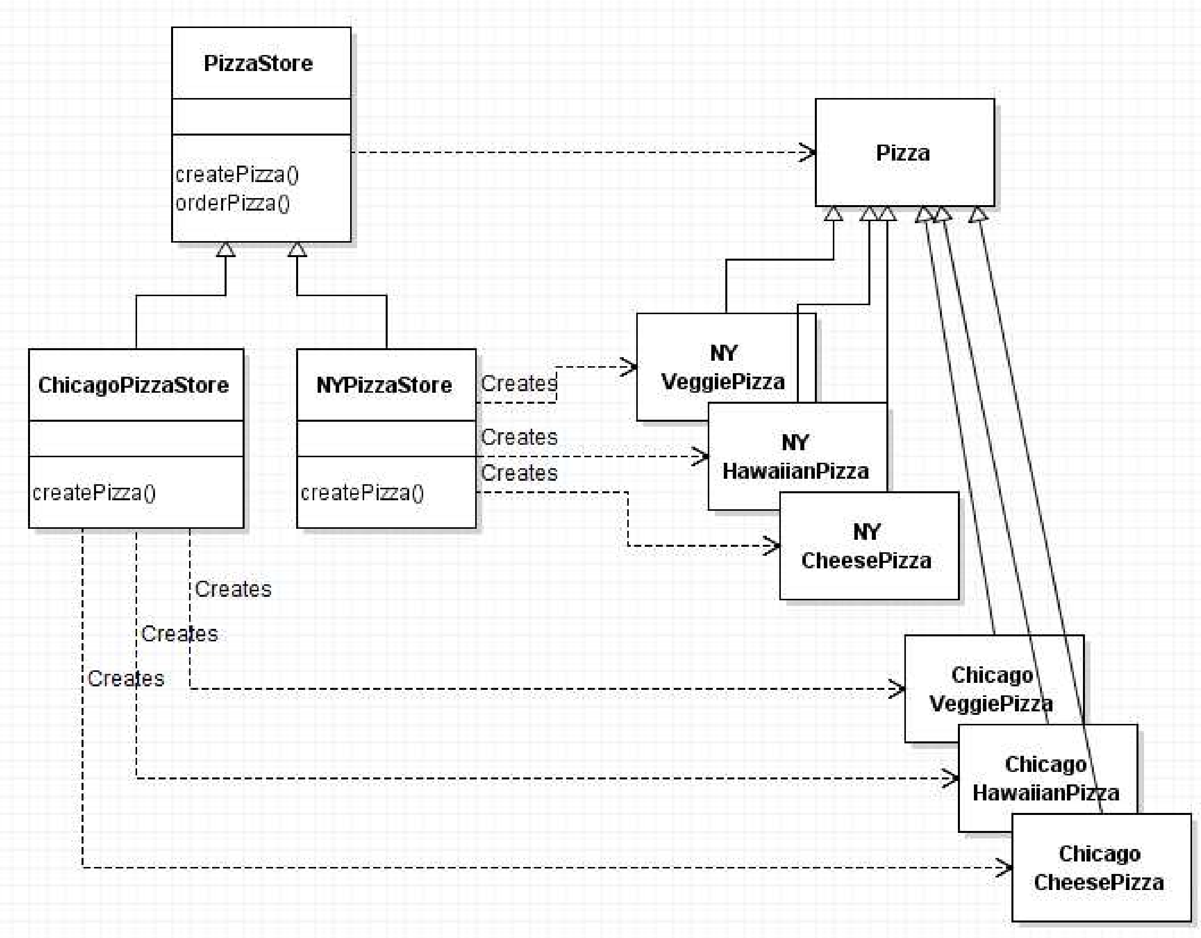
- It’s ugly having PizzaStore instantiating all know styles and types of pizza.

```
Pizza orderPizza(String type, String style) {
    Pizza pizza = null;
    if (style == "NY") {
        if (type == "Cheese") {
            pizza = new NYCheesePizza();
        } else if (type == "Hawaiian") {
            pizza = new NYHawaiianPizza();
        } else if (type == "Veggie") {
            pizza = new NYVeggiePizza();
        }
    } else if (style == "Chicago") {
        if (type == "Cheese") {
            pizza = new ChicagoCheesePizza();
        } else if (type == "Hawaiian") {
            pizza = new ChicagoHawaiianPizza();
        } else if (type == "Veggie") {
            pizza = new ChicagoVeggiePizza();
        }
    }
    pizza.prepare();
    pizza.bake();
    pizza.box();
    return pizza;
}
```

- What can we do to clean this up?

Defer instantiation to derived class

- Encapsulate what Varies:
  ..
  (derived classes).
- Base class
  - Does work with Pizza
  - Abstract method to create pizzas: createPizza()
- Derived class
  - Overrides createPizza() to instantiate the correct style of pizza



Factory Method Code

```java
public abstract class PizzaStore {

    protected abstract Pizza createPizza(String item);

    public Pizza orderPizza(String type) {
        Pizza pizza = createPizza(type);
        pizza.prepare();
        pizza.bake();
        pizza.cut();
        pizza.box();
        return pizza;
    }
}
```

Abstract method
("Factory Method")
in base class

PizzaStore is a framework for working with any Pizza

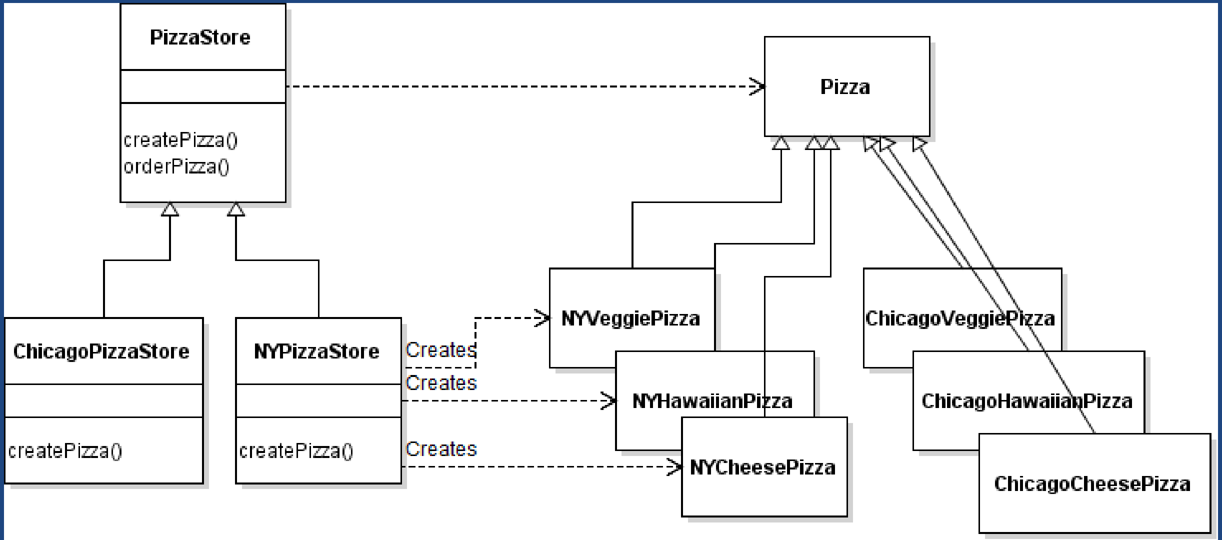
```java
public class NYPizzaStore extends PizzaStore {

    @Override
    protected Pizza createPizza(String item) {
        if (item == "cheese") {
            return new NYStyleCheesePizza();
        } else if (item == "veggie") {
            return new NYStyleVeggiePizza();
        } else if (item == "clam") {
            return new NYStyleClamPizza();
        } else if (item == "pepperoni") {
            return new NYStylePepperoniPizza();
        } else
            return null;
    }
}
```

Override factory method in derived class

Factory Method Idea

- ..
  derived classes instantiate different (families of) objects.
  - Base class
    defines an abstract factory method for creating objects
  - Derived classes
    overrides factory method to instantiate concrete types

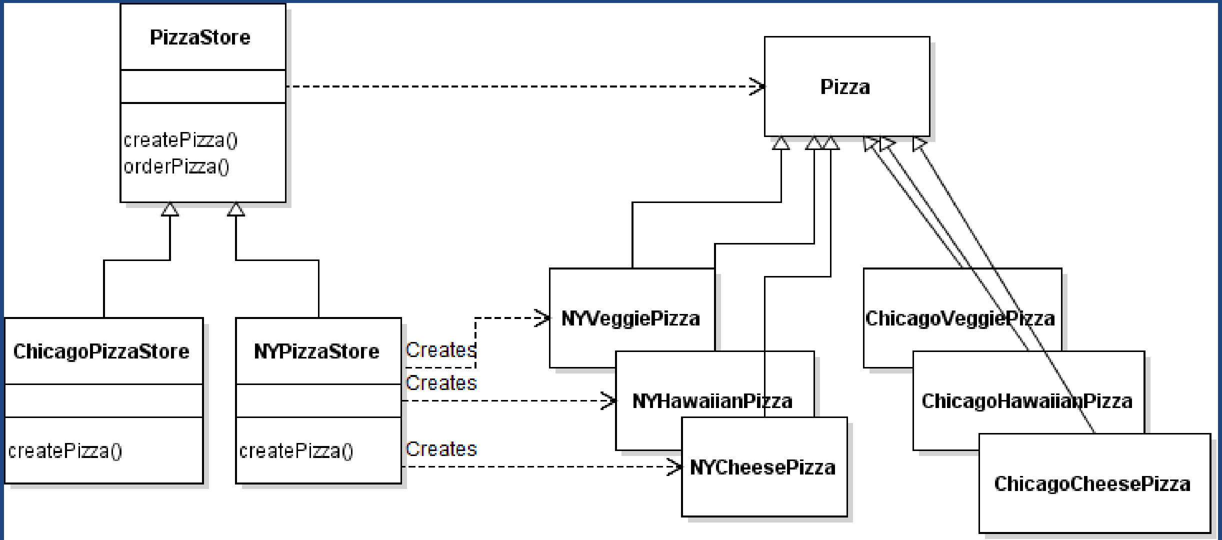


Benefits of Factory Method

- Satisfies..
  and..
  - Adding a new pizza style adds we classes
- High-level class (PizzaStore) depends on an abstract type (Pizza), not a concrete implementation (NYVeggiePizza)

This is actually a "Parameterized factory method": The object is created based on an argument.

Can apply this pattern without arguments to the factory method.



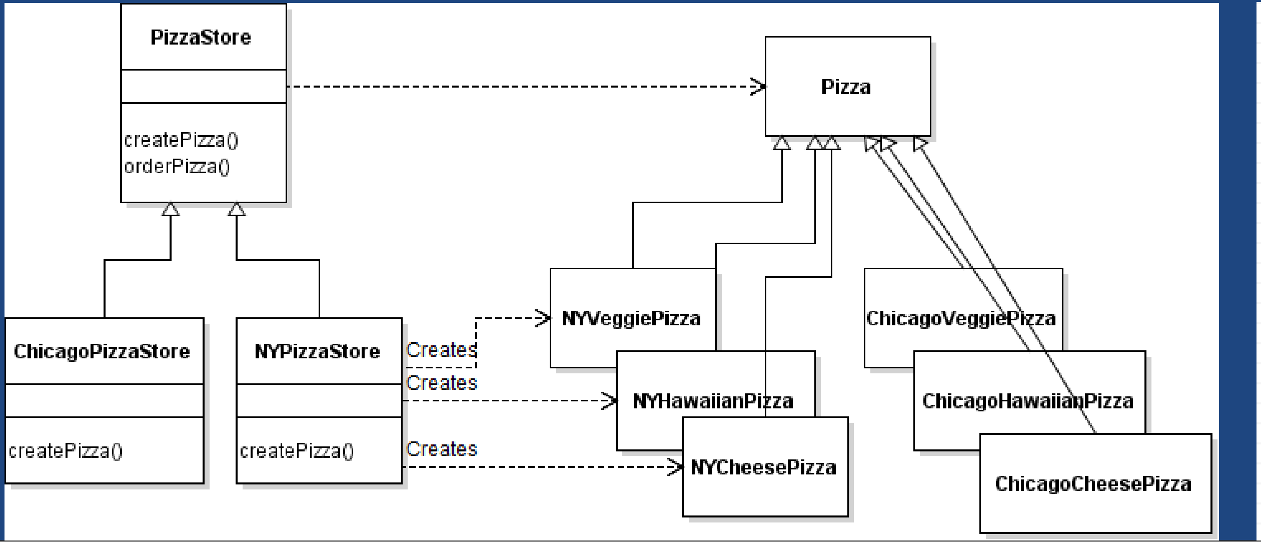
Exercise: Writing Client Code

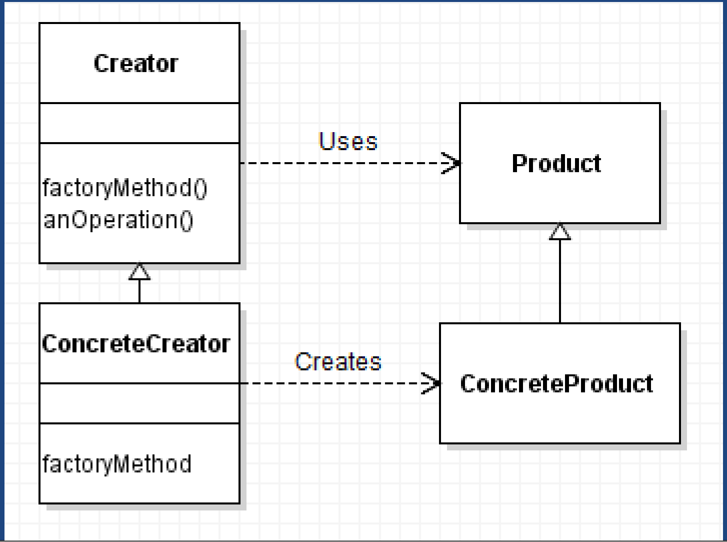
- Write client code which
  1. creates a NYPizzaStore and
  2. orders a Cheese pizza.
    - Trace with UML

!See factory.pizzafm.PizzaTestDriver

Factory Method Design Pattern

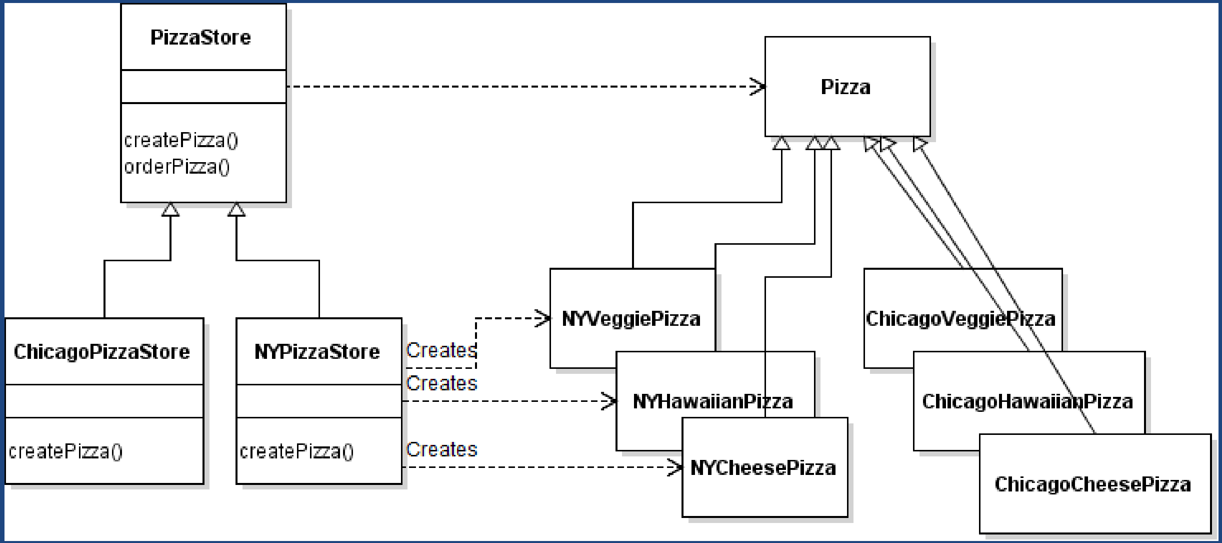
- Factor Method Design Pattern:
  - Define an interface for creating an object (abstract function), but let subclasses decide which class to instantiate.
  - Factory Method design pattern..
- .. : all the PizzaStores
- .. : all the Pizza’s





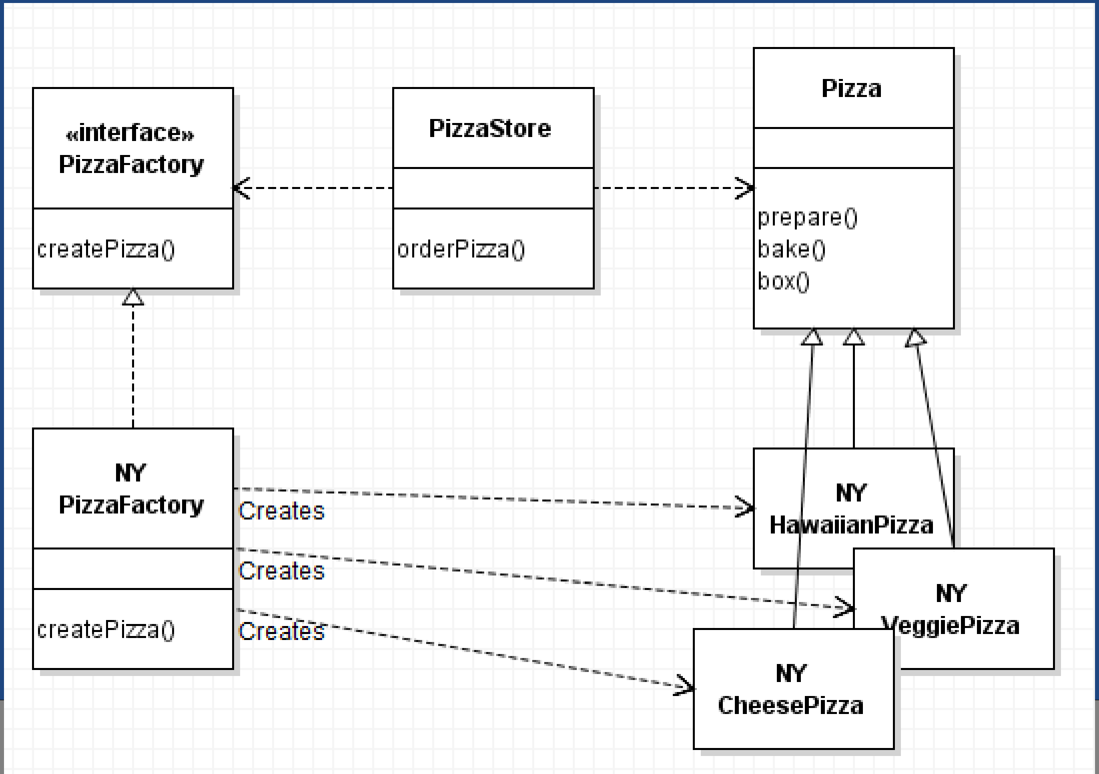
Drawbacks

- Parallel Hierarchies
  - ..
- Add a VancouverPizzaStore?
  Adding a new class to creator hierarchy requires adding new classes to products
- Add a GreekPizza?
  Adding a product class requires:
  - changing all creators
  - creating matching products for each creator



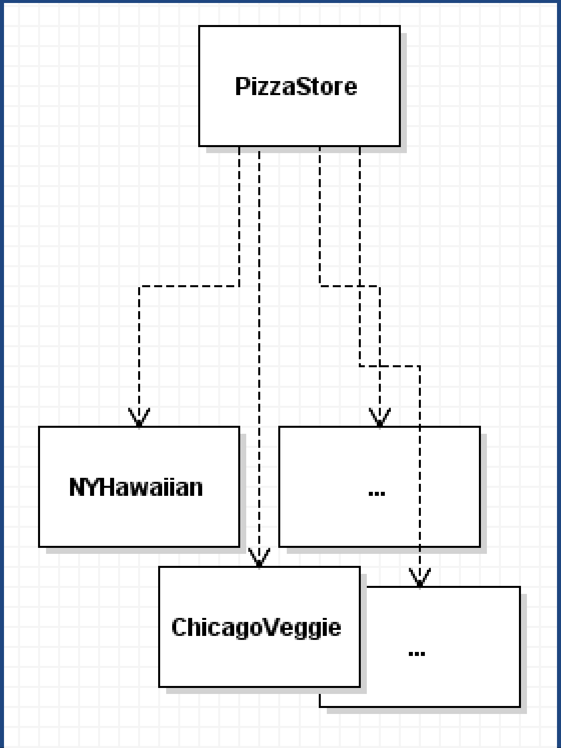
Drawbacks

- Inheritance is fixed at runtime:
  - Cannot..
- This is addressed by using the..
  - Define a separate object for instantiation (factory object)
  - PizzaStore has-a PizzaFactory (NYPizzaFactory,...)
  - Design Principle: Favour composition over inheritance

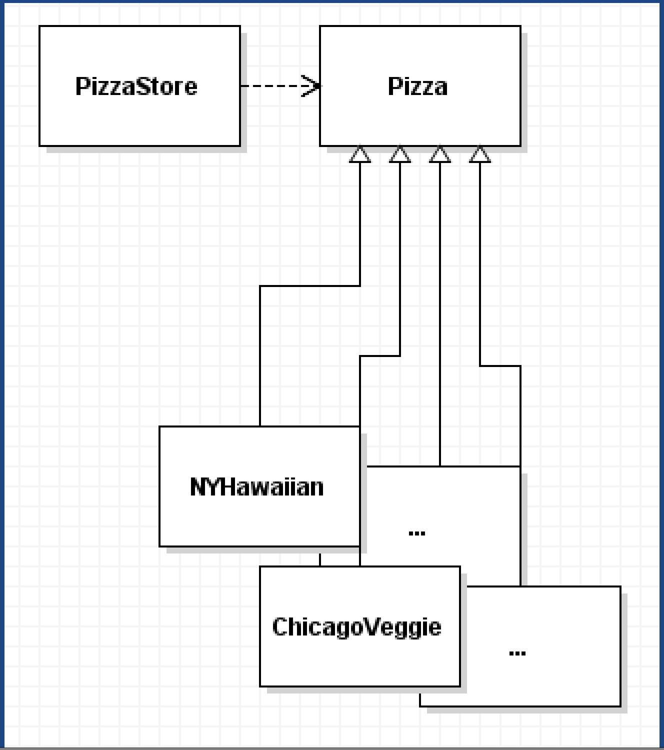


Dependency Inversion

- *Without* Factory Method
  PizzaStore depends on..



- *With* Factory Method
  PizzaStore and all concrete pizzas depends on..



Design Principle: Dependency Inversion

- Design Principle: Dependency Inversion
  - ..
    Do not depend upon concrete classes.
- Similar to “Code to an interface, not an implementation” but this is stronger:
  - DIP: Have both high and low level classes
    ..
  - “Code to interface” motivated by flexibility:
    ability to change object type later.
  - DIP motivated by cleaning up the dependencies from high to low and coupling
- We invert the dependency lines in the UML for PizzaStore

Summary

- Creating an object with new couples code to a concrete class.
- High-level code should not depend on concrete types: therefore it should not instantiate with new!
  - Dependency Injection: For when we can be handed the objects we need.
  - Factory Method: Delegate instantiation of concrete objects to a derived class (inheritance).
  - Abstract Factory Pattern: Delegate instantiation of concrete objects to a factory object (composition).