FOCUS ON QUALITY ATTRIBUTES

AND CONFLICTS BETWEEN THEM

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Where do we stand?

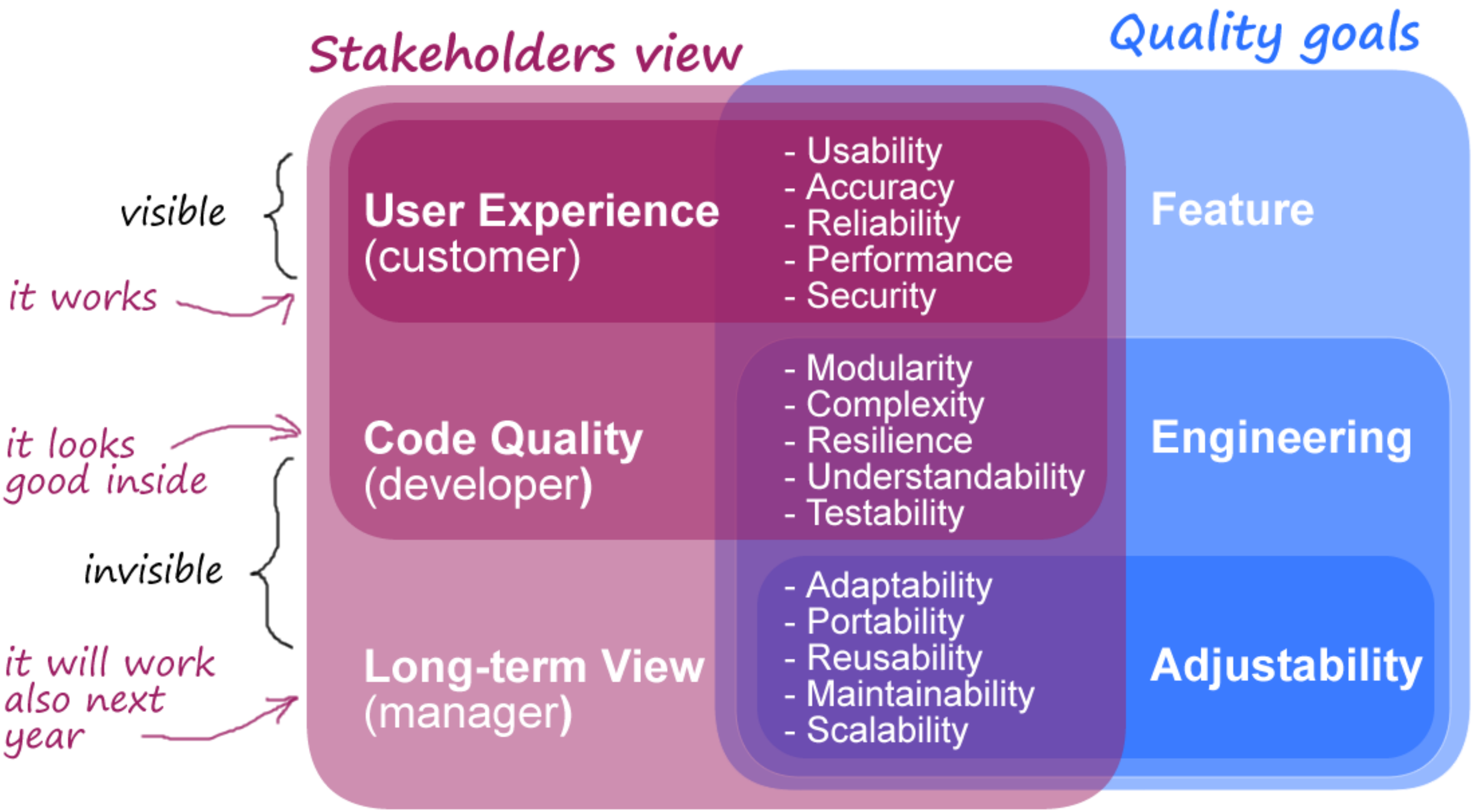
We already understand many topics, including:

- **Clean code principles**
  - **Four rules of simple design** (Tests pass, No duplication, etc.)
  - **SOLID** (Single responsibility, Open/closed, Liskov substitution, etc.)
  - **GRASP** (High cohesion, Low coupling, Polymorphism, etc.)
- **Bad code smells**
  - Abstraction levels, dependencies, cohesion, naming conventions, etc.
- **Refactoring**
  - When, where and how
- **Unit testing**

What "quality" means to you?

… and your customer?

… and your manager?



Outline of the lecture

- Bad code smells for
  - Performance
  - Scalability
  - Reliability
  - Testability
  - Maintainability

Our big five

- Tactics for
  - Discussed quality attributes
  - Conflicts between them

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Bad code smells for Performance

- Let's assume our code is perfectly **CLEAN**
- **What about performance?**
  Are there any performance code smells we could check for?

Let's discuss four **performance smells**:

- Smell #1: Redundant Work
- Smell #2: One by One Processing
- Smell #3: Long Critical Section
- Smell #4: Busy Waiting

Motivating example #1: Fibonacci Sequence

- 1, 1, 2, 3, 5, 8, 13, 21, …
- Fib(0) = Fib(1) = 1
  Fib(n+2) = Fib(n+1) + Fib(n) where n≥0

In Java:

```
public int fibonacci(int n) {
  if(n <= 1) return 1;
  return fibonacci(n-1) + fibonacci(n-2);
}
```

Smell #1: Redundant Work

- Description
  - A time-consuming method computes the same many times in a single execution path
- Consequences
  - A slower execution time since the time-consuming operation is performed multiple times
- Solution
  - Call the heavy method only once and store the result for further reuse

Note: Applies also in more complex scenarios, such as caching of database results in distributed systems.

Example #1: Fibonacci refactored

```
Map<Integer,Integer> cache1 = new HashMap<Integer,Integer>();

long fibonacci(int n) {
  if (cache1.containsKey(n))
    return cache1.get(n);
  if (n==0 || n==1) {
    int var1 = 1;
    cache1.put(n, var1);
    return var1;
  }
  int var2 = fibonacci(n-1) + fibonacci(n-2);
  cache1.put(n, var2);
  return var2;
}
```

Motivating example #2: Search

```
private ArrayList<Item> list = new ArrayList<Item>();

List<Item> findGreaterThan(int value) {
  List<Item> ret = new ArrayList<Item>();

  for (Item item : list) {
    if (item.isGreaterThan(value)) {
      ret.add(item);
    }
  }
  return ret;
}
```

Smell #2: One by One Processing

- Description
  - Overused linear search/processing
- Consequences
  - Slower performance
- Solution
  - Use smarter algorithms and/or data structures (binary search, sorted collections, map with precomputed search predicates)

Note: Become familiar with the performance of operations you execute on different types of data structures. And think about the complexity of your algorithms.

Example #2: Search refactored

```
private List<Item> list = new ArrayList<Item>();
private List<Item> var1 = new SortedList<Item>( ... );

...

List<Item> findGreaterThan(int value) {
  return subList(var1, value);
}
```

Motivating example #3: Password Cracking

```
static List<String> passwordsToCheck;

// launch 100 threads and FOR each thread
void run() {
  while (!passwordsToCheck.isEmpty()) {
    synchronized(passwordsToCheck) {
      if (!passwordsToCheck.isEmpty()) {
        String pwd = passwordsToCheck.remove(0);
        checkPassword(pwd);
      }
    }
  }
}
void checkPassword() { ... }
```

Smell #3: Long Critical Section

- Description
  - Unnecessary code performed in a critical section
- Consequences
  - More like single-threaded model
- Solution
  - Move the code outside the critical section

Note: Sometimes it is favorable to use multiple locks within a class to enable partial locking of an object. See an example below.

Example #3: Password Cracking refactored

```
static List<String> passwordsToCheck;

// launch 100 threads and FOR each thread
void run() {
  while (!passwordsToCheck.isEmpty()) {
    synchronized(passwordsToCheck) {
      if (!passwordsToCheck.isEmpty()) {
        String pwd = passwordsToCheck.remove(0);
      }
    }
    checkPassword(pwd);
  }
}
void checkPassword() { ... }
```

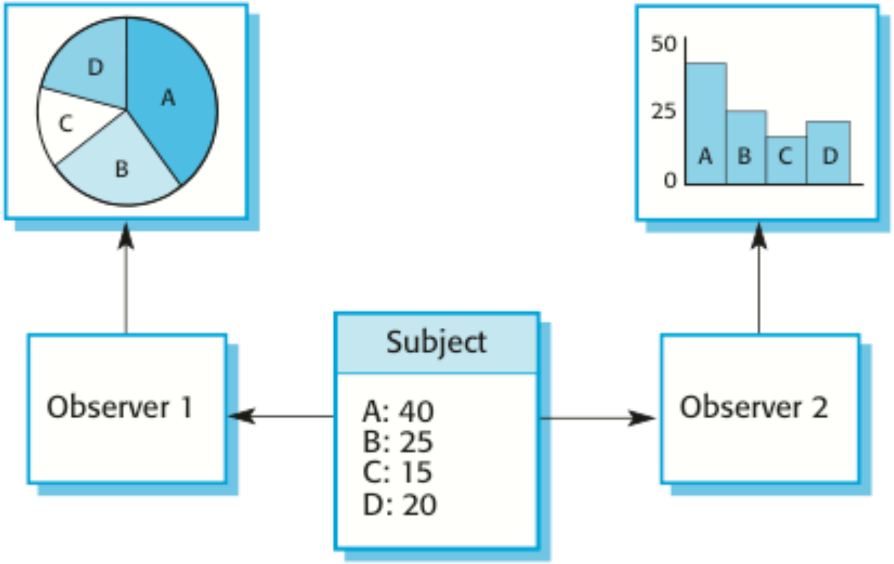
Example #3.b: Multiple locks within a class

```
public class MyUpdater {
  private long var1 = 0;
  private long var2 = 0;

  public void updateVar1() {
    synchronized(this) {
      // update var1
    }
  }
  public void updateVar2() {
    synchronized(this) {
      // update var2
    }
  }
}
```

```
...
private Object lock1 = new Object();
private Object lock2 = new Object();

public void updateVar1() {
  synchronized(lock1) {
    // update var1
  }
}
public void updateVar2() {
  synchronized(lock2) {
    // update var2
  }
}
...
```

Smell #4: Busy Waiting

- Description
  - Repeatedly checking if something interesting happened (e.g. value changed, user input arrived).
- Consequences
  - A lot of work with mostly no value, slowing down the system
- Solution
  - Hollywood principle: "Don't call us, we'll call you."
  - Observer pattern (Gang of Four book)



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Bad smells (beliefs) for Scalability

- Smell #1: Distribution improves performance
  - Not always. Distributed systems must use network I/O, more CPU to maintain coherence, partitioning and replication.
- Smell #2: Just performance
  - If you want to get distributed, there are many lessons to learn in reliability, maintainability, security, testability, and many other domains.
- Smell #3: My framework takes care of it

- Distributed applications must address many new concerns:
  - State sharing
  - Data consistency
  - Caching
  - Load balancing
  - Failure management

Fowler's First Law of Distributed Object Design: Don't distribute your objects.
Advice: Better clean up your application and stay local, if you can.

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Bad code smells for Reliability

- Smell #1: Input Kludge
  - Check all **inputs for validity**! On all user interfaces and service interfaces.
- Smell #2: Blind Faith
  - Do **not trust others** (limit access to your code, check bug fixes), **nor yourself** (check the correctness of your results).
- Smell #3: Poorly Handled Exceptions
- Smell #4: Unguarded Sequential Coupling
  - Assumptions on the **right ordering of method calls** without control.
- Smell #5: Fashionable Coding
  - Usage of all the **new cool technologies** and constructs you do not really understand.

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Bad code smells for Testability

- Smell #1: **Global State**
  - Do not allow your objects to communicate secretly.
- Smell #2: Lack of **Dependency Injection**
  - Make your dependencies explicit.
- Smell #3: **Law of Demeter** violation
  - Only talk to your immediate friends.
- Smell #4: Misplaced and Hard Coded **new** Operator
  - Do not mix factory and service code.

Note: In over 90% of cases, Global State is the problem.

General advice: If your code is difficult to test, do not ask how to hack it, but what is wrong with that code!

Motivating example #1: Secret Communication

```
class X {
  ...
  X() { ... }

  public int doSomething() { ... }
}

int a = new X().doSomething();
int b = new X().doSomething();
```


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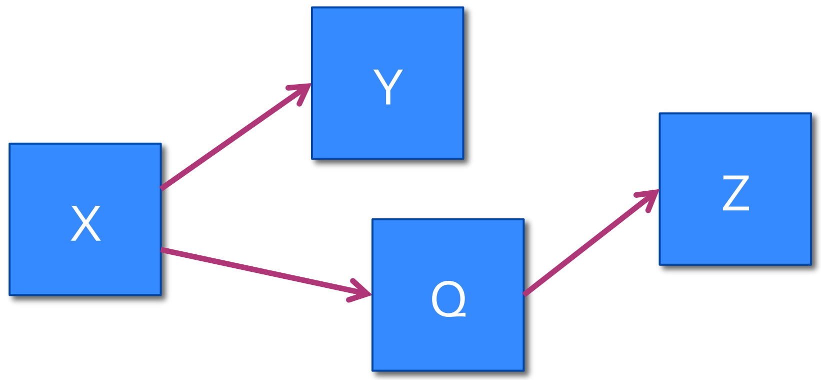
Motivating example #1: Secret Communication

```
class X {
  ...
  X() { ... }

  public int doSomething() { ... }
}

int a = new X().doSomething();
int b = new X().doSomething();
```

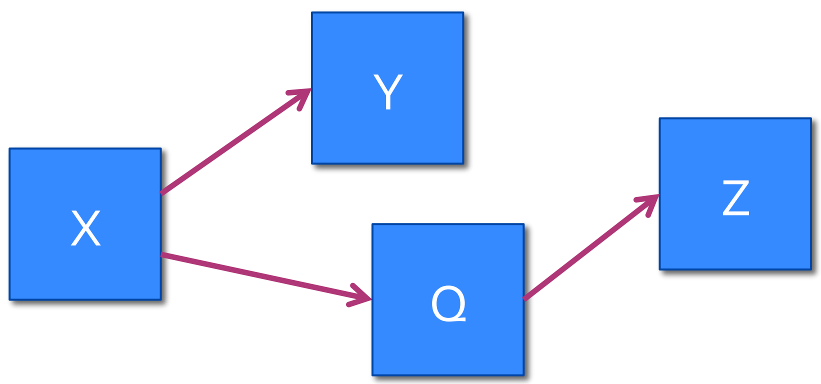
Does a==b ??

Motivating example #1: Secret Communication

`a = new(X)` →



`b = new(X)` →



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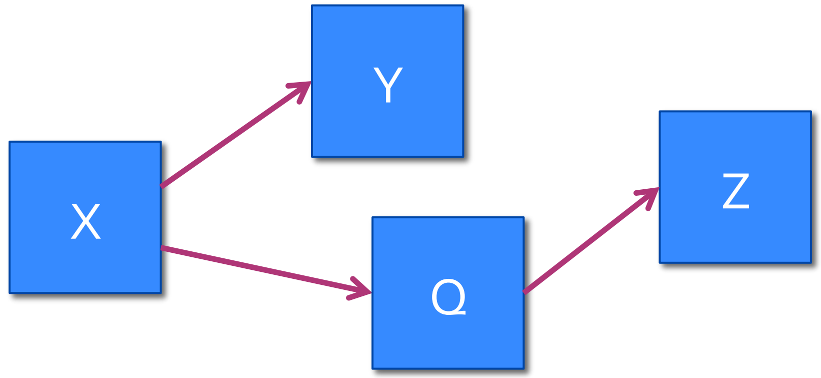
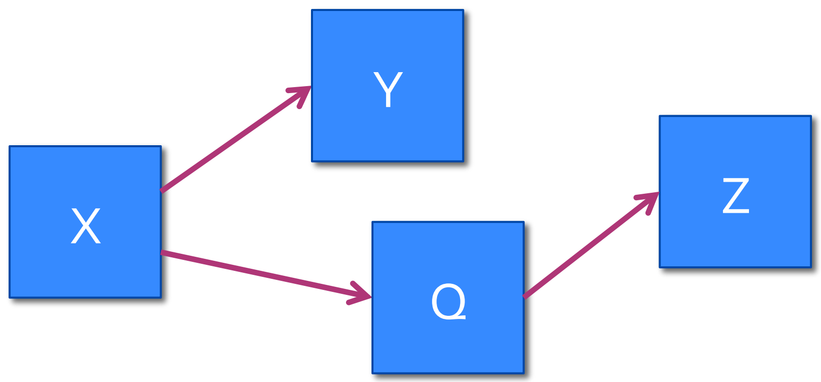
Motivating example #1: Secret Communication

```
a = new(X) →
a.doSomething()
```



a==b ✔

```
b = new(X) →
b.doSomething()
```



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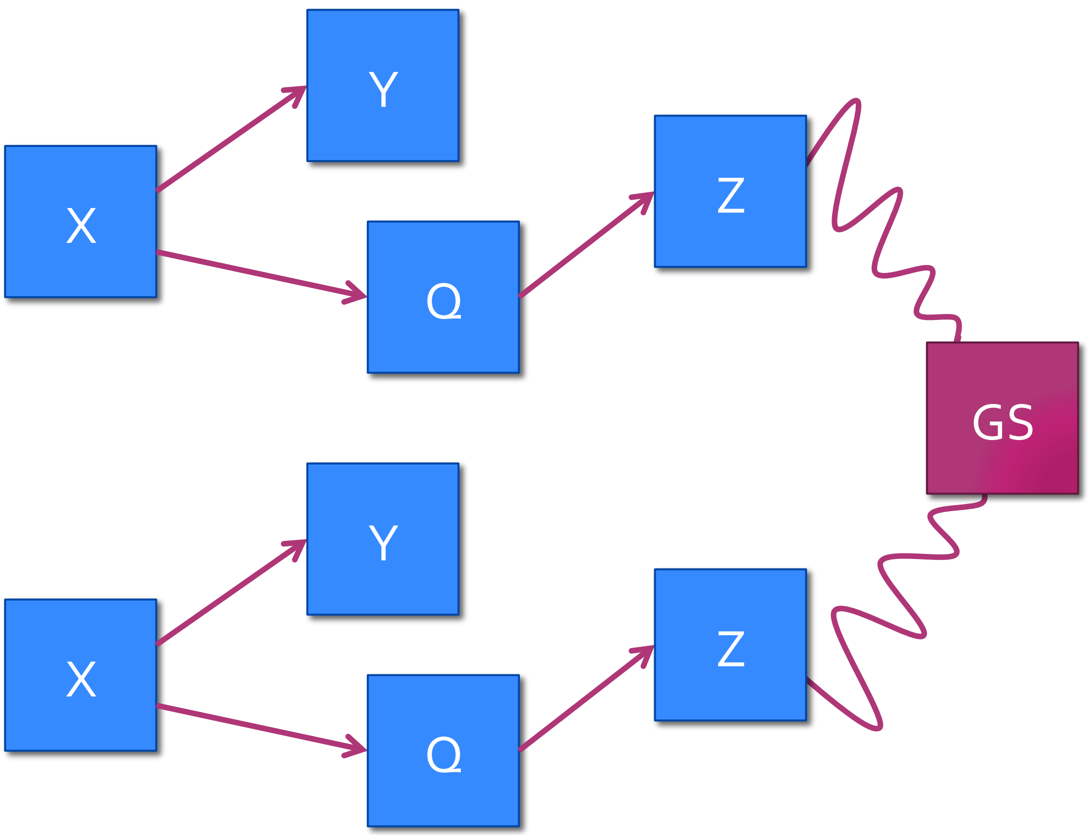
Motivating example #1: Secret Communication

```
a = new(X) →
a.doSomething()
```

a==b ✖

```
b = new(X) →
b.doSomething()
```



Smell #1: Global State

- Multiple executions can produce different results
  - Test flakiness
  - Order of tests matters
  - Cannot run tests in parallel

What about Singletons?

- Unbounded location of state
  - Transitive dependencies
- Hidden Global State in JVM
  - System.currentTime()
  - new Date()
  - Math.random()

Motivating example #2: Deceptive API

```
testCharge() {
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”);
  cc.charge(100);
}
```

Motivating example #2: Deceptive API

```
testCharge() {
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”);
  cc.charge(100);
}
```

java.lang.NullPointerException
at talk3.CreditCard.charge(CredicCard.java:48)

Motivating example #2: Deceptive API

```
testCharge() {
  CreditCardProcessor.init(...);
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”);
  cc.charge(100);
}
```

Motivating example #2: Deceptive API

```
testCharge() {
  CreditCardProcessor.init(...);
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”);
  cc.charge(100);
}
```

java.lang.NullPointerException
at talk3.CreditCardProcessor.init(CredicCardProcessor.java:146)

Motivating example #2: Deceptive API

```
testCharge() {
  OfflineQueue.start();
  CreditCardProcessor.init(...);
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”);
  cc.charge(100);
}
```

Motivating example #2: Deceptive API

```
testCharge() {
  OfflineQueue.start();
  CreditCardProcessor.init(...);
  CreditCard cc;
  cc = new CreditCard("1234567890121234");
  cc.charge(100);
}
```

java.lang.NullPointerException
at talk3.OfflineQueue.start(OfflineQueue.java:16)

Motivating example #2: Deceptive API

```
testCharge() {
  Database.connect(...);
  OfflineQueue.start();
  CreditCardProcessor.init(...);
  CreditCard cc;
  cc = new CreditCard("1234567890121234");
  cc.charge(100);
}
```

Motivating example #2: Deceptive API

```
testCharge() {
  Database.connect(...);
  OfflineQueue.start();
  CreditCardProcessor.init(...);
  CreditCard cc;
  cc = new CreditCard("1234567890121234");
  cc.charge(100);
}
```

- **CreditCard API lies**
  - It pretends to not need the CreditCardProcessor even though in reality it does.

Motivating example #2: Better API

```
testCharge() {
  ??
  CreditCard cc;
  cc = new CreditCard("1234567890121234", ccProc);
  cc.charge(100);
}
```

Motivating example #2: Better API

```
testCharge() {
  ??
  ccProc = new CreditCardProcessor(queue);
  CreditCard cc;
  cc = new CreditCard("1234567890121234", ccProc);
  cc.charge(100);
}
```

Motivating example #2: Better API

```
testCharge() {
  ??
  queue = new OfflineQueue(db);
  ccProc = new CreditCardProcessor(queue);
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”, ccProc);
  cc.charge(100);
}
```

Motivating example #2: Better API

```
testChange() {
  db = new Database(...);
  queue = new OfflineQueue(db);
  ccProc = new CreditCardProcessor(queue);
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”, ccProc);
  cc.charge(100);
}
```

Motivating example #2: Better API

```
testCharge() {
  db = new Database(...);
  queue = new OfflineQueue(db);
  ccProc = new CreditCardProcessor(queue);
  CreditCard cc;
  cc = new CreditCard(“1234567890121234”, ccProc);
  cc.charge(100);
}
```

Dependency Injection

Smell #2: Lack of Dependency Injection

- **Dependency injection** makes your **dependencies explicit**
  - It does not make the dependencies in your code better or worse
  - It only makes them visible
- If there are **too many dependencies**, **do not blame DI**!
  - The dependencies have always been there, DI only showed them to you
- **Dependency injection** enforces the **order of initialization at compile time**
  - Compiler helps to prevent illegal test setup

Won't my system get flooded with arguments passed around?

Smell #2: Lack of Dependency Injection

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- If there are **too many dependencies**, **do not blame DI**!
  - The dependencies have always been there, DI only showed them to you
- **Dependency injection** enforces the **order of initialization at compile time**
  - Compiler helps to prevent illegal test setup

Won't my system get flooded with arguments passed around?

NO

```
testCharge() {
  db = new Database(...);
  queue = new OfflineQueue(db);
  ccProc = new CreditCardProcessor(queue);
  CreditCard cc;
  cc = new CreditCard("1234567890121234", ccProc);
  cc.charge(100);
}
```


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Smell #3: Law of Demeter violation

Law of Demeter: "Only talk to your immediate friends"

- If an object needs links to too many objects, there may be something wrong with the object
- Revealed by **Dependency Injection**

- "Our code often smells because we have a **few objects** doing **too much work**, which requires them to **know about too many other objects**." [Brandon Keepers]
  - A nice rule of thumb is to check if we are able to **describe the purpose** of each class and method without using AND and OR.

Single Responsibility Principle

Smell #4: Misplaced and Hard Coded new Operator

To avoid misplace, clearly separate:

- "Code with a whole bunch of **`new`** operators and no **`if`** statement"
  = code responsible for **starting and wiring things**, i.e. Factories.
- "Code with a whole bunch of **`if`** statements and no **`new`** operator"
  = code that is actually **doing something**, i.e. Services.

To avoid hard coding, make sure that:

- Constructor only **constructs** the object and its dependencies.
  - Doing any **other work** in the constructor can significantly **hinder testing**.
  - You can end up doing unrelated work (e.g. sending emails) every time you need the object in your test.

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Bad code smells for Maintainability

- Smell #1: Early Tuning
  - Never compromise code clarity for premature code optimization.
- Smell #2: Super-Flexibility
  - "Flexibility breeds complexity."
  - Do not shoot for something that is flexible from the early beginning. Shoot for something that is simple and build flexibility upon that.
- Smell #3: Simple = Stupid, Complex = Smart
  - "Too complicated answers are always wrong,
    no matter what the question was."
  - Even very smart systems can be based on simple structures. Look at **embedded systems** or **human brain**!

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Tactics for Performance

- Tactic #1: Take a **profiler** into action
  - **Do not guess** where the performance problem is.
    Start your profiler and find the bottlenecks objectively.
  - It helps you to understand what is **happening in the background**.
- Tactic #2: Examine **complexity** and **frequency** of your computations
  - **Complexity** – Maybe you can do the thing **more efficiently**.
  - **Frequency** – Maybe you can do the thing **less often**.
- Tactic #3: **Concurrency**
  - Only if you **understand all aspects and consequences** of parallel execution.
- Tactic #4: Control the use of **resources**
  - Balance the load, control access, cache, replicate, etc.

Tactics for Reliability

- Tactic #1: **Monitor** what is going on
  - **Acceptance checking** for individual methods and code fragments, **events** collection, **processing** and **logging**.
- Tactic #2: Handle **exceptions** carefully
  - Think twice about exception handling strategy and **responsibilities** inside the system.
- Tactic #3: Make your system **fault tolerant**
  - **Redundancy** and **self-healing**, e.g. seamless rebinding to a new service provider.
- Tactic #4: Implement **restart/recovery** capabilities
  - Redirection to a **filled-in form** when the form submission fails.
  - System **diagnostics** and **clean-up** after major failure.

Note 1: We only care about SW reliability (because this is a Software Quality course), not HW, although HW fault tolerance is a very interesting topic.

Note 2: We assume that we do not deal with an ultra-reliable system.
If so, other mechanisms would need to be in place (e.g. …).

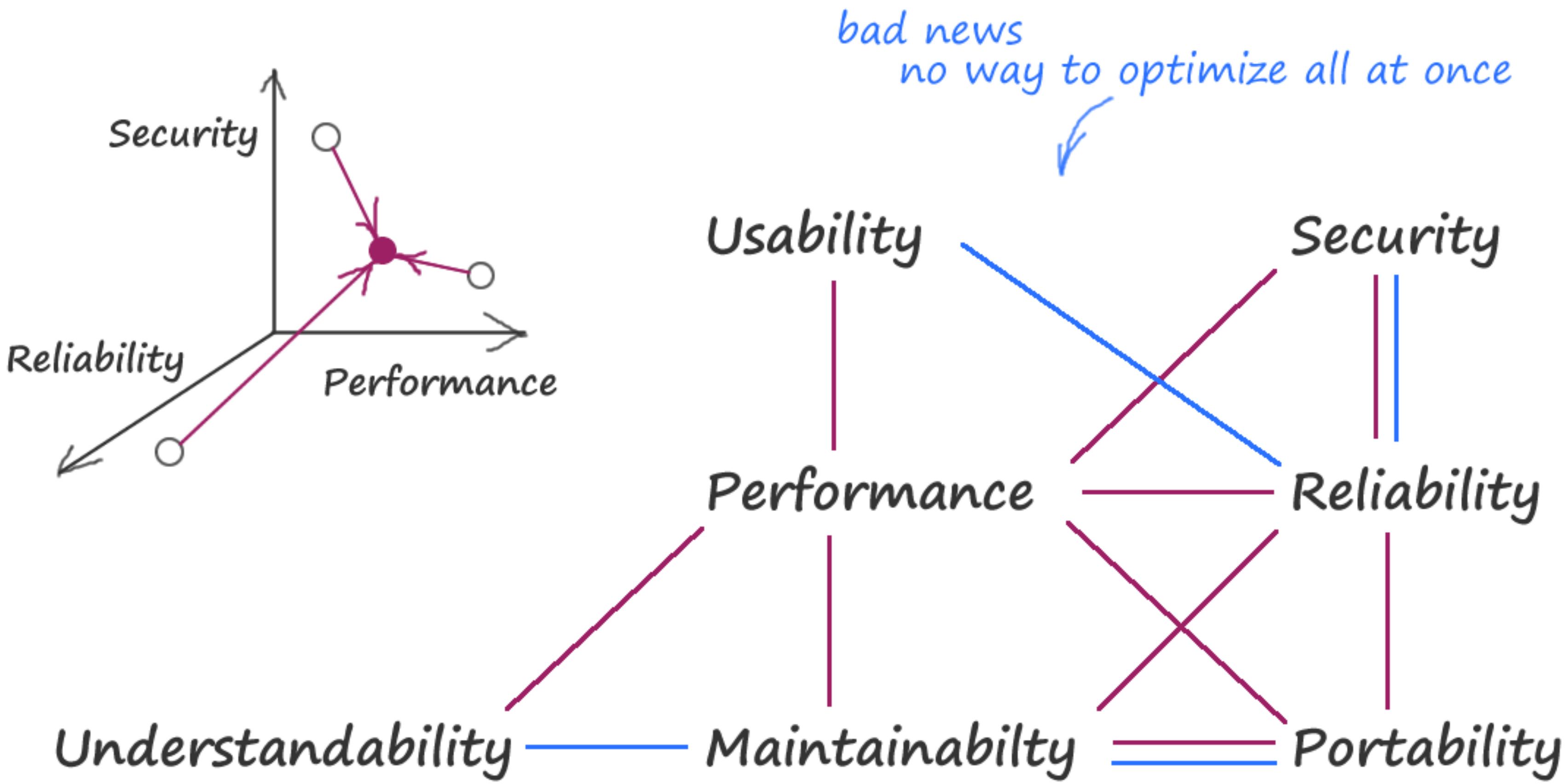
Tactics for Testability

- Tactic #1: Write CLEAN code
  - Simplicity matters.
- Tactic #2: Avoid global state
  - Including its **hidden** forms.
- Tactic #3: Separate interfaces from implementation
  - Make it possible to **exchange implementations** during testing.
- Tactic #4: Make your dependencies explicit
  - It makes the life of developers/testers easier, and then even **compiler can help** to inspect it.
- Tactic #5: Separate factories from business logic
  - During testing it is important to have **access to each of these parts** without mixing it with the other.

Tactics for Maintainability

- Tactic #1: Write CLEAN code
  - "Premature optimization is the root of all evil."
  - Clean code is not only easier to change, but also easier to optimize (e.g. for performance, scalability).
- Tactic #2: Get ready for change
  - "Change is the only constant."
  - Understand – Interfaces, Inheritance, Polymorphism, Design Patterns.
- Tactic #3: Design your SW Architecture carefully
  - Proper modularization of your system is one of the keys for maintainability.
- Tactic #4: Watch all dependencies
  - Check – Law of Demeter, High Cohesion, Low Coupling.

Conflicts between quality attributes



Takeaways

- **Bad Code Smells** apply also to **quality attributes**.
  - They are just **not that easy to Google.**
- **Tactics** in comparison to **Bad Code Smells** are usually defined on a higher level of abstraction.
- Each **tactic for a specific quality** attribute can act as an **anti-pattern** for a different quality attribute.
  - That is where **conflicts** between quality attributes emerge.

thanks for listening

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contact me

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