

Design Patterns

Singletons, Pools and Factories

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<https://github.com/NagyAttila/DesignPatterns>

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- Object Oriented Design Principles

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- Meyers Singleton
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- 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_`

```

1 class Singleton {
2 public:
3     static Singleton& Instance() {
4         if (nullptr == pInstance) {
5             pInstance = new Singleton;
6         }
7         return *pInstance;
8     }
9
10 private:
11     Singleton () = default;
12     Singleton (const Singleton&) = delete;
13     Singleton operator= (const Singleton&) = delete;
14     ~Singleton () = delete;
15
16     static Singleton* pInstance;
17     // More Functions and Data
18 };
19 Singleton* Singleton::pInstance = nullptr;

```

Singleton - How?

- private constructors
- static `_pInstance_` and `_Instance_`

Destructor was
never called!
(memory leak)

```

1 class Singleton {
2 public:
3     static Singleton*
4         if (nullptr)
5             pInstance = new Singleton();
6     }
7     return pInstance;
8 }
9
10 private:
11     Singleton() {}
12     Singleton(Singleton const&) {}
13     Singleton(Singleton&) {}
14     ~Singleton() {}
15
16 static Singleton* pInstance;
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Meyers Singleton

- local static `_instance_`


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5         return instance;  
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8 private:  
9     Singleton () = default;  
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⇒ private destructor is called at process termination

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

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- ⑤ **undefined behaviour** (probably crash)

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- order of deallocation of static objects is not deterministic

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- 4 Logger's static object "shell" is still available
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Why?

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Solution?

- on-demand reallocation of *Singleton* after destruction
⇒ 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"

```

1 class Singleton {
2 public:
3     static Singleton& Instance() {
4         if (destroyed) {
5             new(pInstance) Singleton;
6             atexit(KillSingleton);
7         }
8         if (nullptr == pInstance) {
9             static Singleton instance;
10            pInstance = &instance;
11        }
12        return *pInstance;
13    }
14    static void KillSingleton(void) {
15        pInstance->~Singleton();
16    }

```

```

17 private:
18     Singleton () {
19         destroyed = false;
20     }
21     Singleton (const Singleton&) = delete;
22     Singleton operator= (const Singleton&) =
23         delete;
24     ~Singleton () {
25         destroyed = true;
26         pInstance = nullptr;
27     }
28     static bool destroyed;
29     static Singleton* pInstance;
30 };
31 bool Singleton::destroyed = false;
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- functions registered on stack

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Solution?

- Read the Manual!
- Use the newest compilers!

Multithreading

Problem:

- general lazy initialization problem
- race condition

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Solution:

A local static instance (Meyers approach)

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B locking

```
1 static Singleton& Instance() {  
2     Lock guard(mutex);  
3     if (nullptr == pInstance) {  
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C double-check locking

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Notes

Why not global?

- uniqueness
- lack of laziness
- pollute global scope
- not always possible
 - dependency
 - need data for init

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Possible extensions and alternative solutions:

- longevity control for dead reference problem
- registry high number of singletons
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Possible extensions and alternative solutions:

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Final thought:

- should be used sparingly
 - ⇒ if needs a lot:
 - ⇒ use registry, or
 - ⇒ change design

Object Pool

Purpose:

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Empty pool:

- 1 report error
- 2 increase pool size
- 3 blocking request

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Similar patterns

- Connection Pool
- Thread Pool

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Used as

- Singleton

Connection Pool and Thread Pool

Connection Pool

- cache of DB connections
- creates new connection if empty pool (2nd approach)

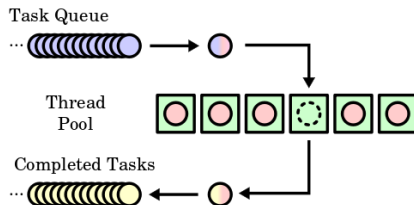
Connection Pool and Thread Pool

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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

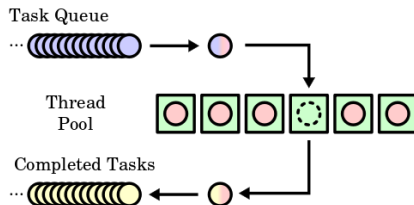
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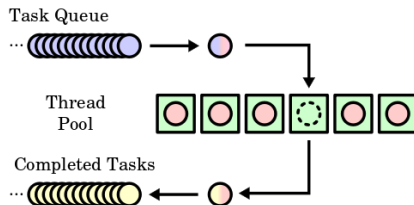
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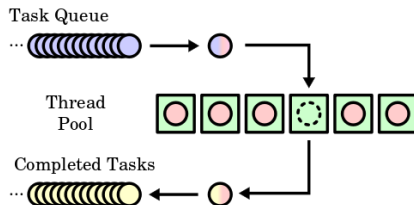
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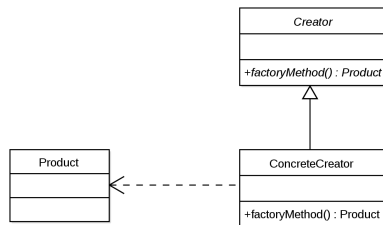
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Factory Method

A.k.a: Virtual Constructor

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



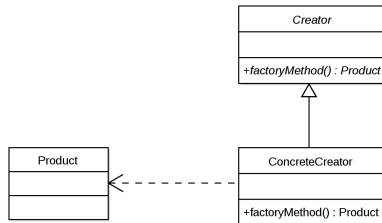
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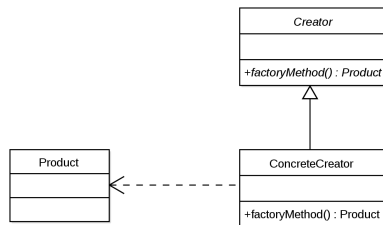
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Application areas:

- unit testing (stubs)
- Abstract Factory



Abstract Factory

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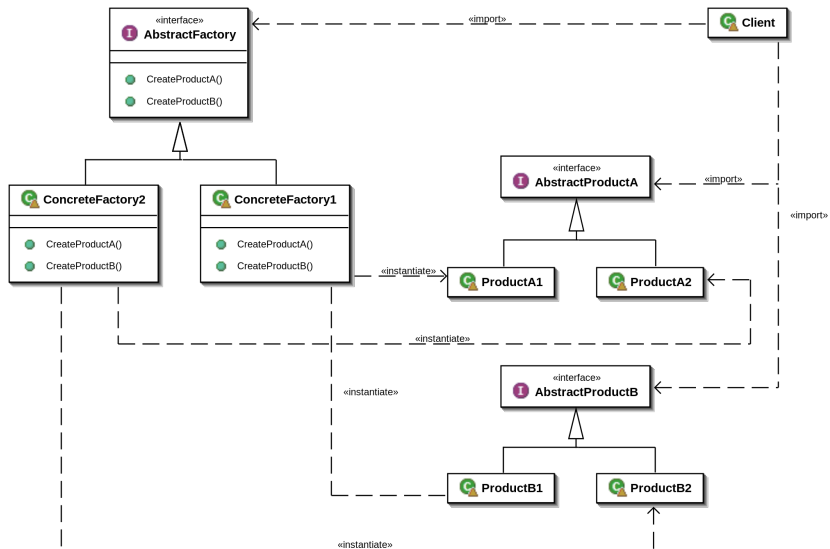
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Drawbacks:

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

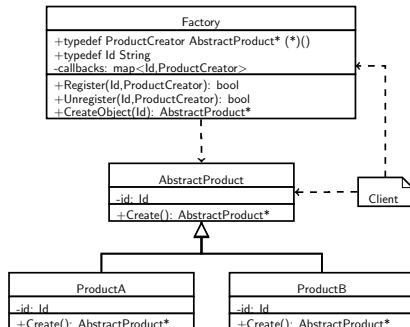
Abstract Factory



Object Factory

Features:

- each product has to register
- uses the priority inversion principle
- one family of product
- create callbacks stored in map



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!