Design Patterns

Singletons, Pools and Factories

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https://github.com/NagyAttila/DesignPatterns

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- Object Oriented Design Principles

- Singleton
- Meyers Singleton
- Phoenix Singleton

- Object Pool
- Connection Pool
- Thread Pool

- Factory Method
- Abstract Factory
- Object Factory

Object Oriented Design Principles

Open Close Principle

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Fat interface avoidance.
Clients should not be forced to depend on interface that they don't use.

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Single Responsibility Principle

One class should be responsible for one thing.

Singleton

Purpose:

- class has at most one instance,
- that instance is accessible in a global scope.

Application Areas:

- logging,
- Thread and Connection Pools,
- Factories
- system clock,
- etc.

Singleton - How?

- private constructors
- static _pInstance_ and _Instance_

```
class Singleton {
public:
static Singleton& Instance() {
  if (nullptr == pInstance) {
    pInstance = new Singleton;
  }
  return *pInstance;
}

private:
Singleton () = default;
Singleton (const Singleton&) = delete;
Singleton operator= (const Singleton&) = delete;
~Singleton () = delete;

static Singleton* pInstance;
// More Functions and Data
};
Singleton* Singleton::pInstance = nullptr;
```

Singleton - How?

- private constructors
- static *_pInstance_* and *_Instance_*

```
class Singleton {
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  if (nullp
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  }
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Destructor was never called! (memory leak)

Meyers Singleton

- local static _instance_

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⇒ private destructor is called at process termination

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Dead Reference!

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Dead Reference Problem

How?

1. Two Singleton classes, Logger and Keyboard, in different compilation units

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Solution?

- on-demand reallocation of *Singleton* after destruction

  $\Rightarrow$ Phoenix Singleton

Phoenix Singleton

Combination of the 3 approaches:

- Simple: *_pInstance_* pointer
- Meyers: static life-time
- Dead Reference: detection

Plus:

- on-demand reallocation
- destructor called using *_atexit_*
- multiple time "reborn"

```cpp
class Singleton {
public:
static Singleton& Instance() {
  if (destroyed) {
    new(pInstance) Singleton;
    atexit(KillSingleton);
  }
  if (nullptr == pInstance) {
    static Singleton instance;
    pInstance = &instance;
  }
  return *pInstance;
}
static void KillSingleton(void) {
  pInstance->~Singleton();
}
```

```cpp
private:
Singleton () {
  destroyed = false;
}
Singleton (const Singleton&) = delete;
Singleton operator= (const Singleton&) =
     delete;
~Singleton () {
  destroyed = true;
  pInstance = nullptr;
}
static bool destroyed;
static Singleton* pInstance;
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bool Singleton::destroyed = false;
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Solution?

- Read the Manual!
- Use the newest compilers!

Multithreading

Problem:

- general lazy initialization problem
- race condition

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A local static instance (Meyers approach)

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B locking

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static Singleton& Instance() {
  Lock guard(mutex);
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C double-check locking

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  - dependency
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Possible extensions and alternative solutions:

- longevity control for dead reference problem
- registry high number of singletons
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Final thought:

- should be used sparingly

- if needs a lot:
  - $\Rightarrow$ use registry, or
  - $\Rightarrow$ change design

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Similar patterns

- Connection Pool
- Thread Pool

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Used as

- Singleton

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Connection Pool

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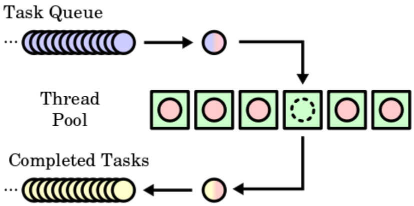
Thread Pool

- asynchronous task processing
- more tasks than threads
- fix or dynamic number of threads



Threads

too many created $\Rightarrow$ wasting resource and time

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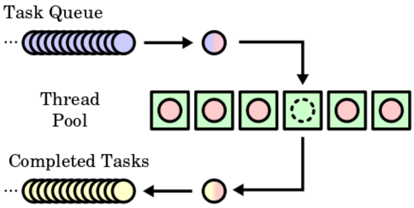

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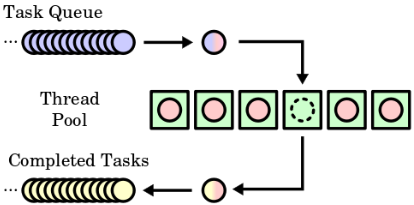

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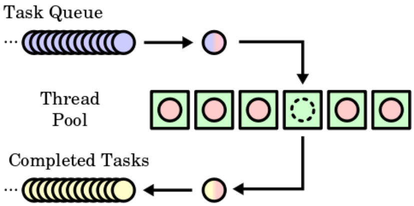

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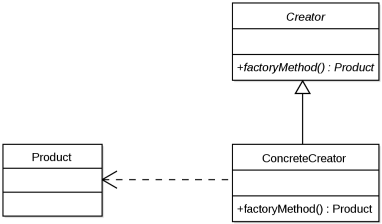
Factory Method

A.k.a: Virtual Constructor

- uses an abstract class for interface
- instantiation determined by subclasses



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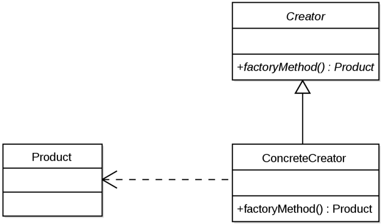

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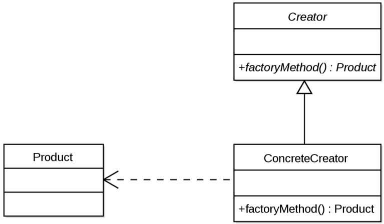
Application areas:

- unit testing
- Abstract Factory



Abstract Factory

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Drawbacks:

- adding new product-family is cumbersome
  - $\Rightarrow$ abstract factory class must change
    - $\Rightarrow$ concrete factory classes must follow the change

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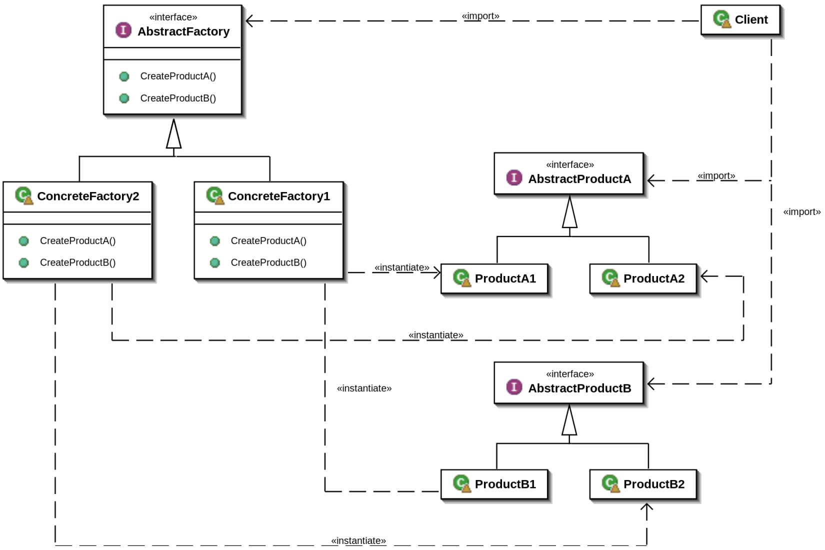
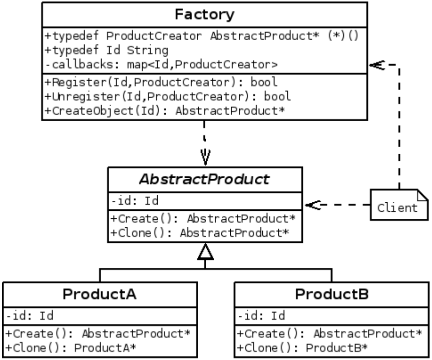


Object Factory

Features:

- each product has to register
- uses the priority inversion principle
- one family of product



Object Factory

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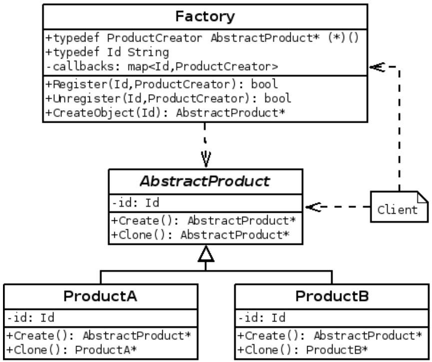
Cloning:

- make use of covariant return type
- common mistake: forgetting to implement _Clone_



Resources

- Design Patterns: Elements of Reusable Object-Oriented Software
  "Gang of Four"
- Modern C++ Design: Generic Programming and Design Patterns Applied
  Andrei Alexandrescu
- Head First: Design Patterns
  Eric Freeman & Elisabeth Freeman

Questions?

Thank You!