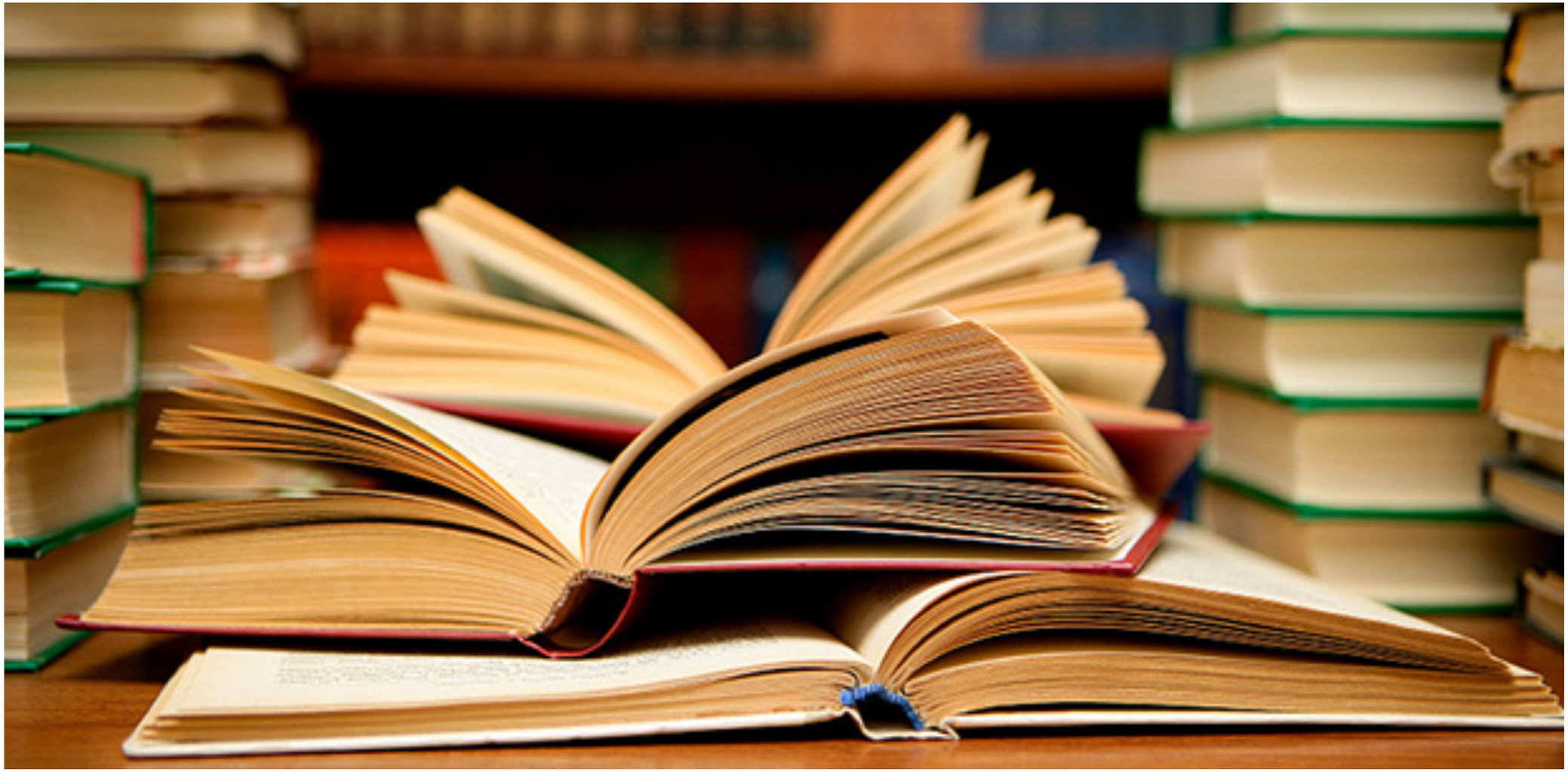
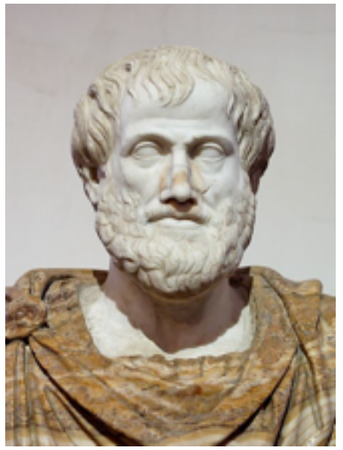
The Epistemology of Software Engineering

Nathan Marz
@nathanmarz



My personal philosophies on software development



Agenda

1. **Limits of human knowledge**
2. **Effect of the limits of knowledge on software development**
3. **Embracing those limits enables you to build better software**

How do I know my software is correct?

How do I know a proposition is true?

Epistemology

How do I know my software is correct?

PREVIEW

You don’t

Your code is wrong

How do I know a proposition is true?

PREVIEW

You don’t

True knowledge is unattainable

But wait... philosophy?

Strawman

Appeal to authority

Appeal to emotion

Circular reasoning

False dilemma

Argument to moderation

Moral highground

Ad hominem attack

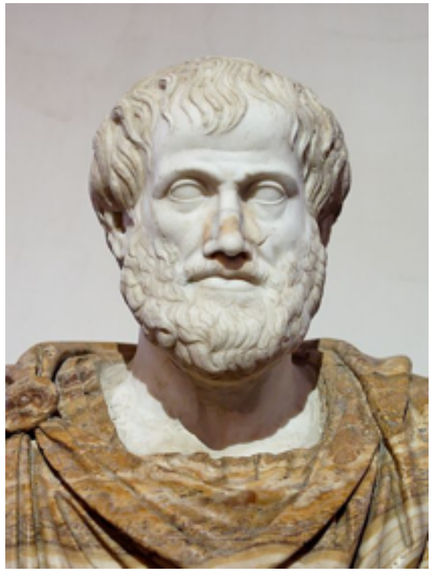
Shotgun argumentation

Correlation vs causation

Equivocation

Burden of proof

Fallacies

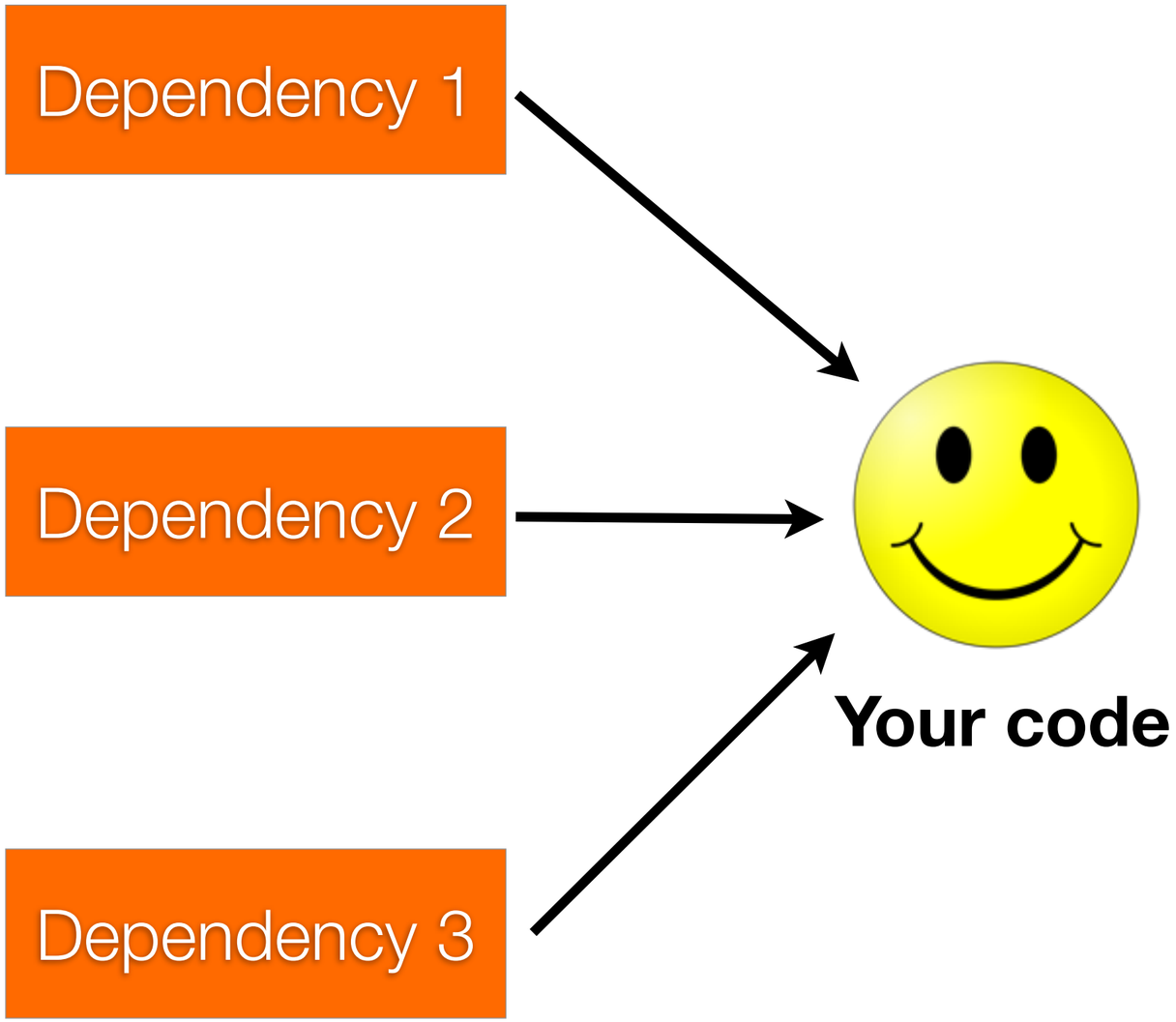


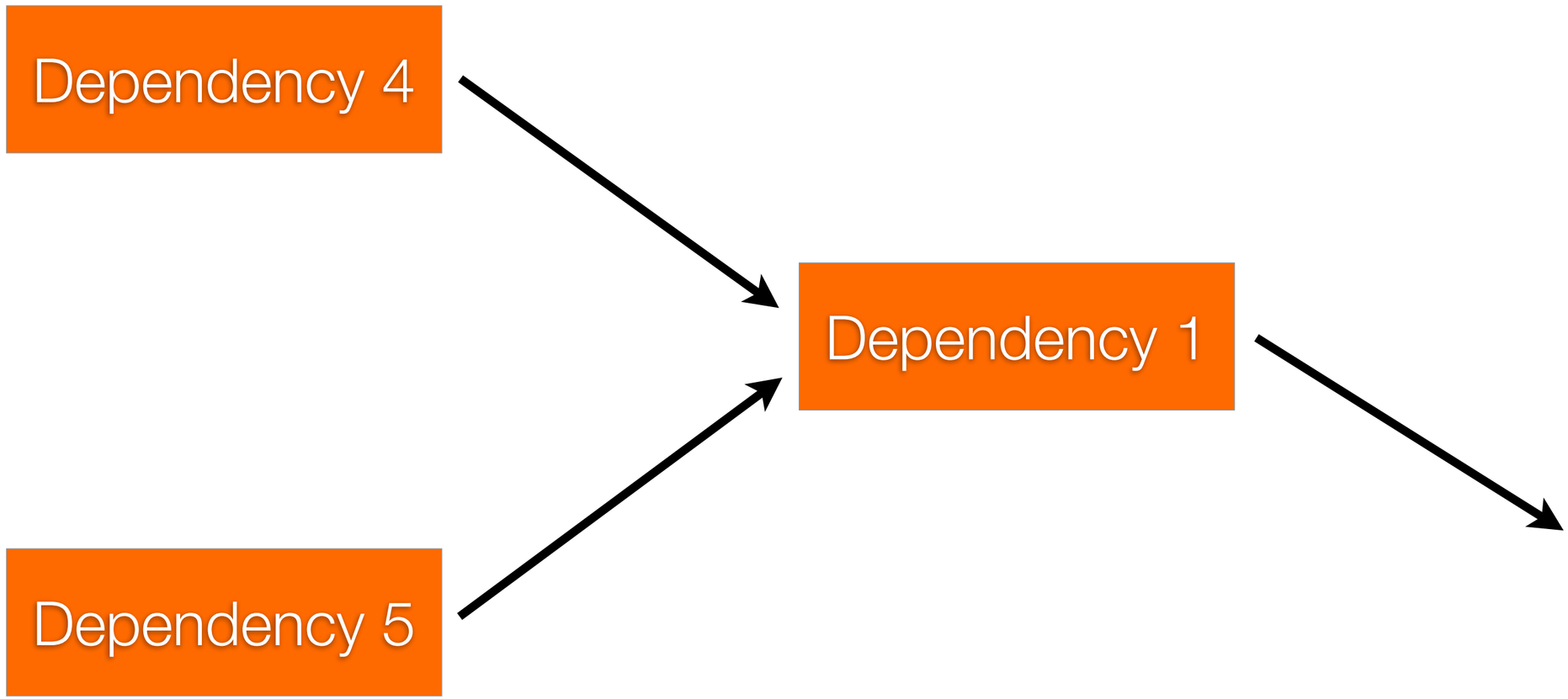
Your code is wrong

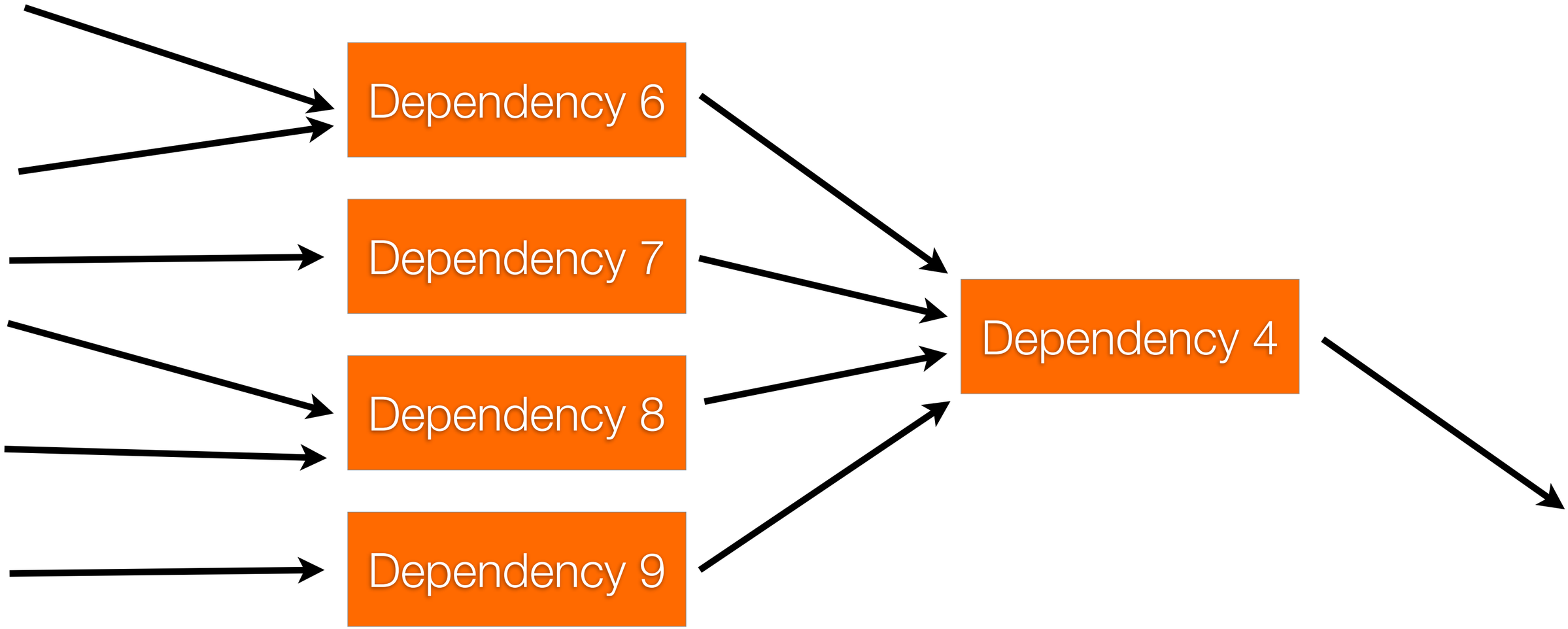
Your code is *literally* wrong

Your code is wrong

Why do you believe your code is correct?


Dependency 1
Dependency 2
Dependency 3
Your code

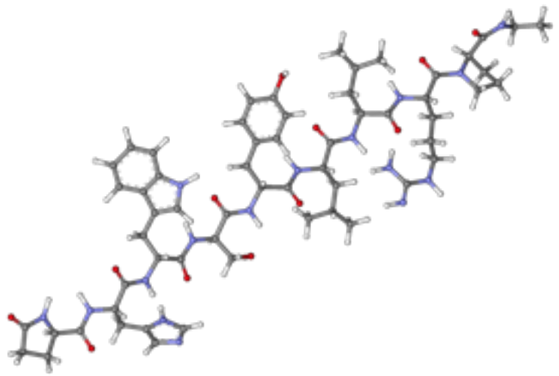

Dependency 4
Dependency 5
Dependency 1


Dependency 6
Dependency 7
Dependency 8
Dependency 9
Dependency 4

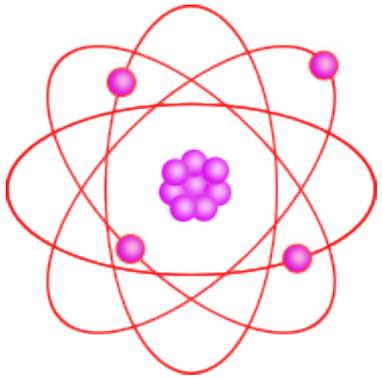
Hardware

Dependency 3,000,000

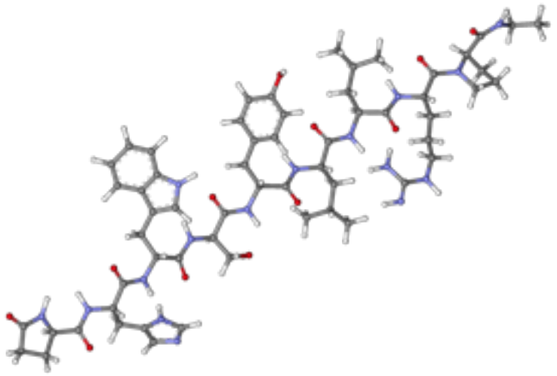
Electronics

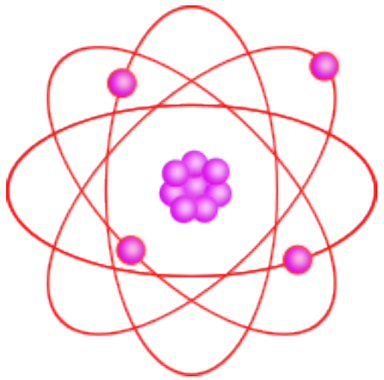


Chemistry



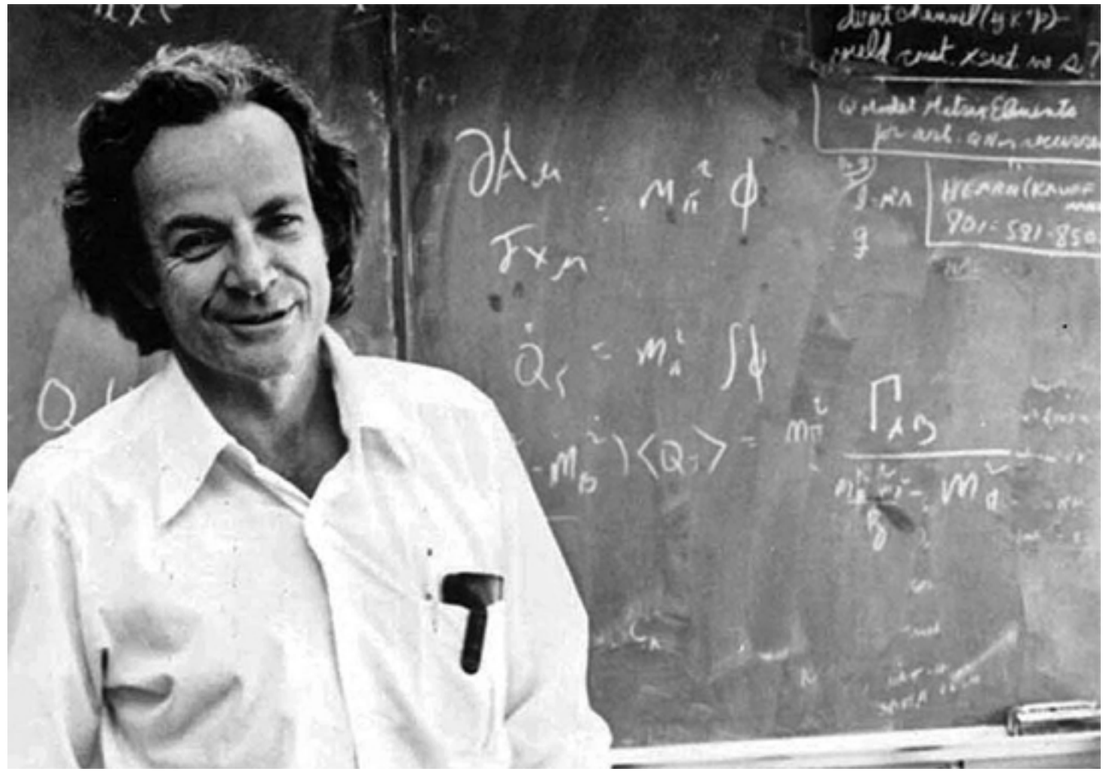
Atomic physics





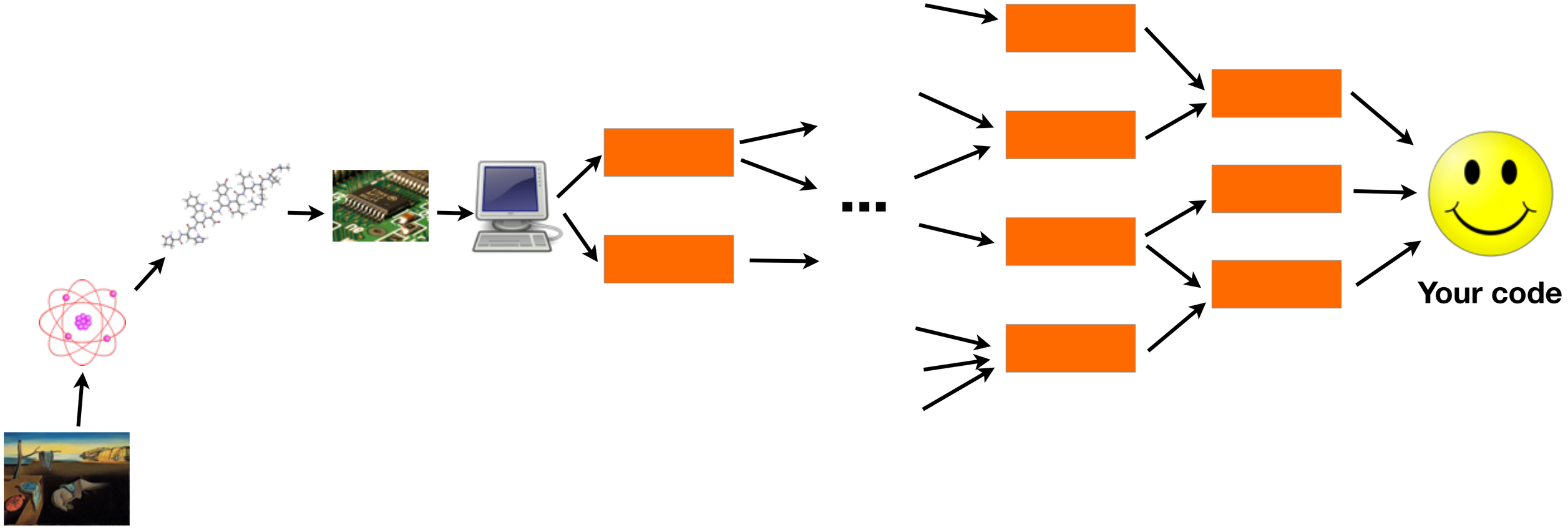
Quantum mechanics

I think I can safely say that nobody understands quantum mechanics.



Richard Feynman

Your code is wrong


Your code

Infinite regress

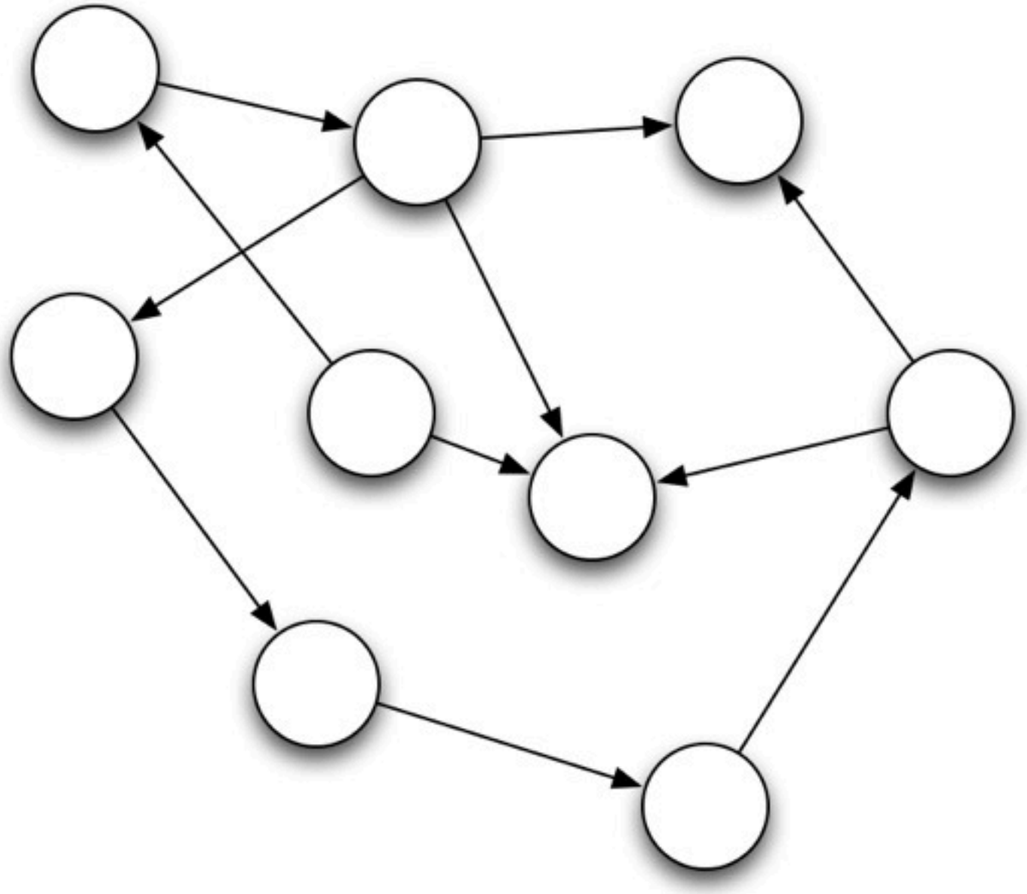
Epistemological “solutions”

1. **Infinitism**

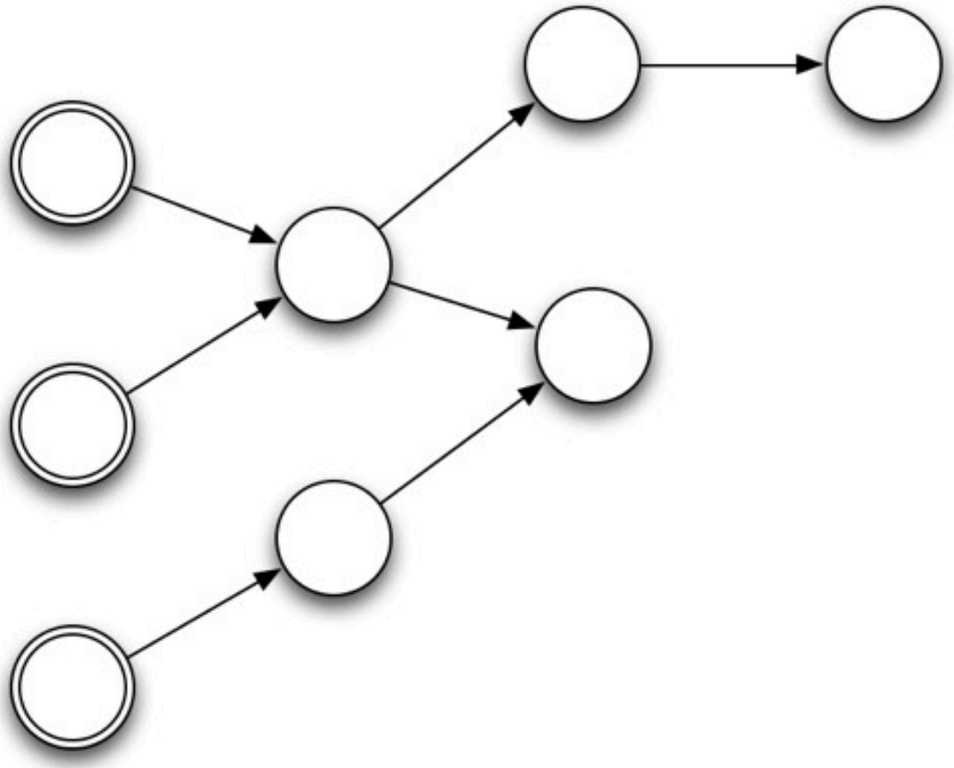
2. **Foundationalism**

3. **Coherentism**

Coherentism



Foundationalism



Axioms

René Descartes

Cogito ergo sum

I think,
therefore I am

CODITO ERGO SUM

I CODE,
THEREFORE I AM

Cartesian foundationalism

1. Limited axioms

2. Knowledge through deduction

Cartesian programming

1. Axioms = rules of programming language

2. Programs = deductions from those axioms

```
public int fib(int n) {
    if(n==0 || n==1) return 1;
    else return fib(n-1) + fib(n-2);
}
```

```
public BigInteger fib(BigInteger n) {
    if(n.equals(0) || n.equals(1))
        return BigInteger.ONE;
    else return fib(n.minus(1)) +
                fib(n.minus(2));
}
```

```
print "Hello world!"
```

```
print "Hello world!"
```

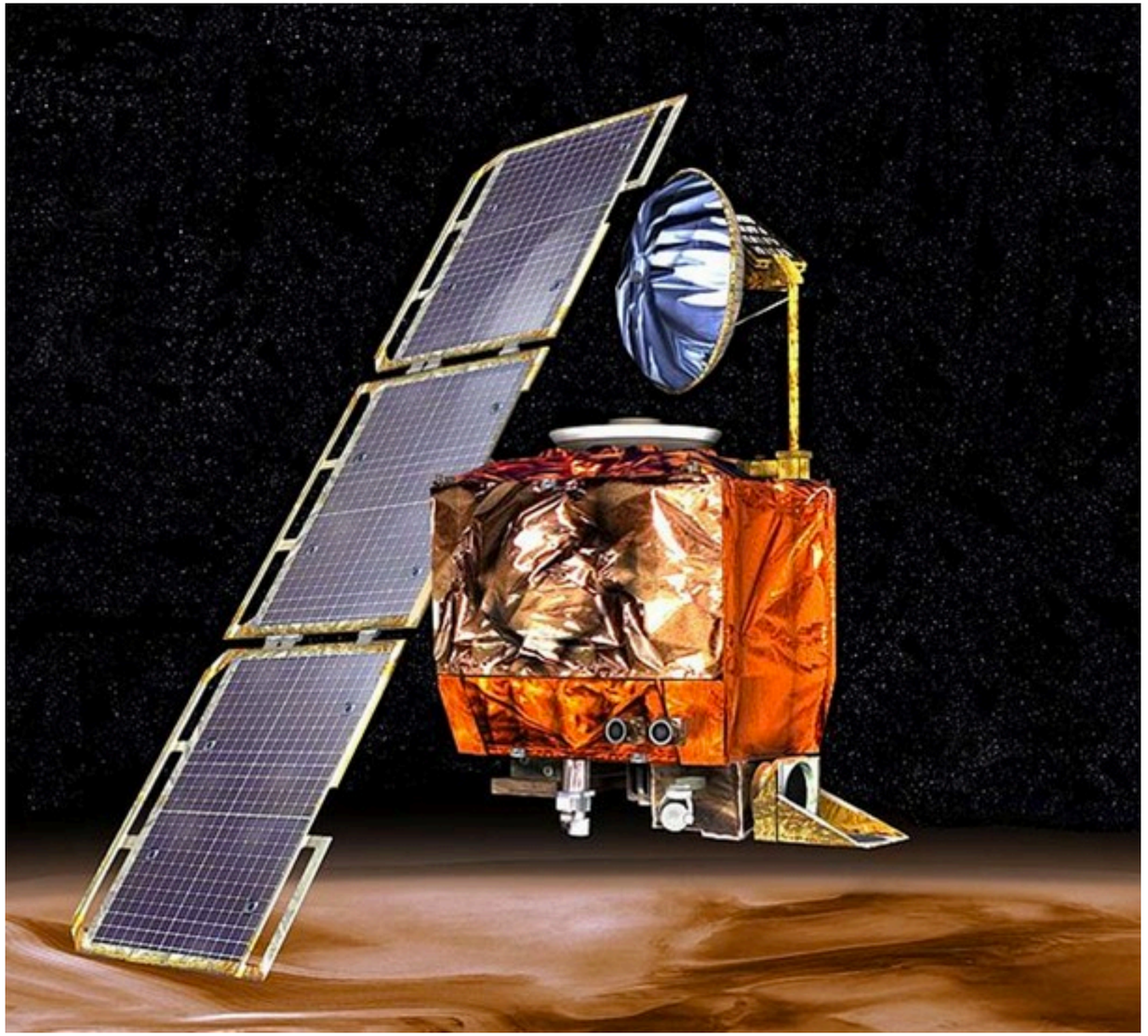
-> OutOfMemoryException

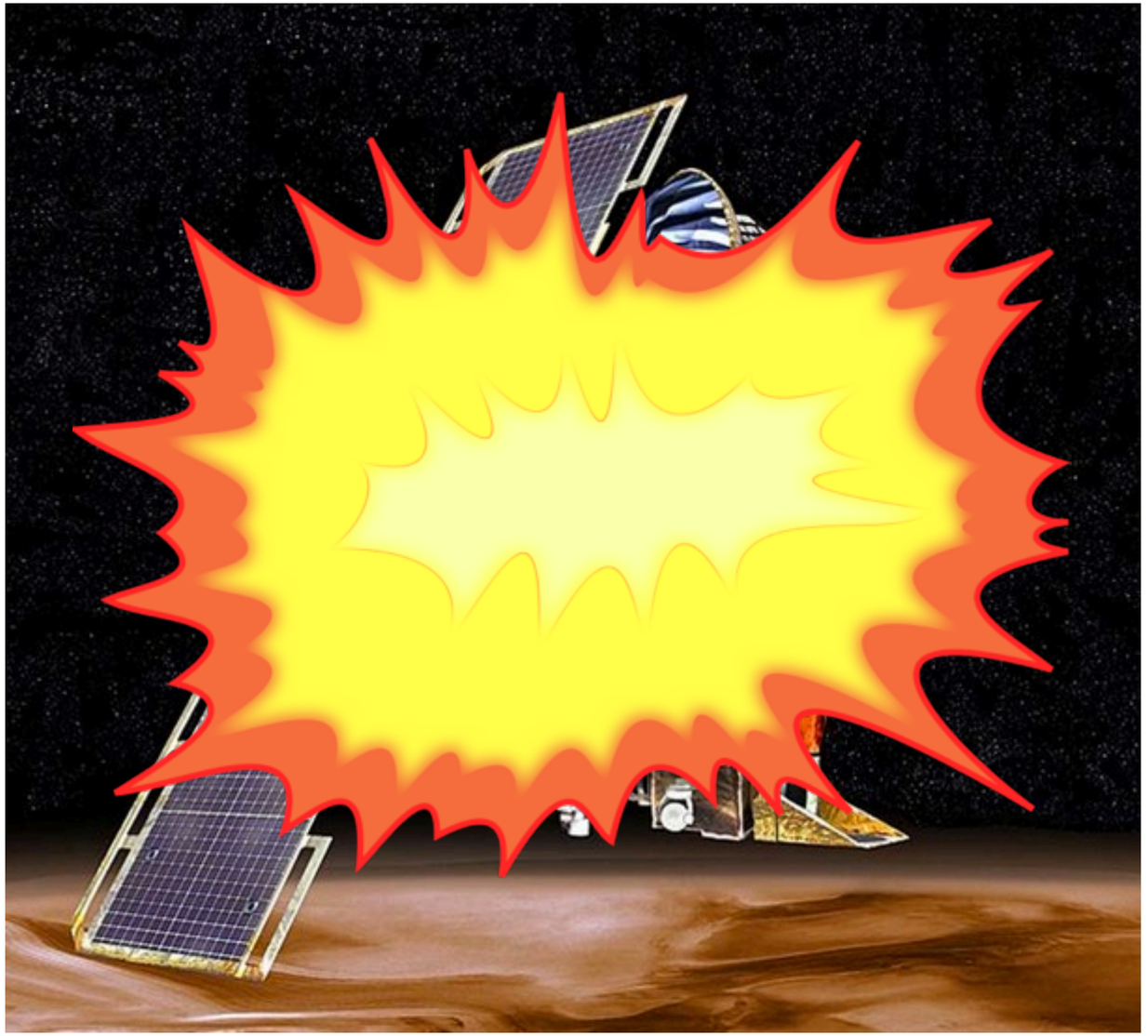
```
print "Hello world!"
```

-> Hallo welt!

All the software you've used has had bugs in it

Including the software
you've written






MySQL


PostgreSQL

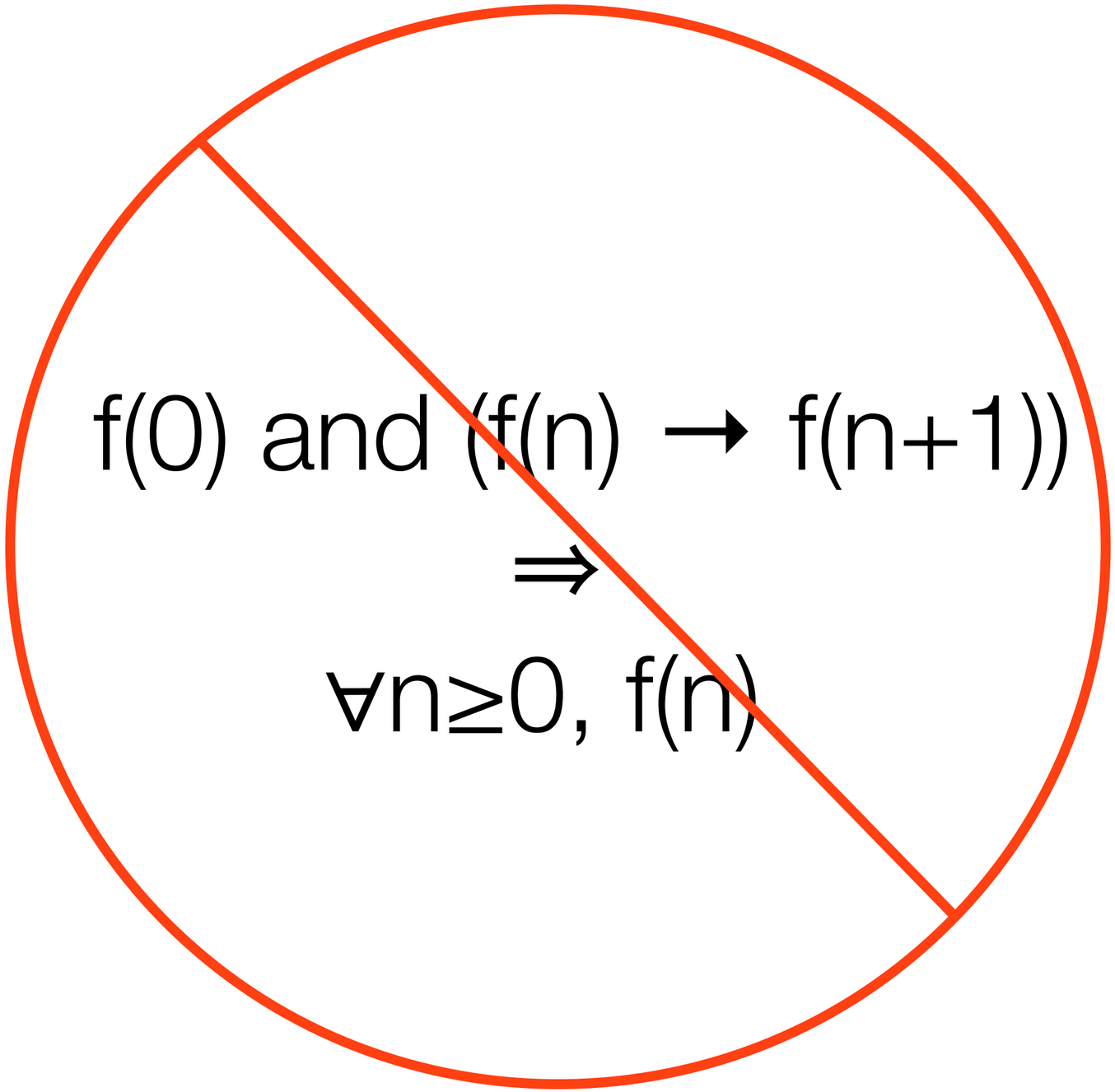

mongoDB


riak


Cassandra


APACHE
HBASE

Induction


f(0) and (f(n) → f(n+1))
⇒
∀n≥0, f(n)

Induction

```
public boolean isSunRisingTomorrow(
        boolean sunAlwaysRisen) {
        if(sunAlwaysRisen) return true;
        else throw new RuntimeException("WTF??");
}
```


MySQL


PostgreSQL


mongoDB


riak


Cassandra

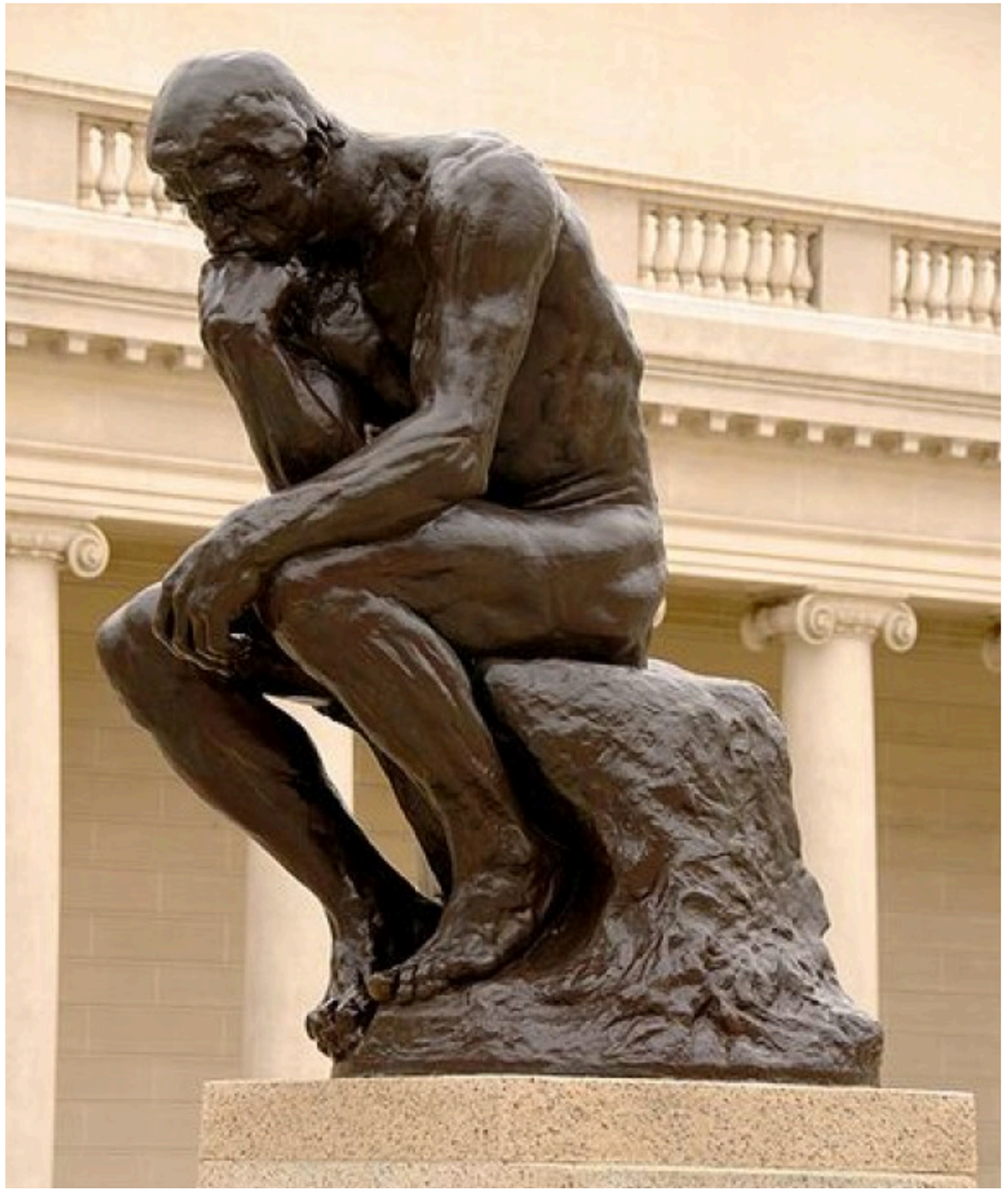

APACHE
HBASE

<sidenote>

David Hume

“Why is inductive reasoning valid?”

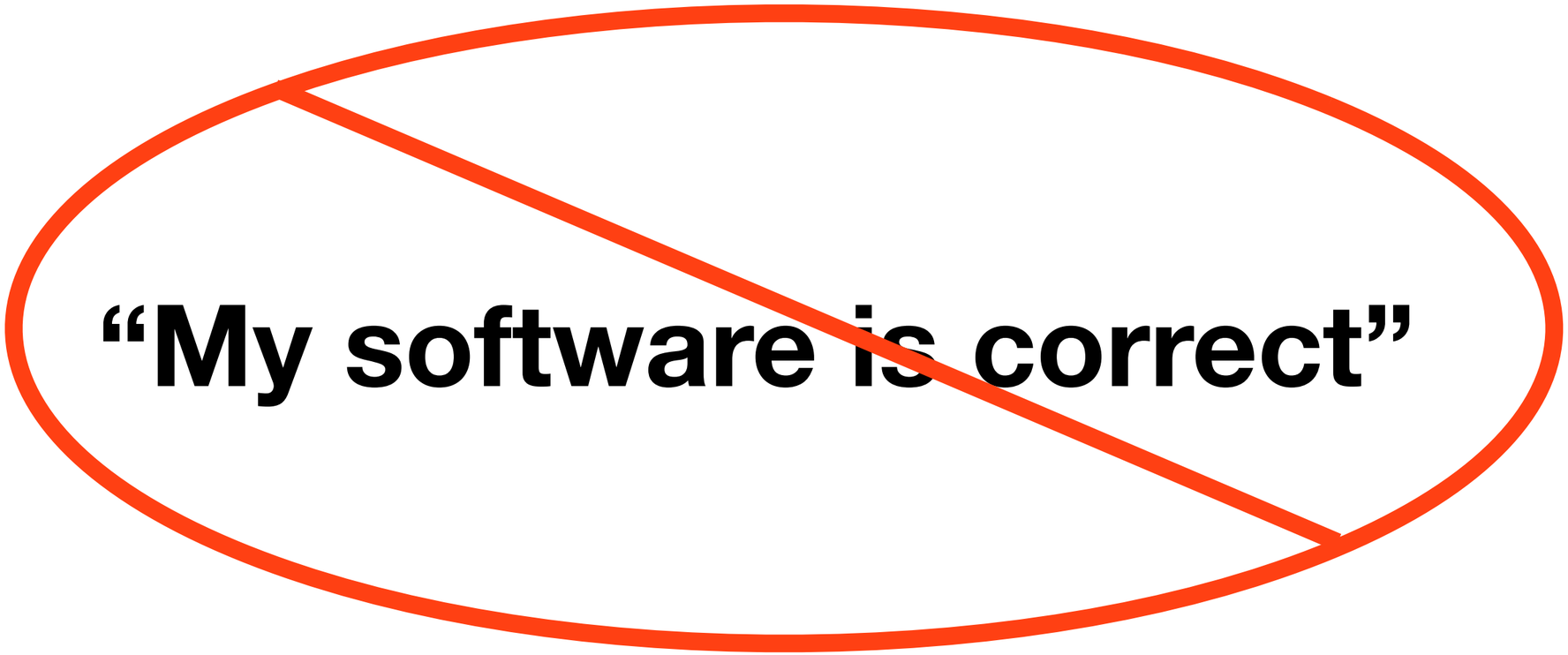
</sidenote>

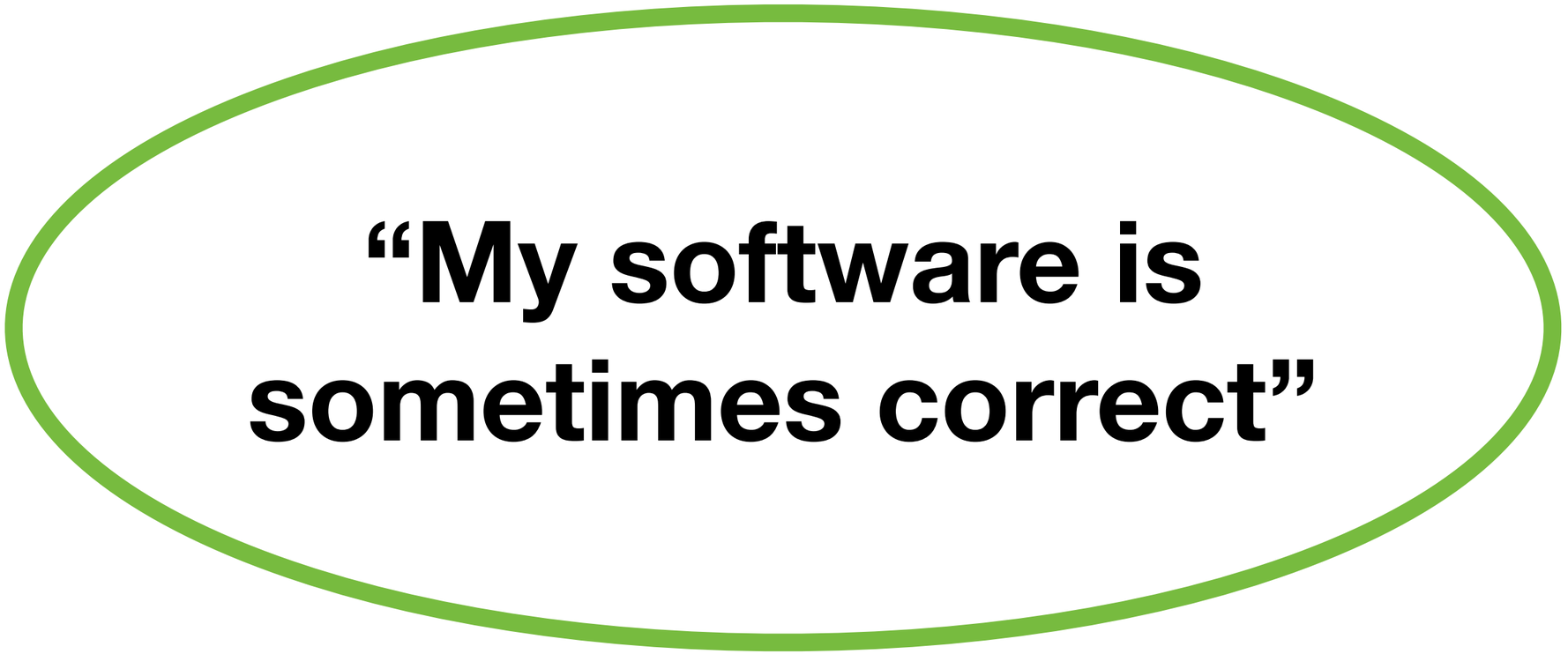


Skepticism


perfect code


value to users


“My software is correct”

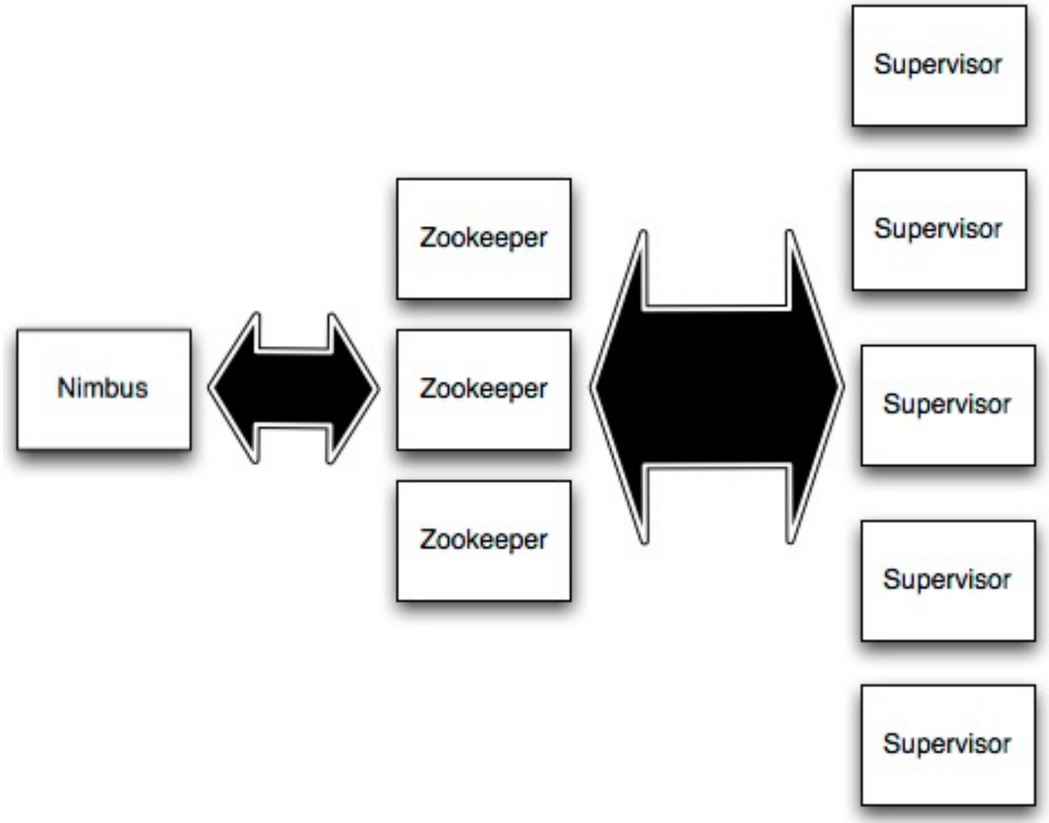

“My software is
sometimes correct”

How do you minimize imperfection?

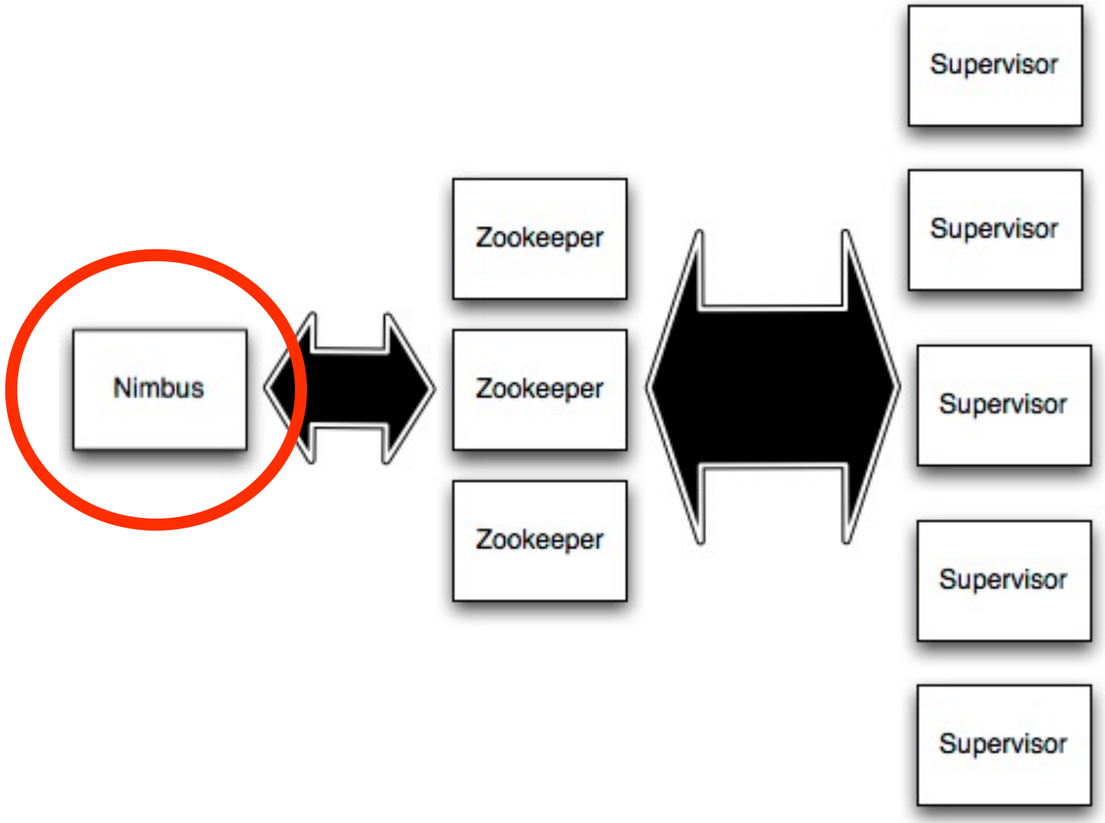
Storm’s “reportError” method

(Storm is a realtime computation system, like Hadoop but for realtime)

Storm architecture

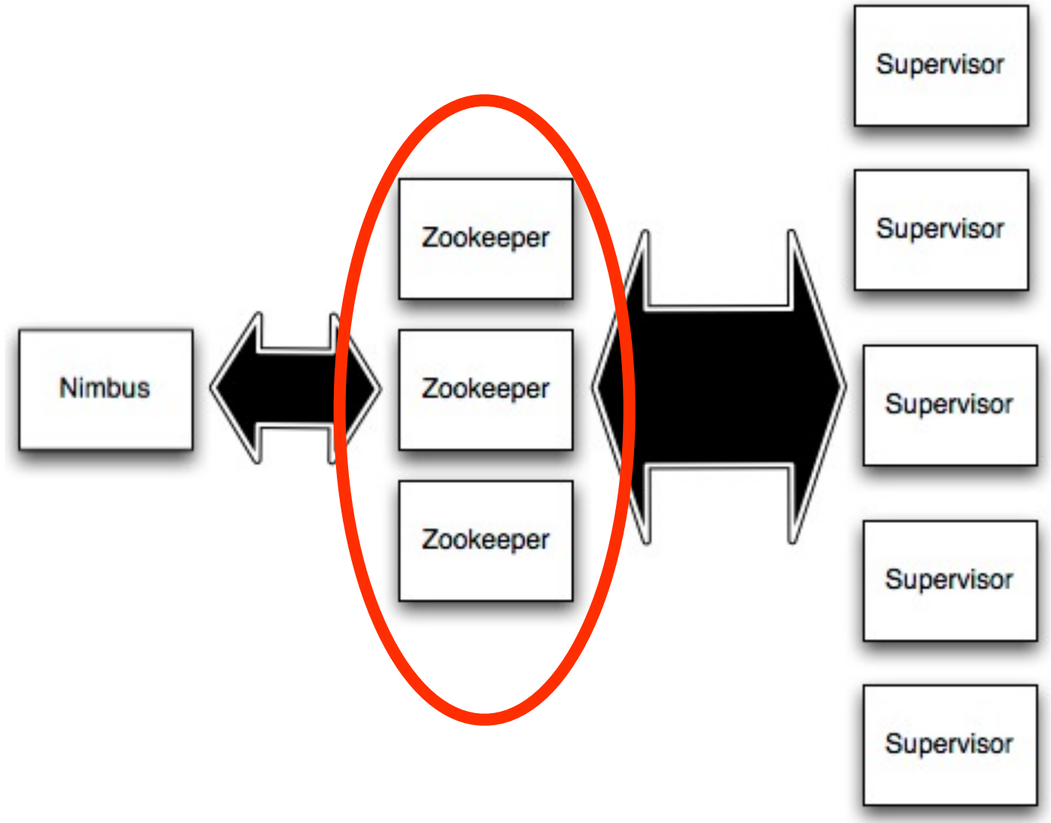


Storm architecture



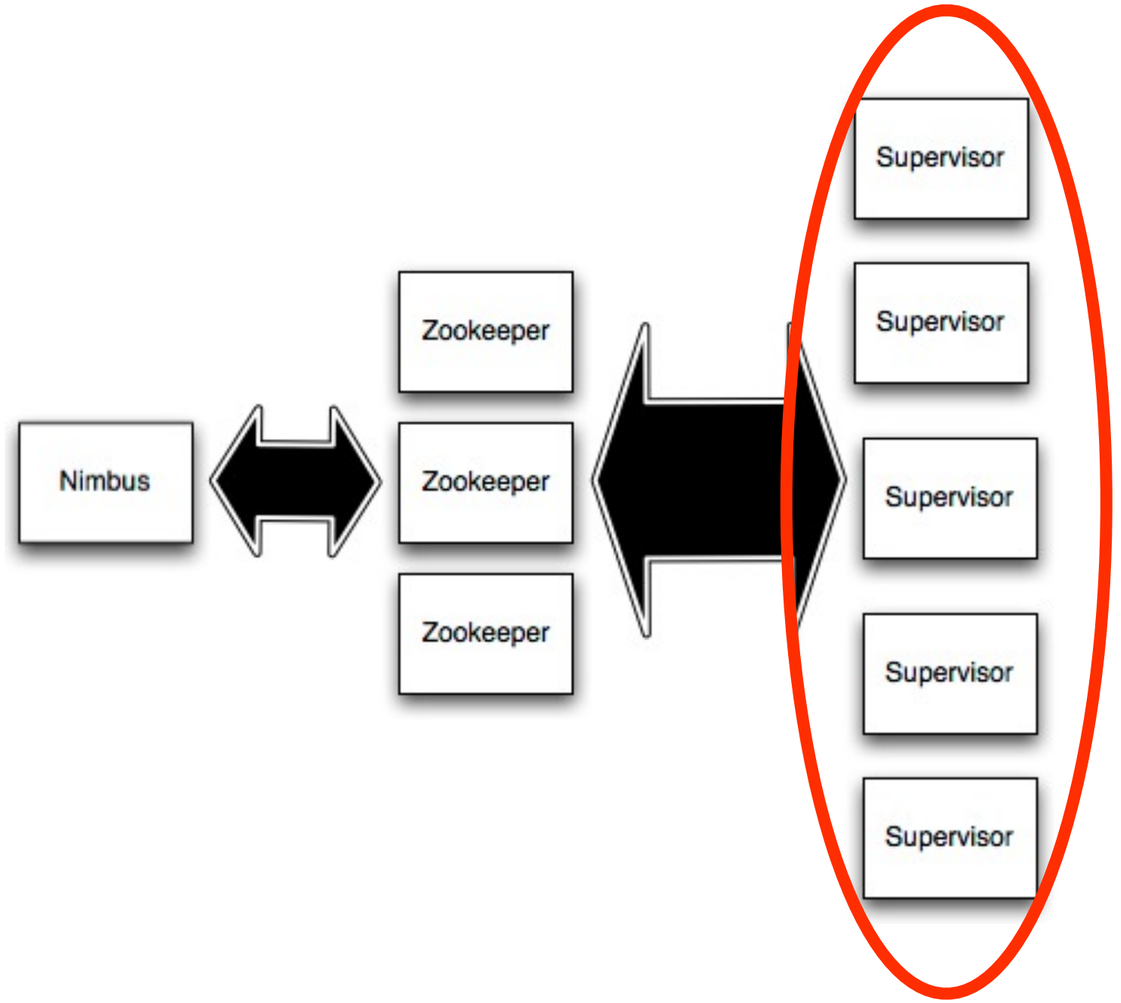
Master node (similar to Hadoop JobTracker)

Storm architecture



Used for cluster coordination

Storm architecture



Run worker processes

Storm’s “reportError” method

Topology stats

Window	Emitted	Transferred	Complete latency (ms)	Acked	Failed
10m 0s	0	0	0		
3h 0m 0s	0	0	0		
1d 0h 0m 0s	0	0	0		
All time	0	0	0		

Spouts (All time)

Id	Executors	Tasks	Emitted	Transferred	Complete latency (ms)	Acked	Failed	Last error
spout	1	1			0			java.lang.NullPointerException at storm.starter.spout.DBSampleSpout.nextTuple(DBSampleSpout.java:104) at backtype.storm.daemon.executor$fn__3968$fn__4009$fn__4010.invoke(executor.clj:433) at backty

Bolts (All time)

Id	Executors	Tasks	Emitted	Transferred	Process latency (ms)	Acked	Failed	Last error
dumperBolt	1	1			0			
final	1	1	0	0	0.000	0	0	
print	1	1	0	0	0.000	0	0	
table	1	1	0	0	0.000	0	0	

Show System Stats

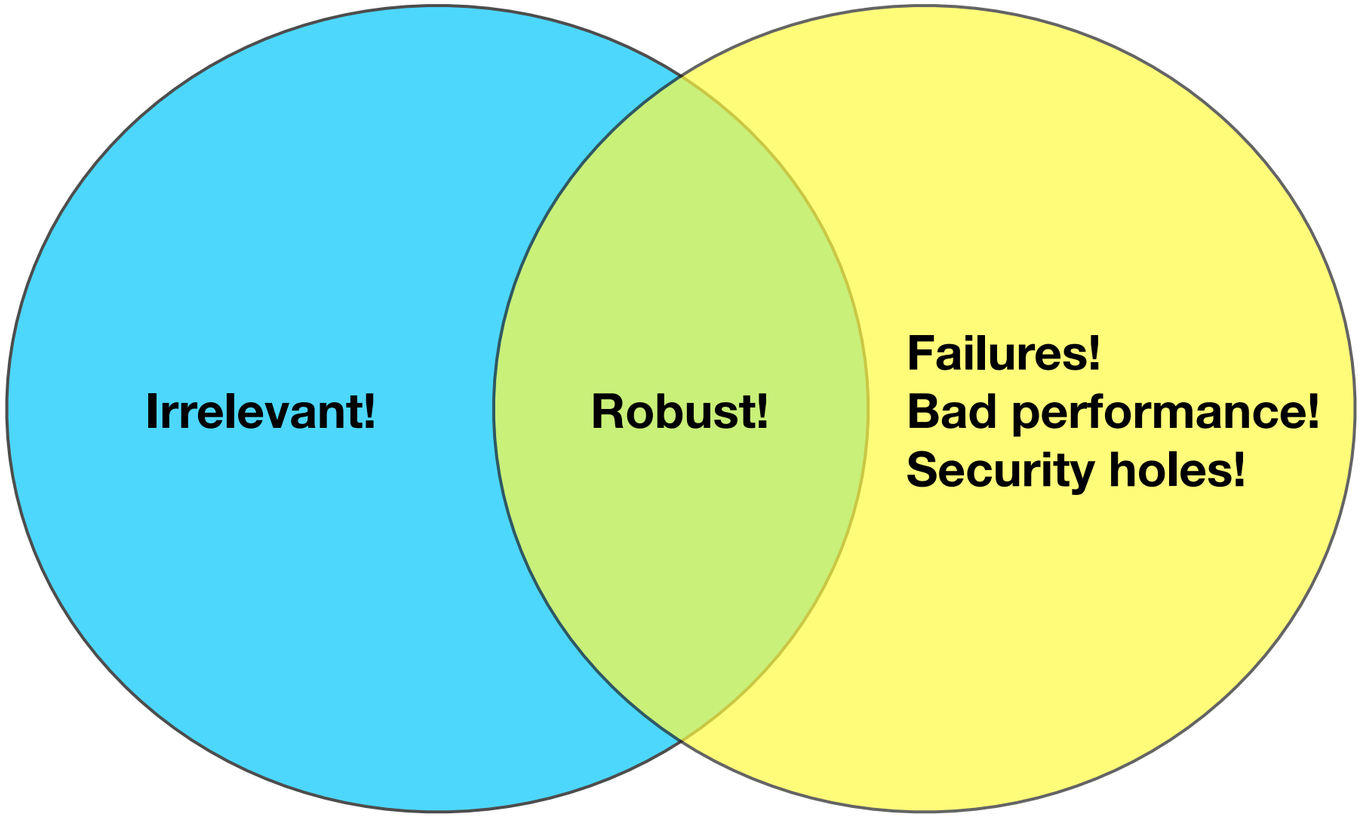
Used to show errors in the Storm UI

Error info is stored in Zookeeper

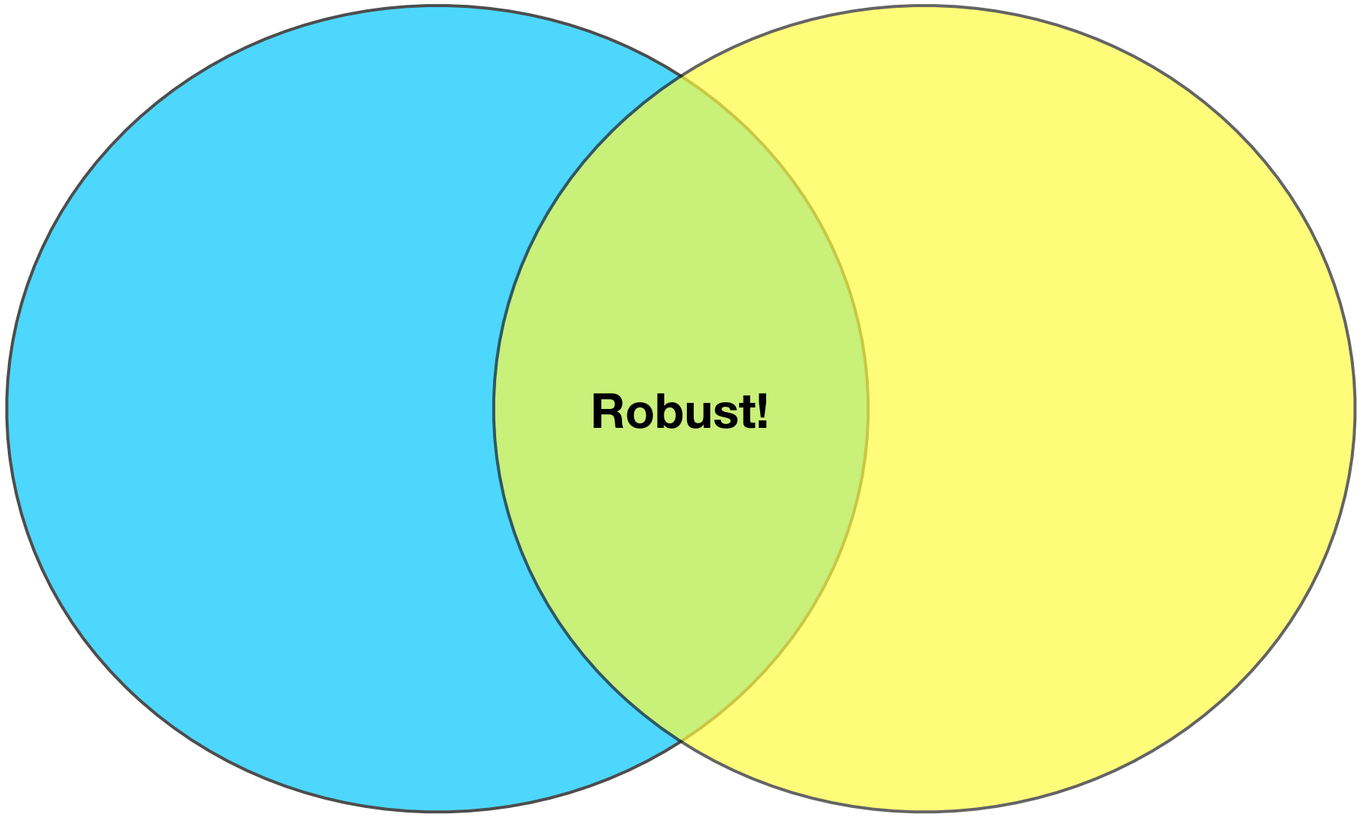
```
try {
    methodThatReturnsNull().foo();
} catch(Exception e) {
    collector.reportError(e);
}
```

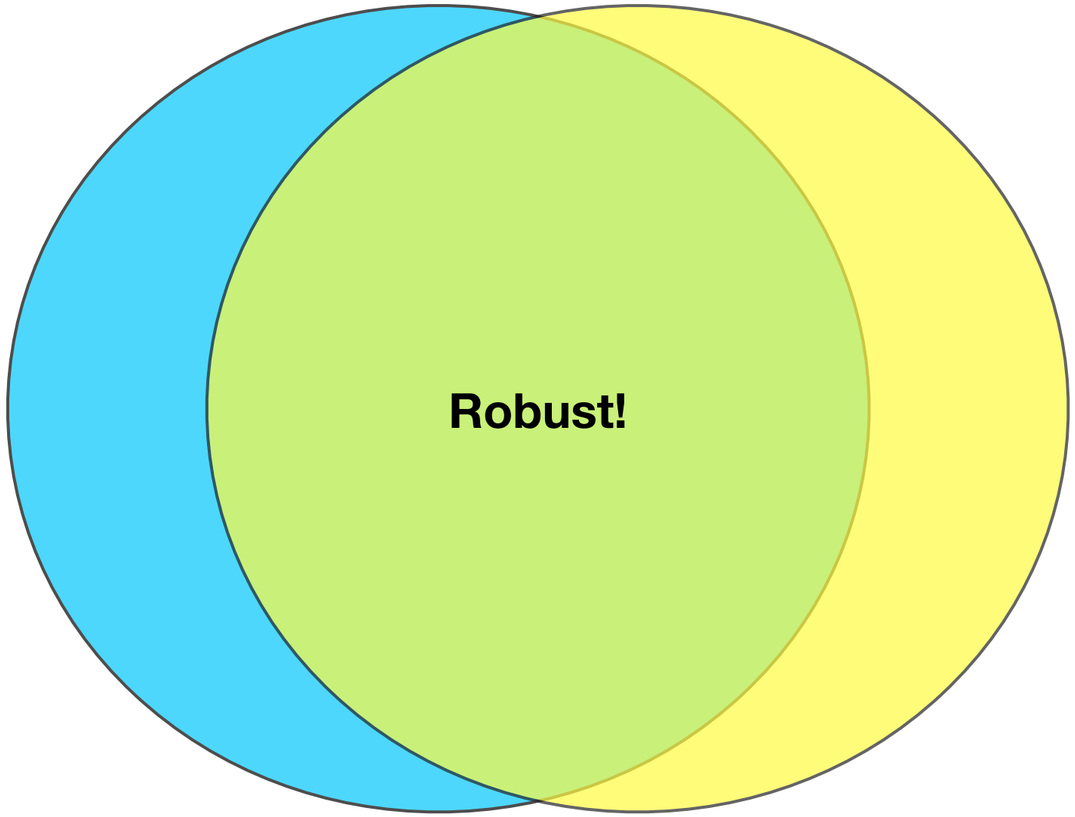
What happens when a user deploys code like this?

Denial-of-service on Zookeeper and cluster goes down


Irrelevant!
Robust!
Failures!
Bad performance!
Security holes!
Designed input space
Actual input space

Implement self-throttling to avoid overloading Zookeeper


Robust!
Designed input space
Actual input space



Designed input space

Actual input space

Epistemology

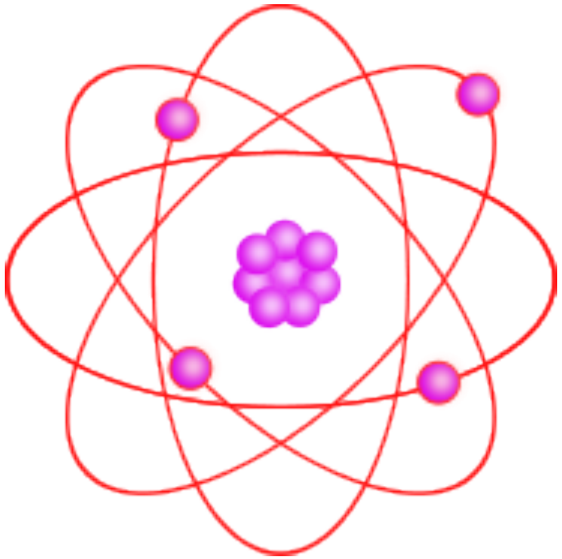
TRTH

TRUT

TRUH

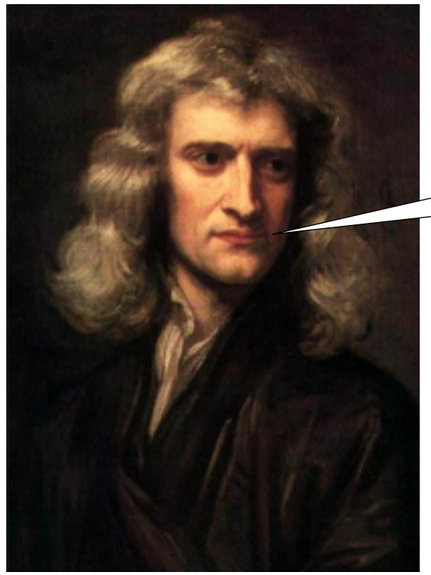
TUTH

TRU



Foundation of modern science

Newton’s laws of motion

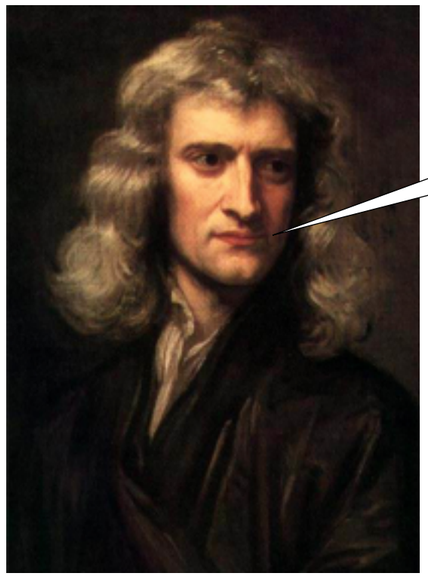


1. When viewed in an inertial reference frame, an object either is at rest or moves at a constant velocity, unless acted upon by an external force.

2. The acceleration of a body is directly proportional to, and in the same direction as, the net force acting on the body, and inversely proportional to its mass. Thus, F = ma, where F is the net force acting on the object, m is the mass of the object and a is the acceleration of the object.

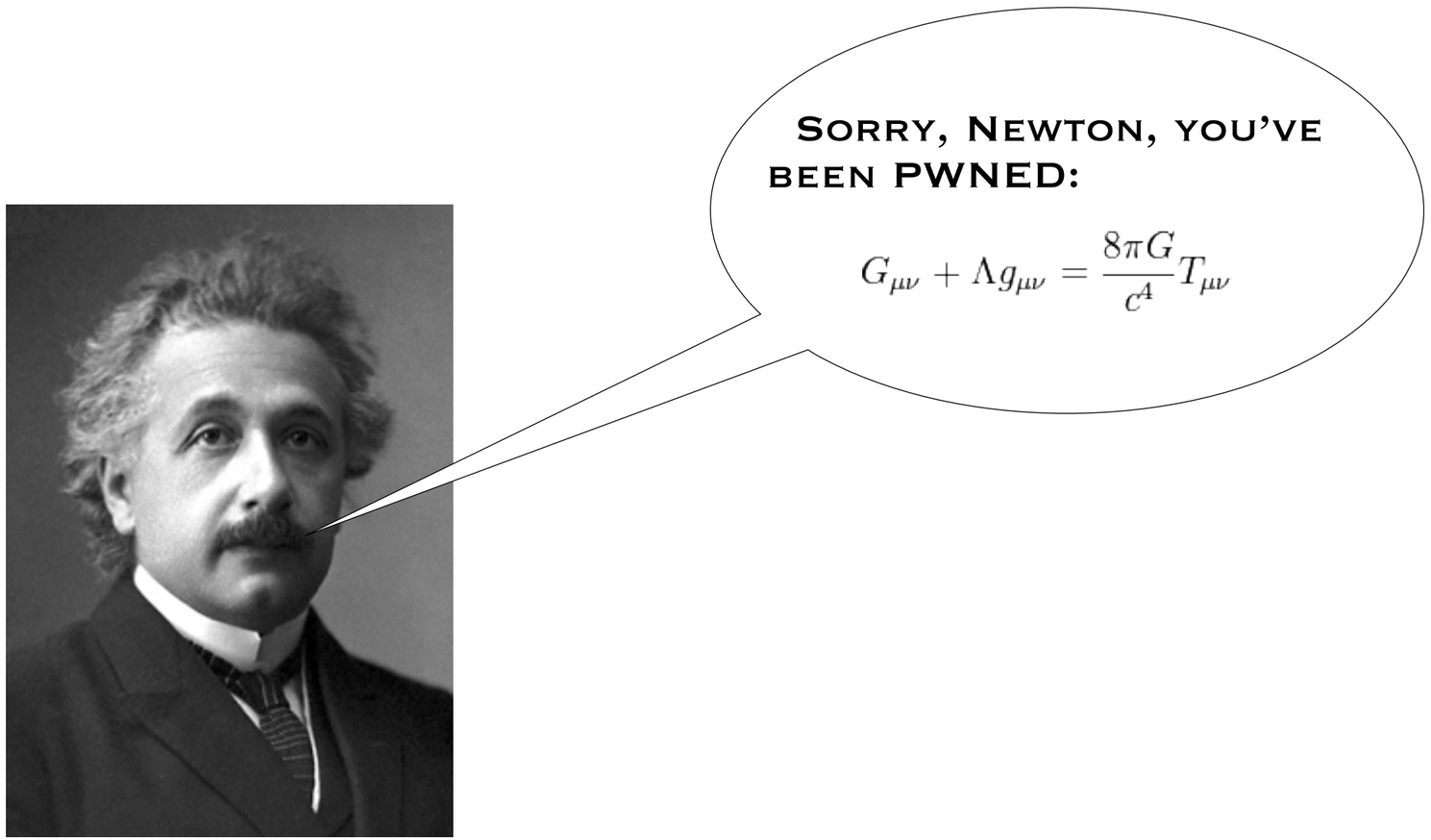
3. When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction to that of the first body.

Orbit of Mercury problem



CAMBRIDGE, WE HAVE A PROBLEM...

Einstein's theory of relativity



$$\lim_{n \to \infty} \text{approximation}^{n}(\text{truth}) = \text{truth}$$

Science algorithm

1. Make observations

2. Find theories consistent with those observations

3. Falsify theories by making more observations

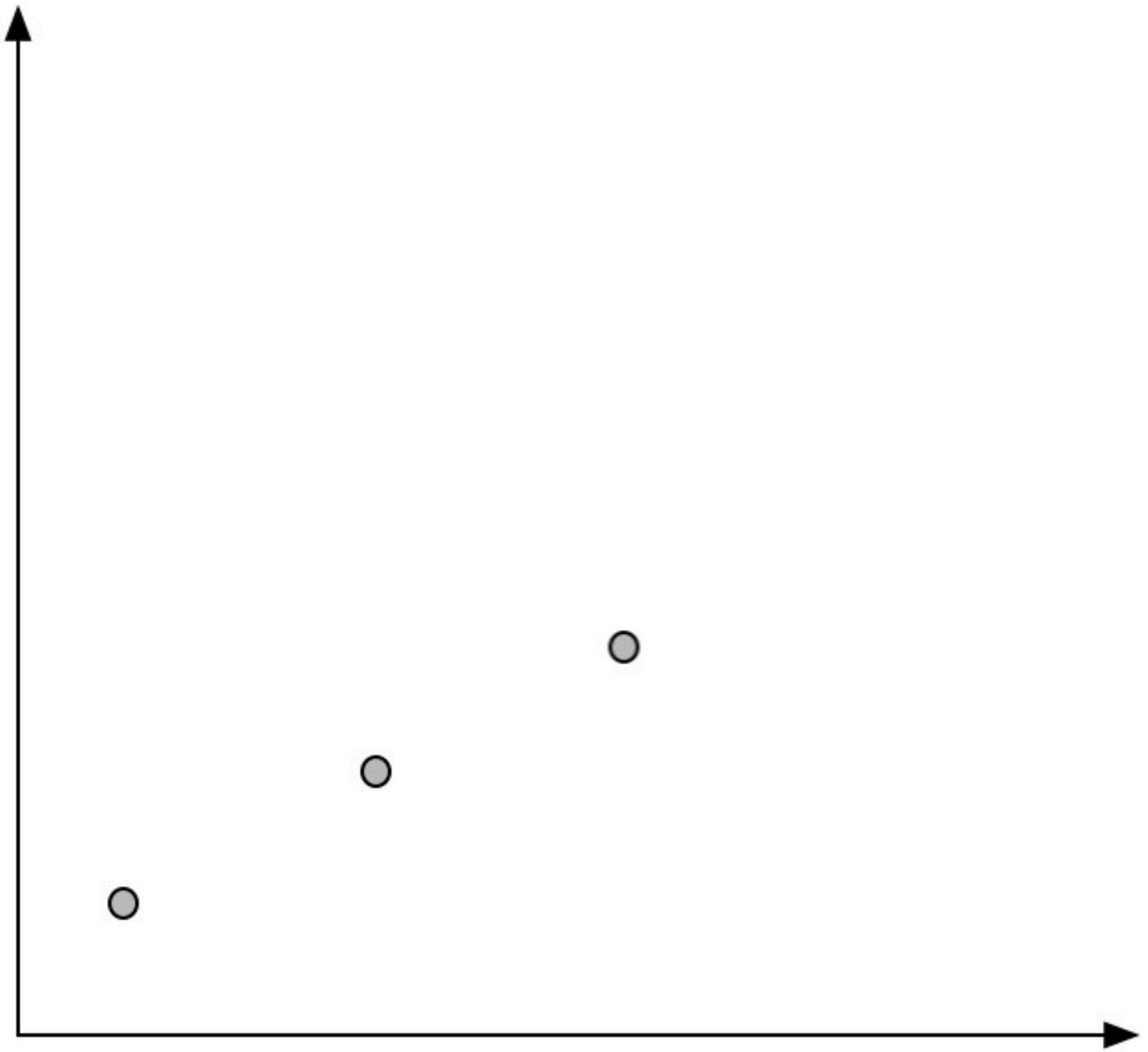
Foundationalism

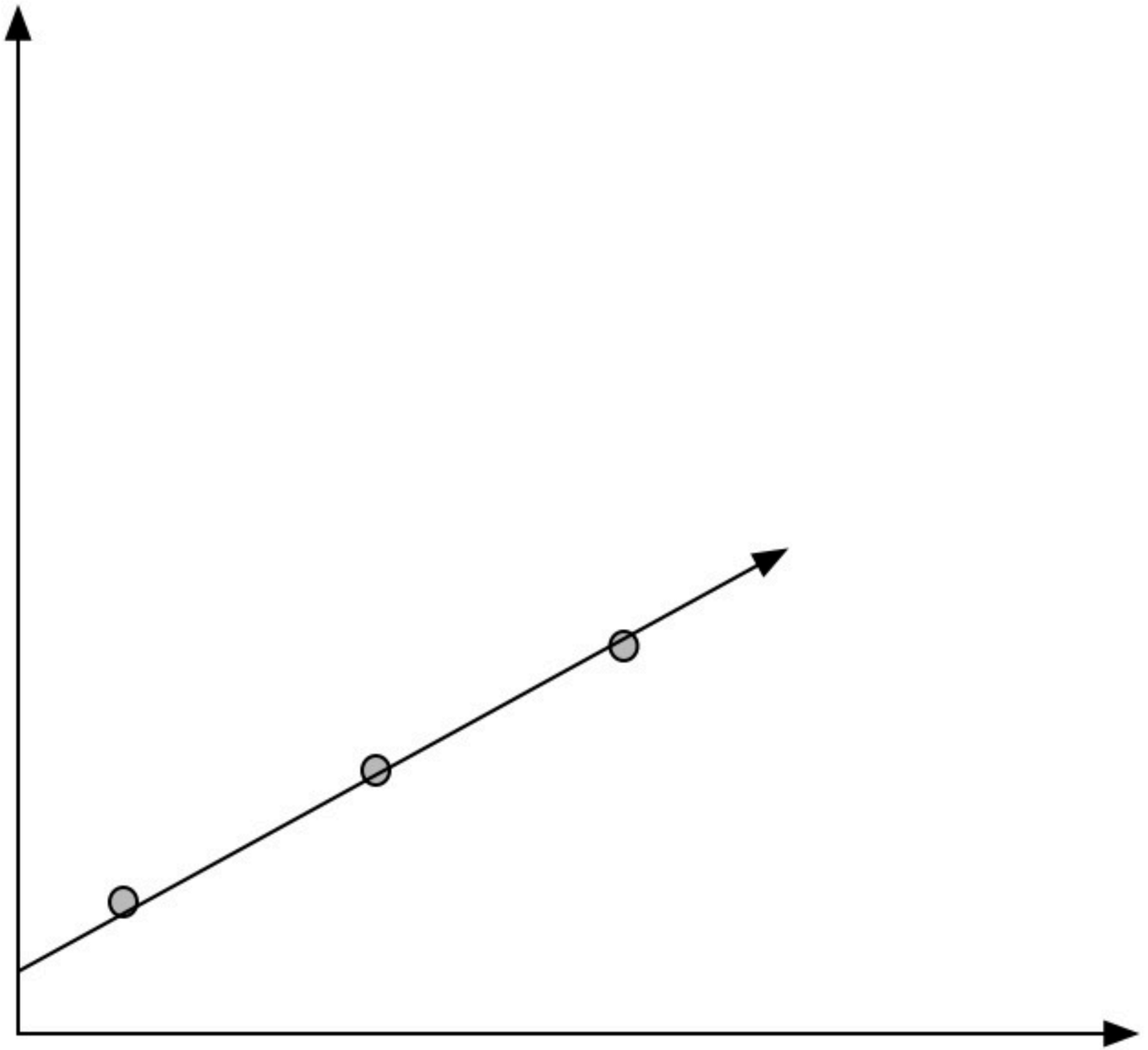
+

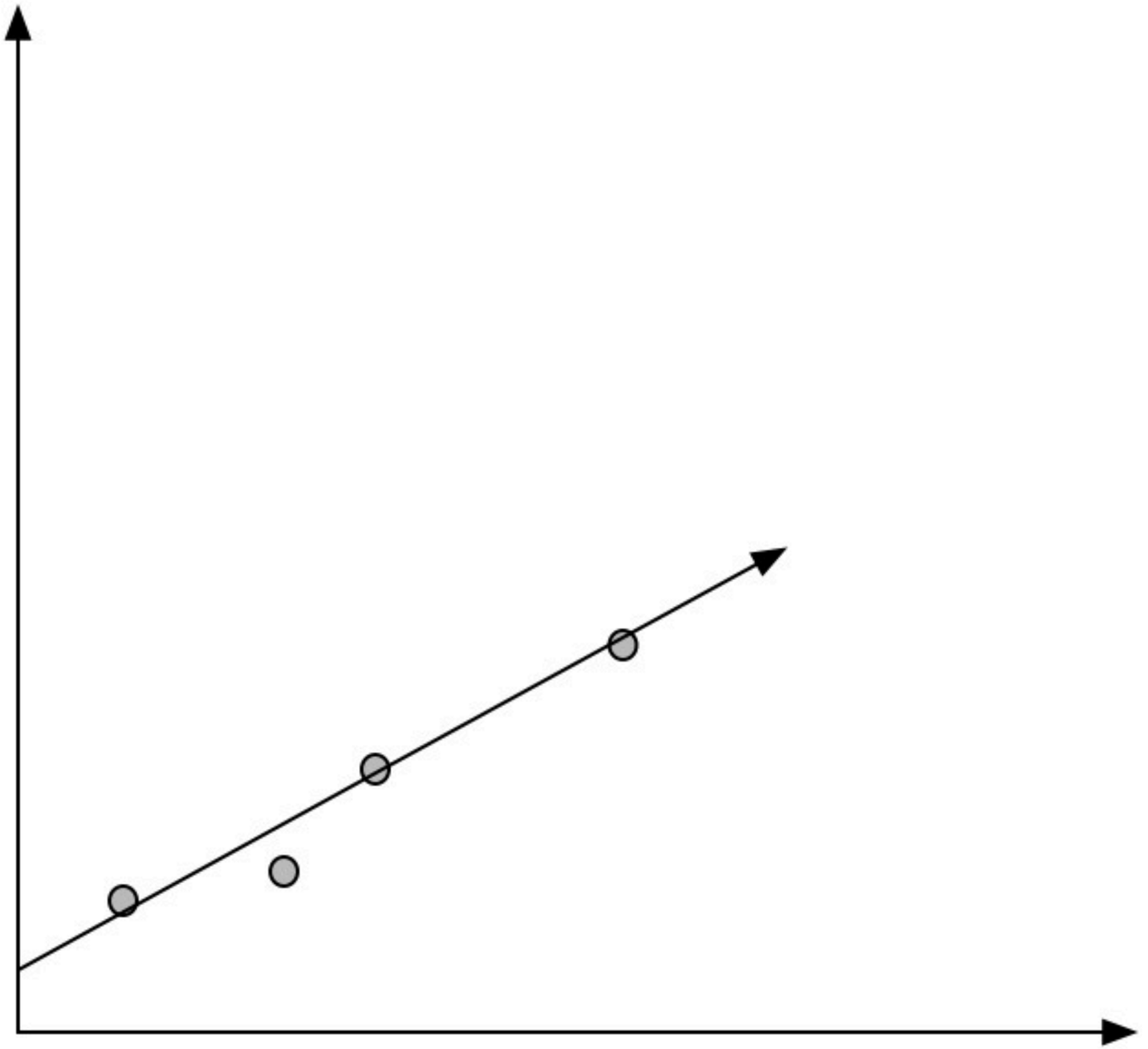
Coherentism

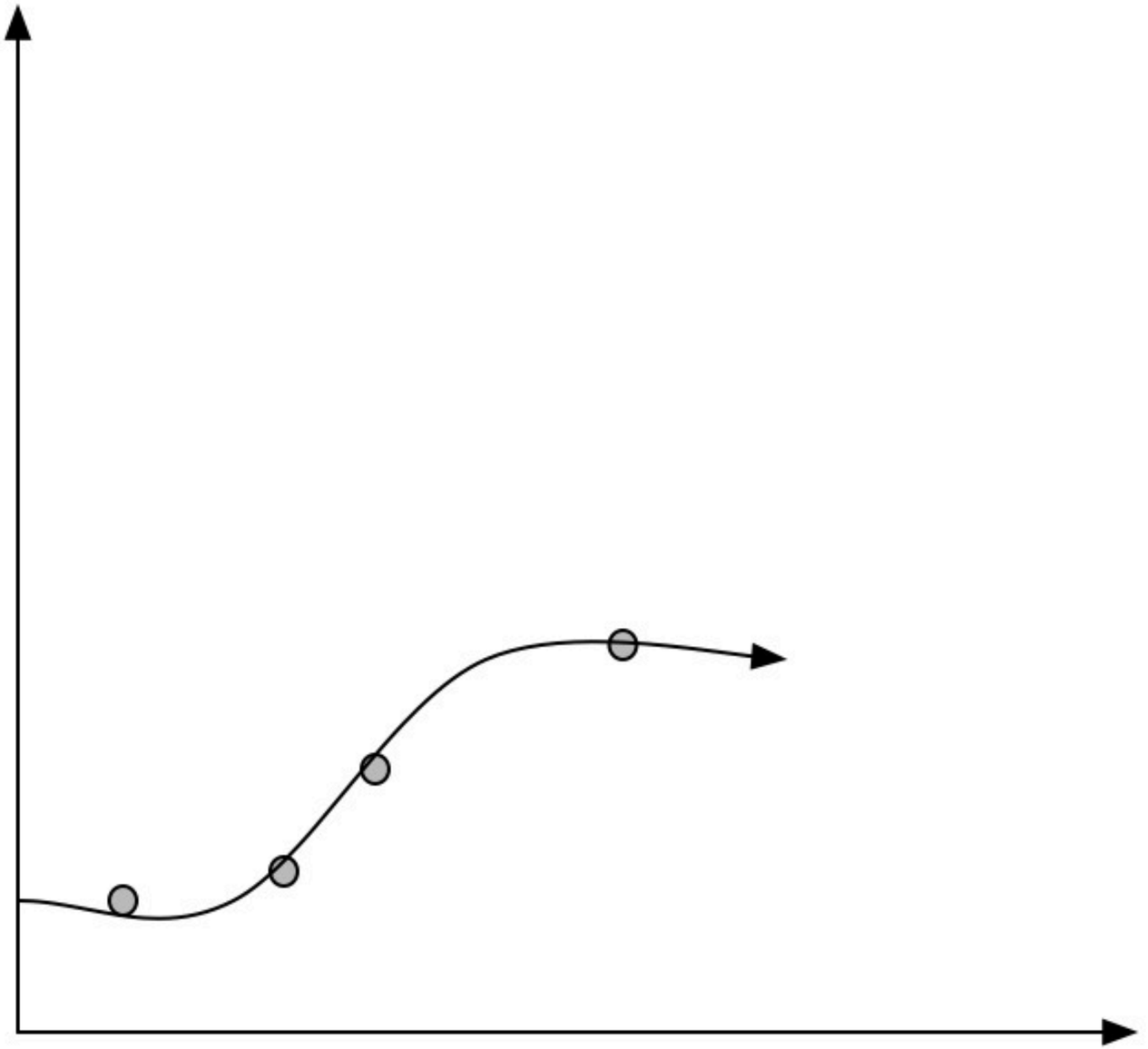
Empirícism

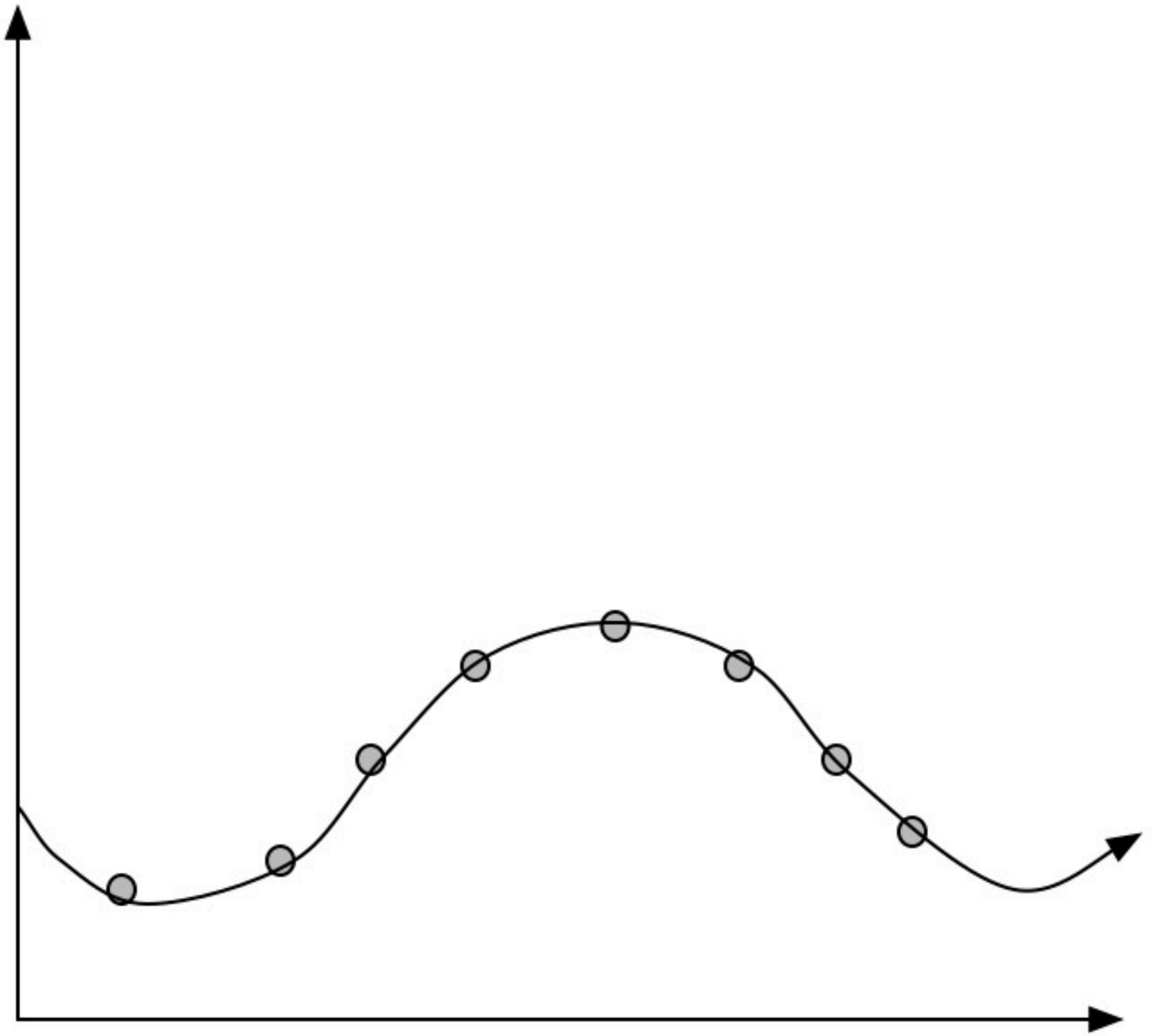
John Locke

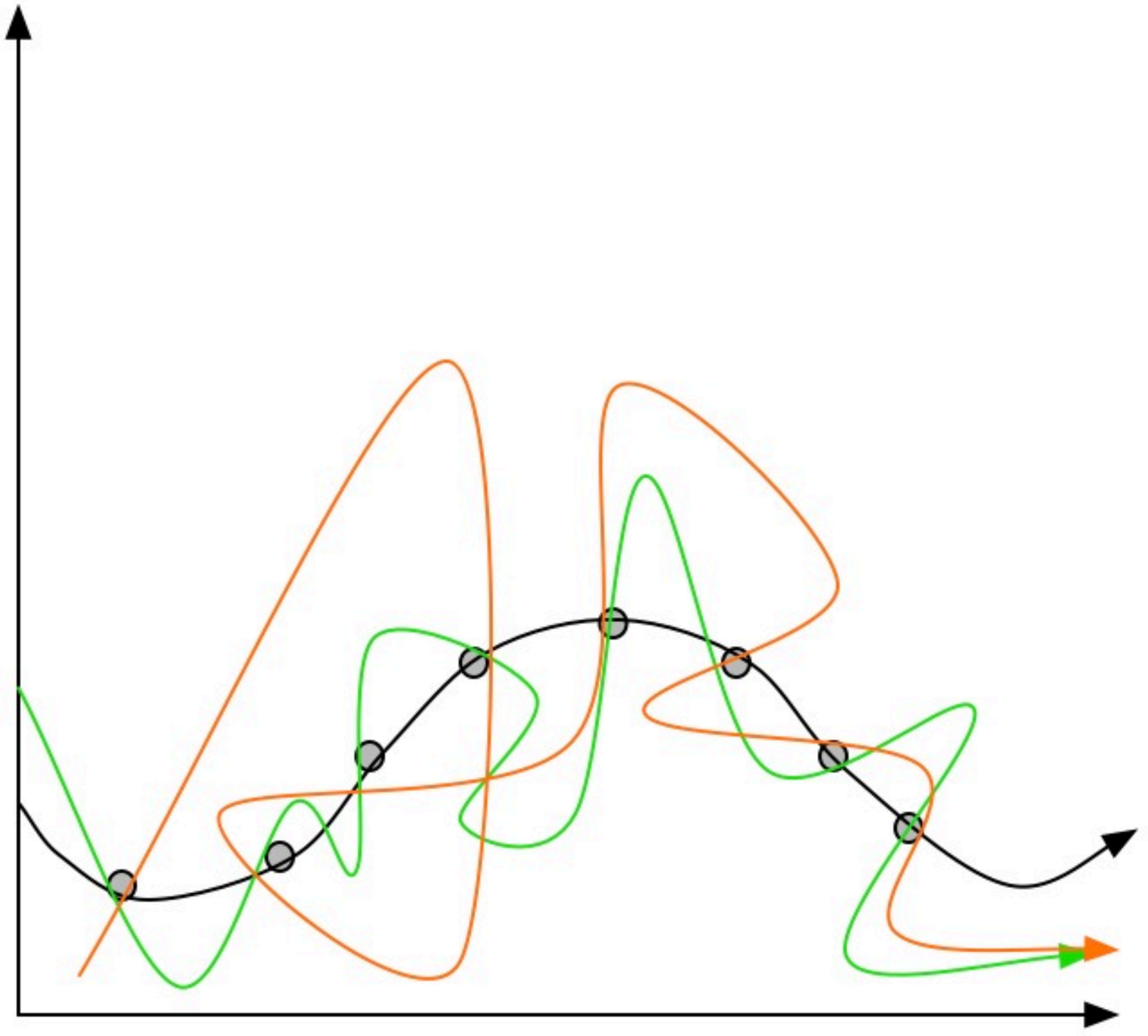




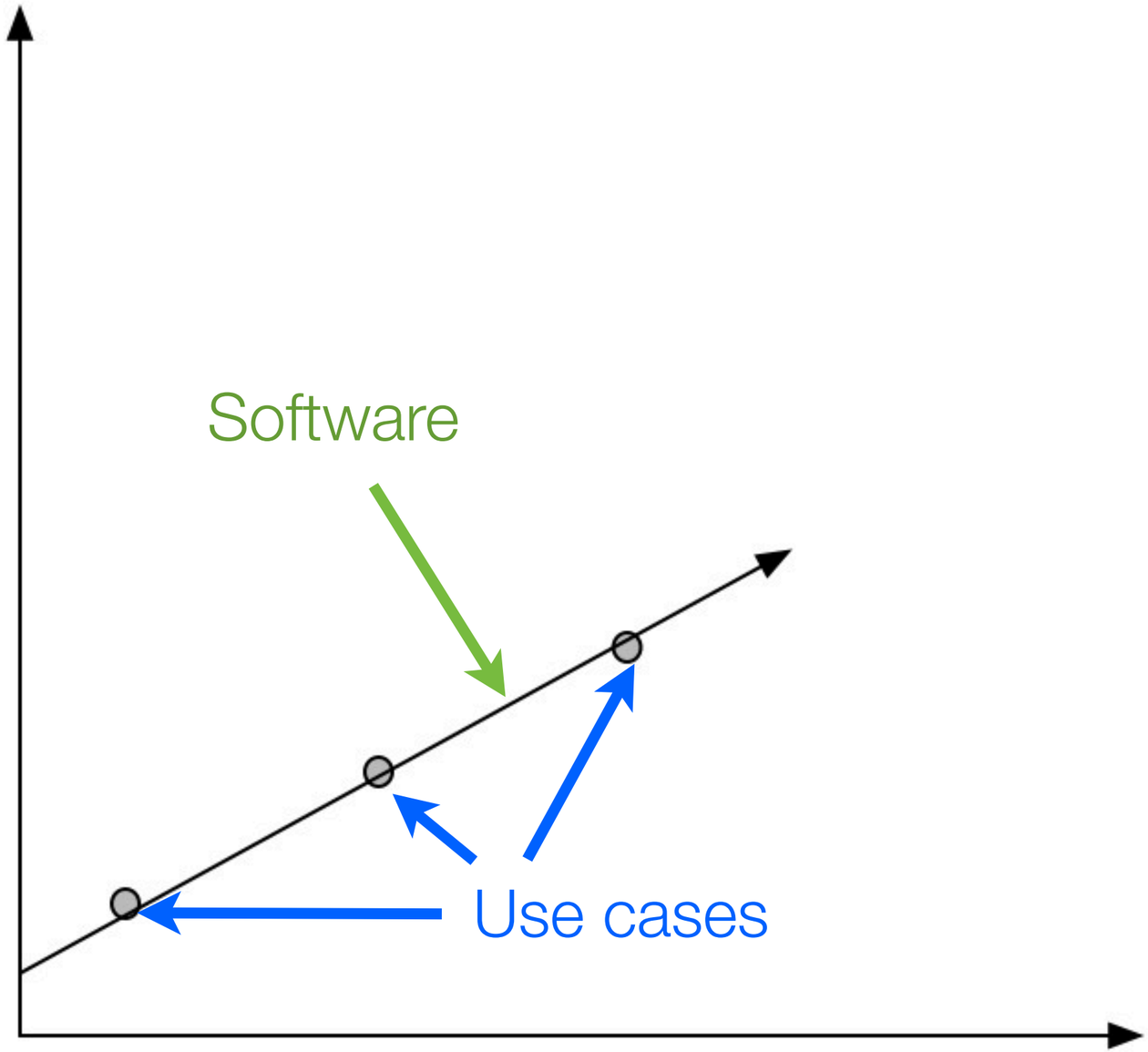


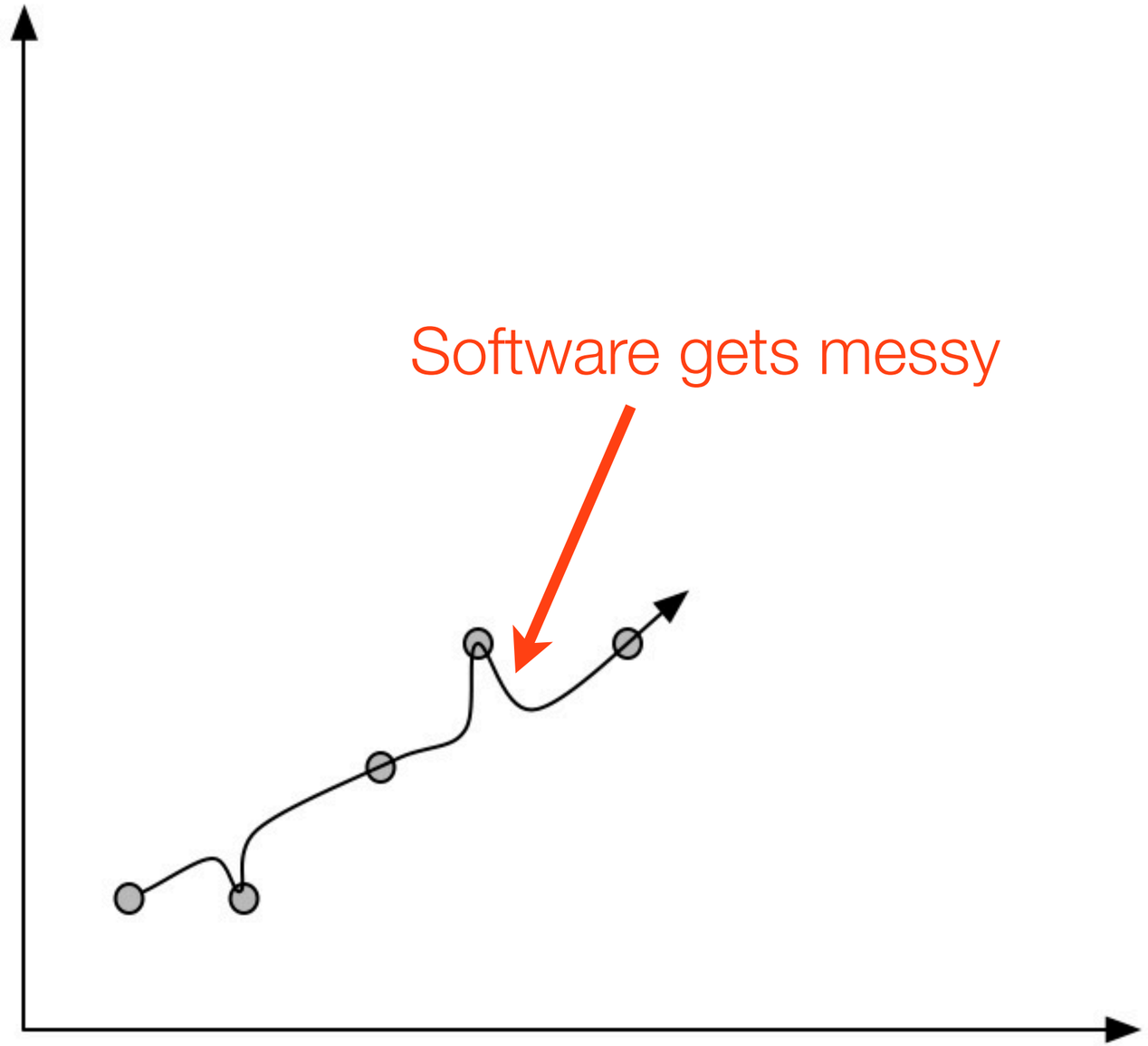


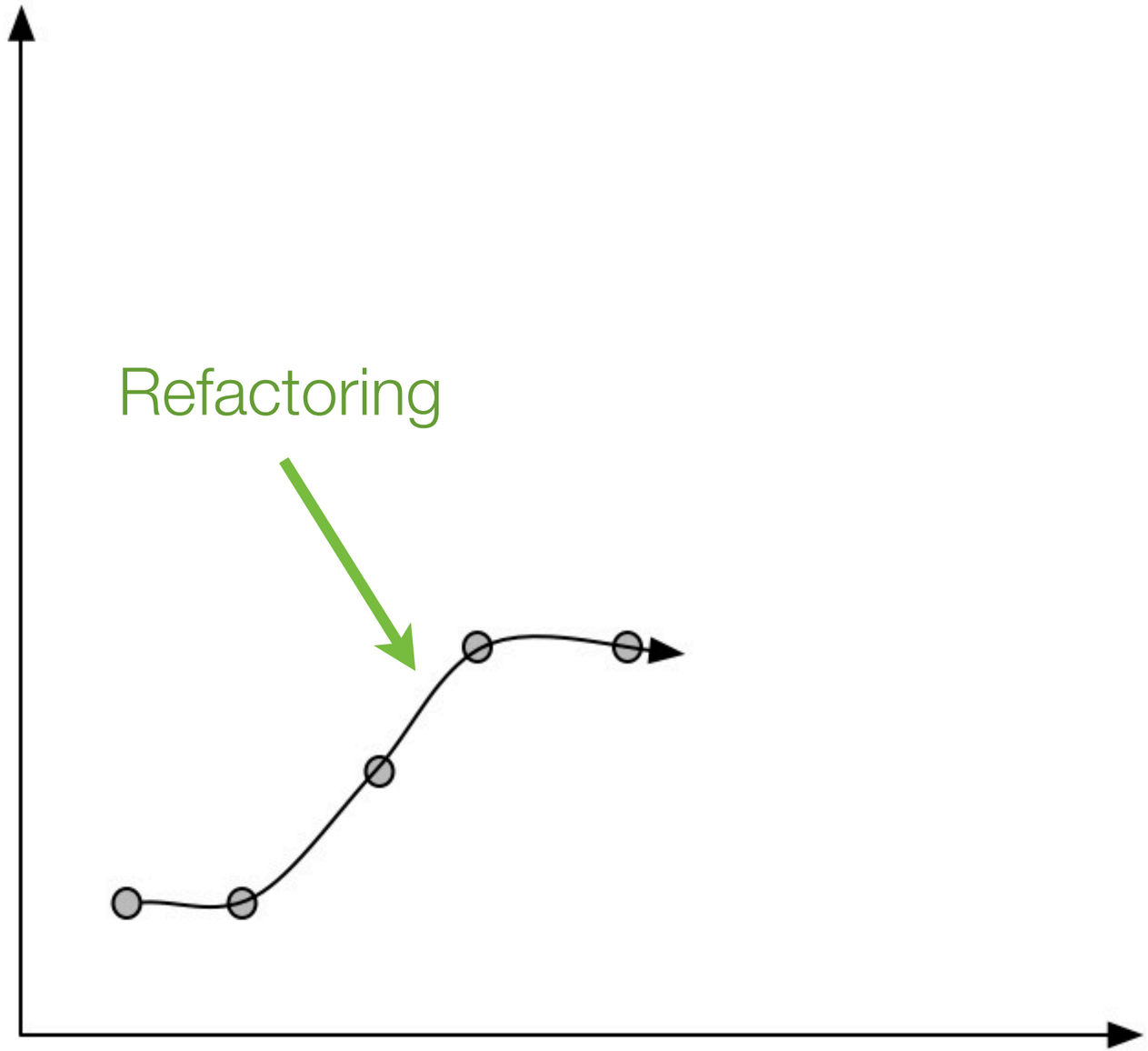


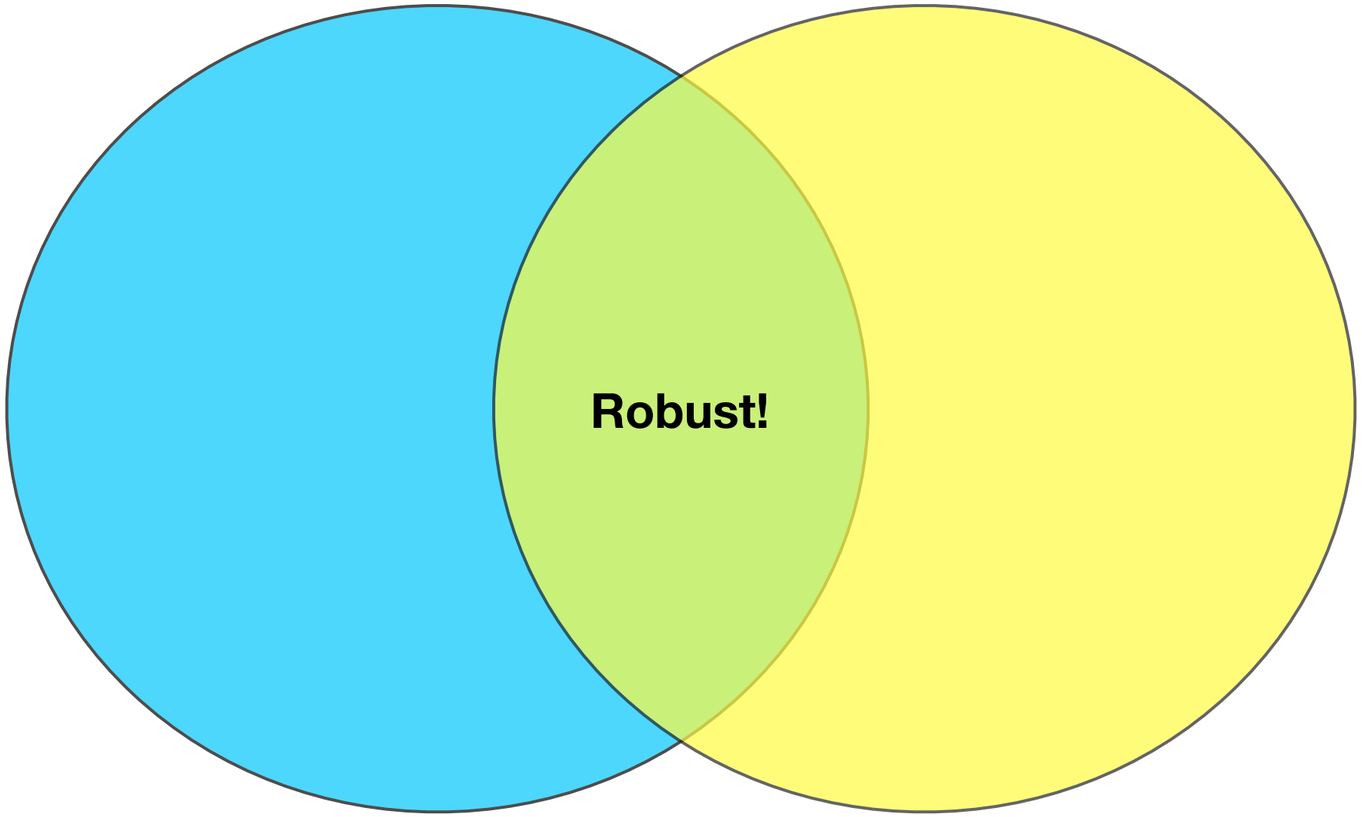


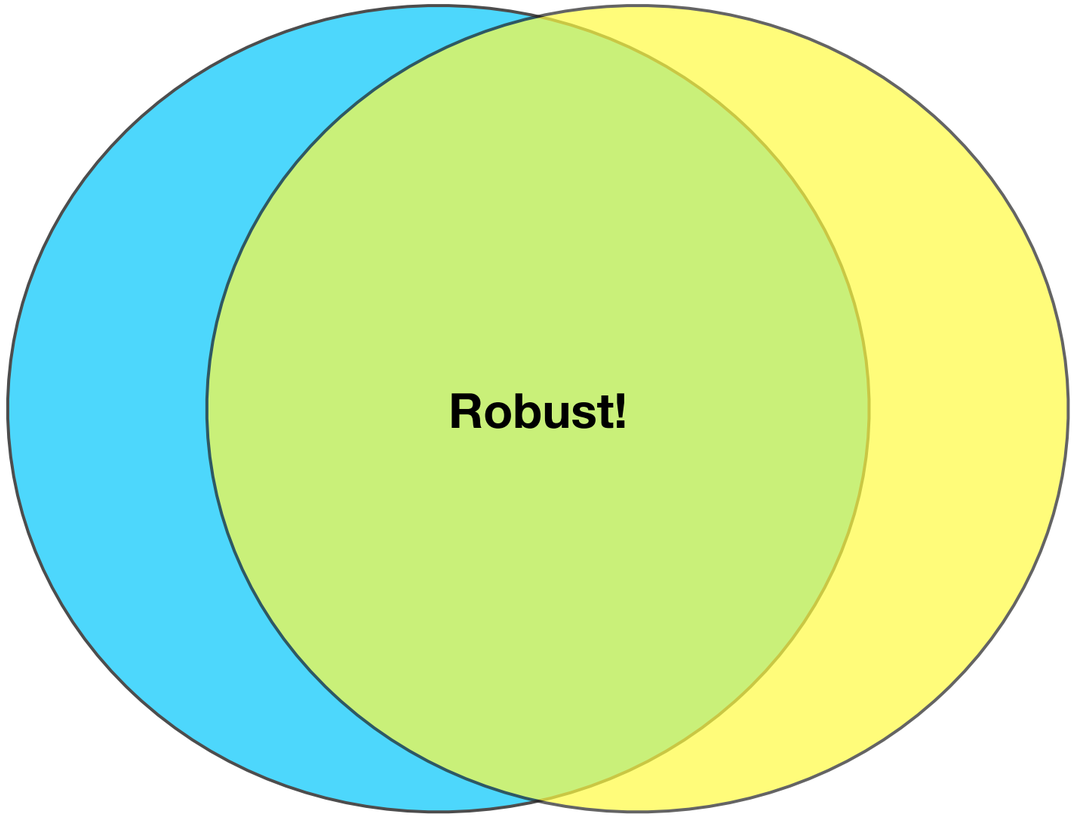
Occam's Razor


Software
Use cases


Software gets messy

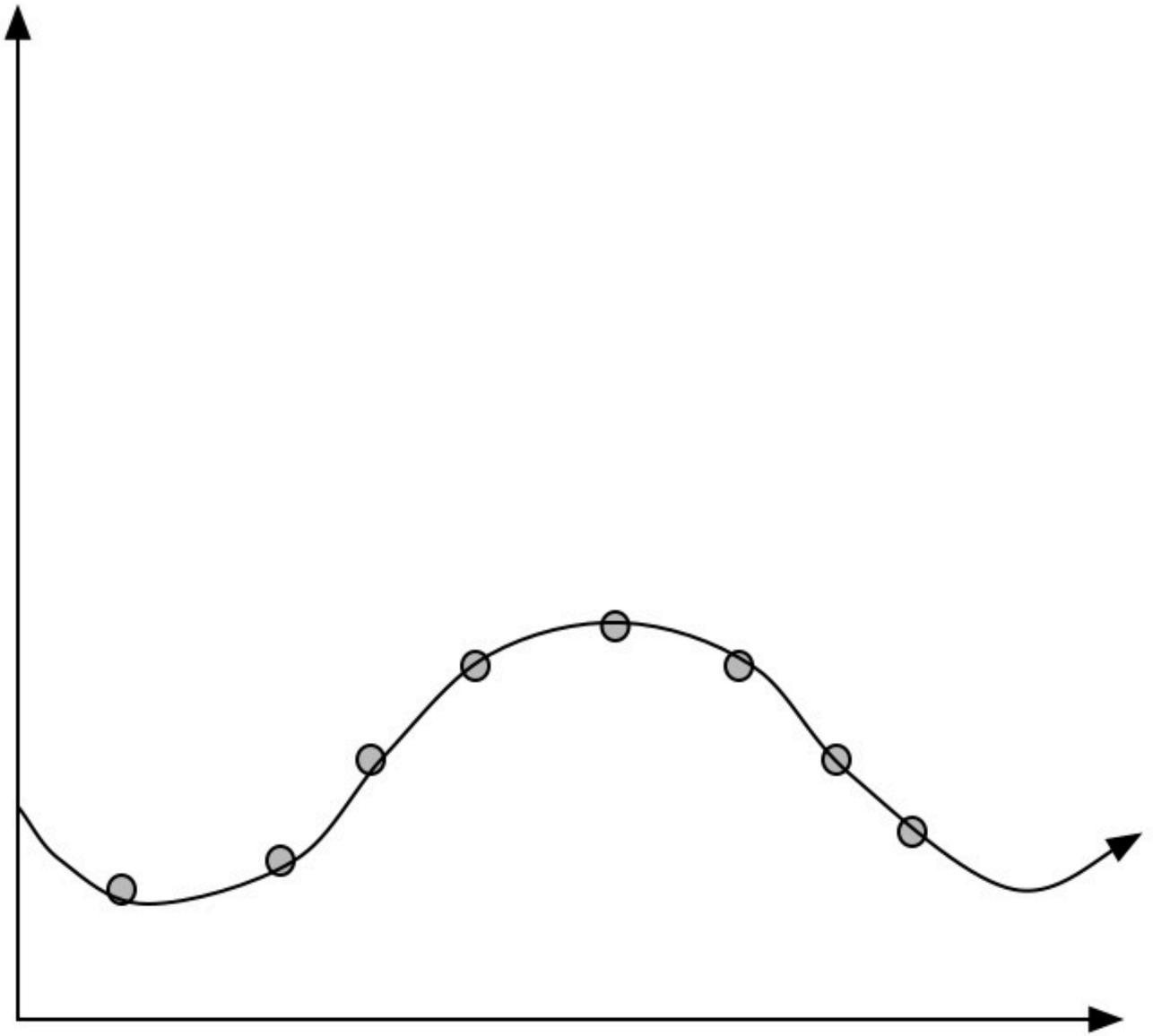

Refactoring


Robust!
Designed input space
Actual input space

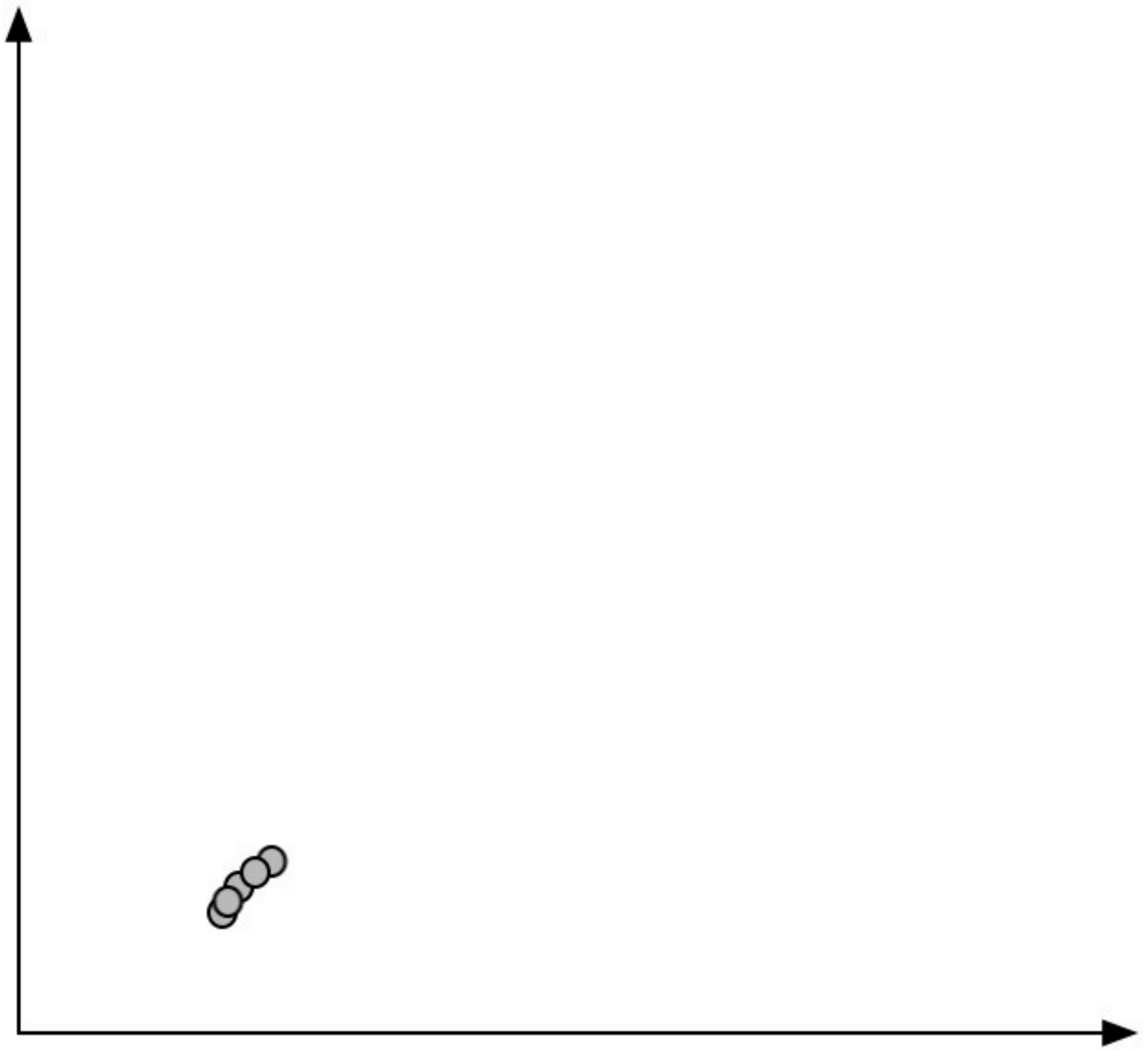


Designed input space

Actual input space



TESTING



```
assert(add(2,3) == 5)
assert(add(3,4) == 7)
assert(add(4,5) == 9)
assert(add(5,6) == 11)
```

Unit testing

Load testing

Stress testing

Fuzz testing

TDD?

Review

1. Cannot perfectly reason about software

- Infinite regress problem
- Deduction is fundamentally flawed
- Evidence shows programmers are not good at deductive reasoning

2. Best you can do is minimize wrongness

- Truth can only be approximate
- Observe/theorize/falsify cycle minimizes wrongness over time
- Testing = empiricism applied to software development
- Make programs less wrong by testing more

Does any of this matter?

YES

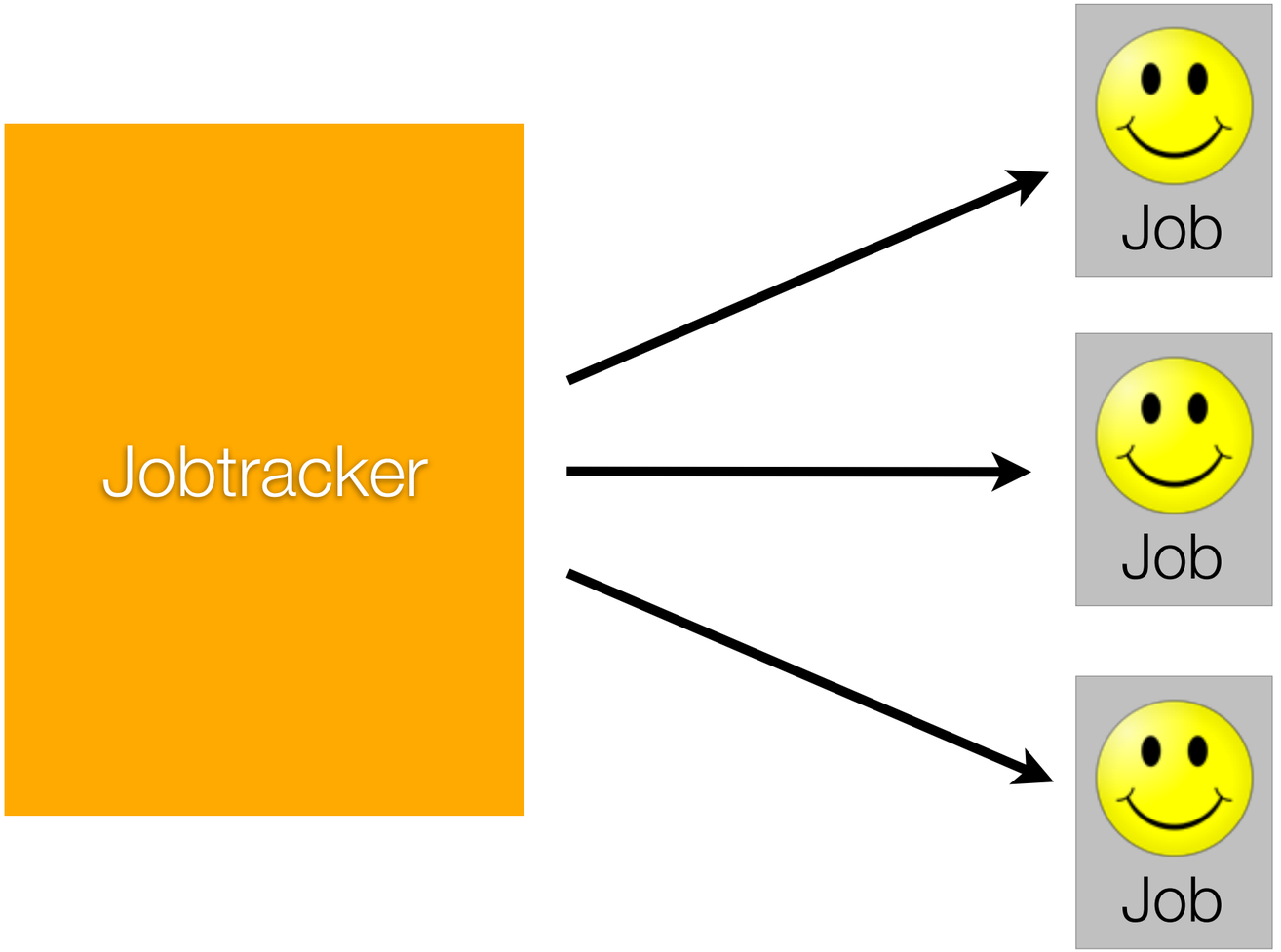
Embrace “your code is wrong”
to design better software

Redundancy

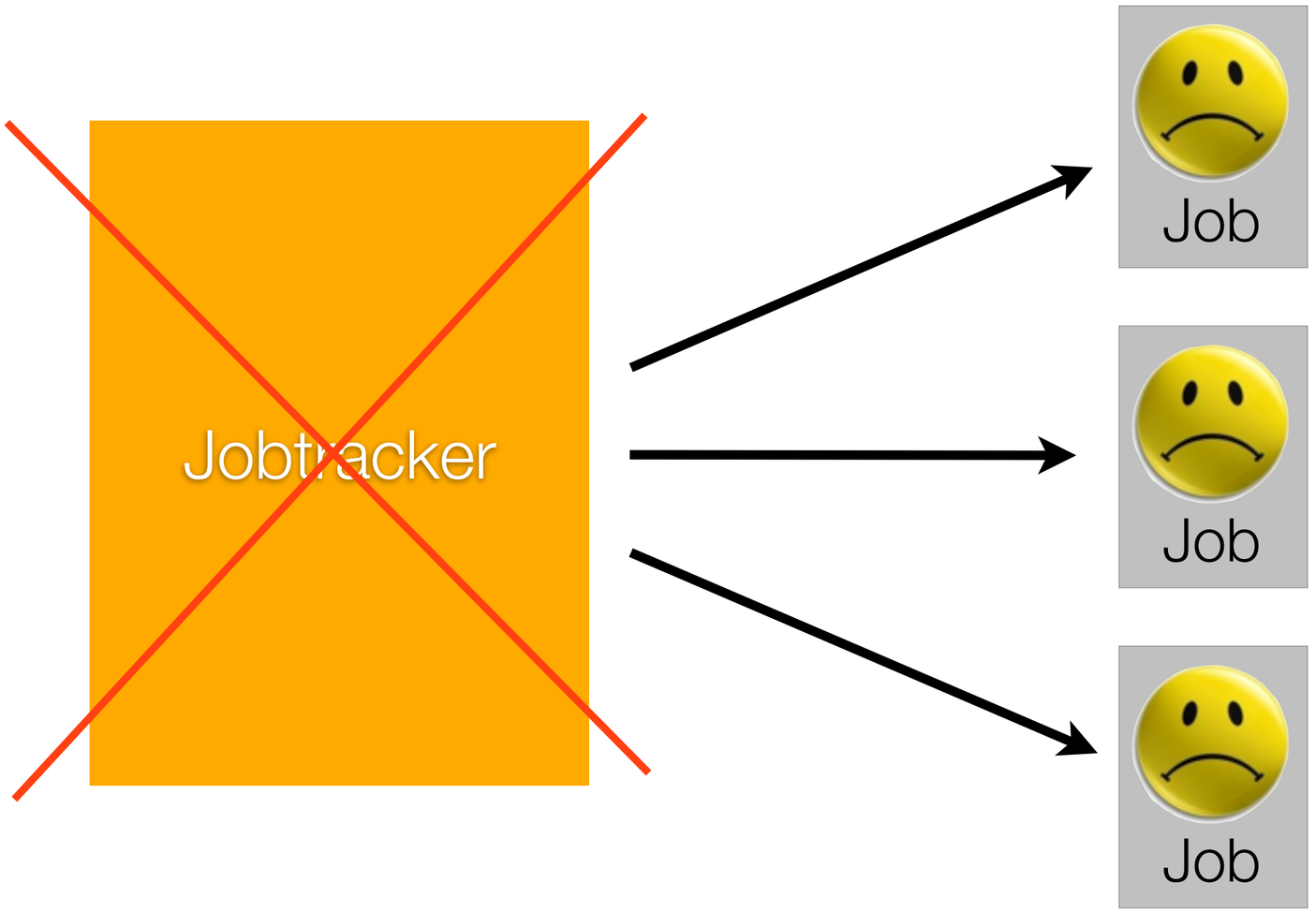
Fault-tolerance > Perfection

An example

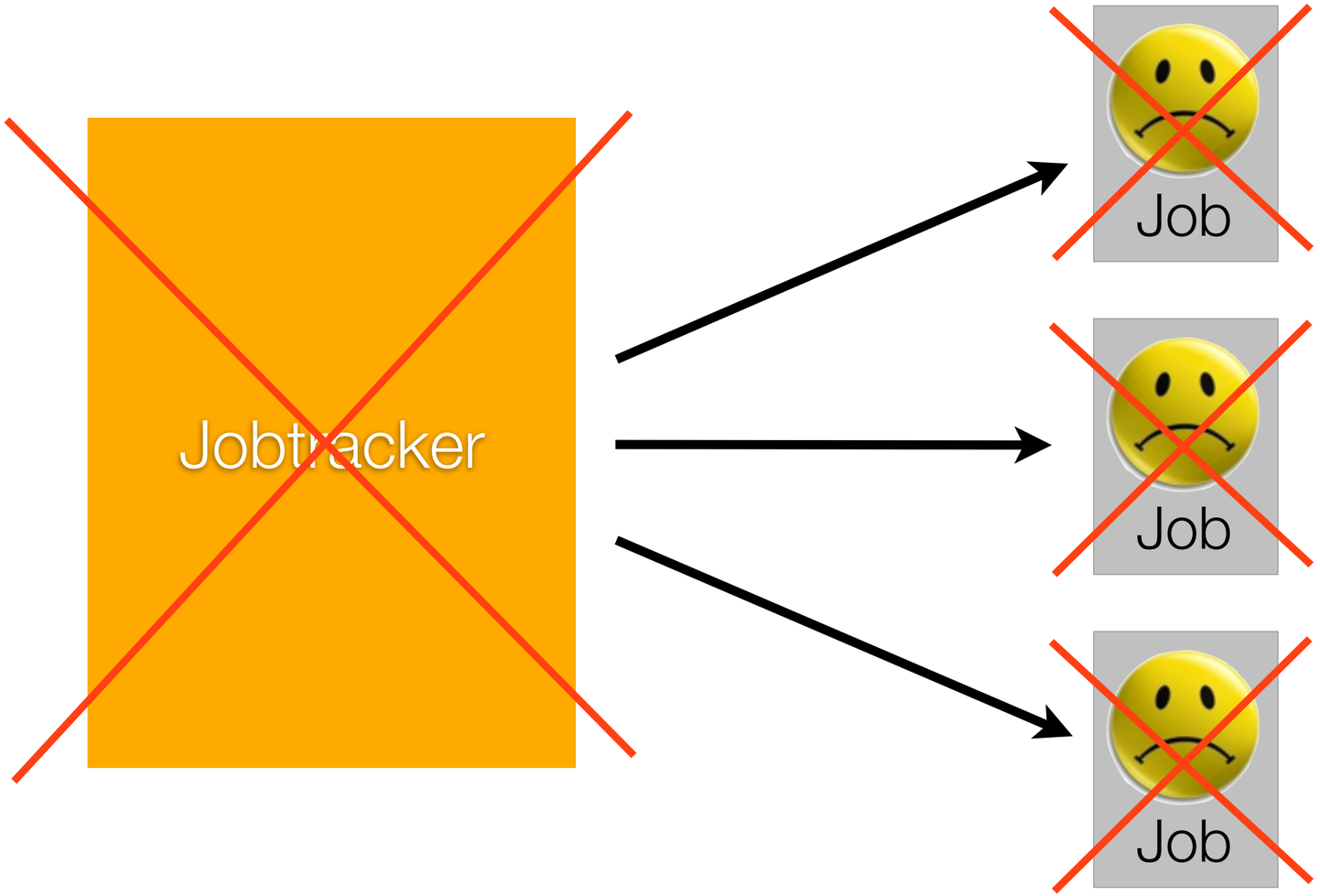
Learning from Hadoop



Learning from Hadoop



Learning from Hadoop

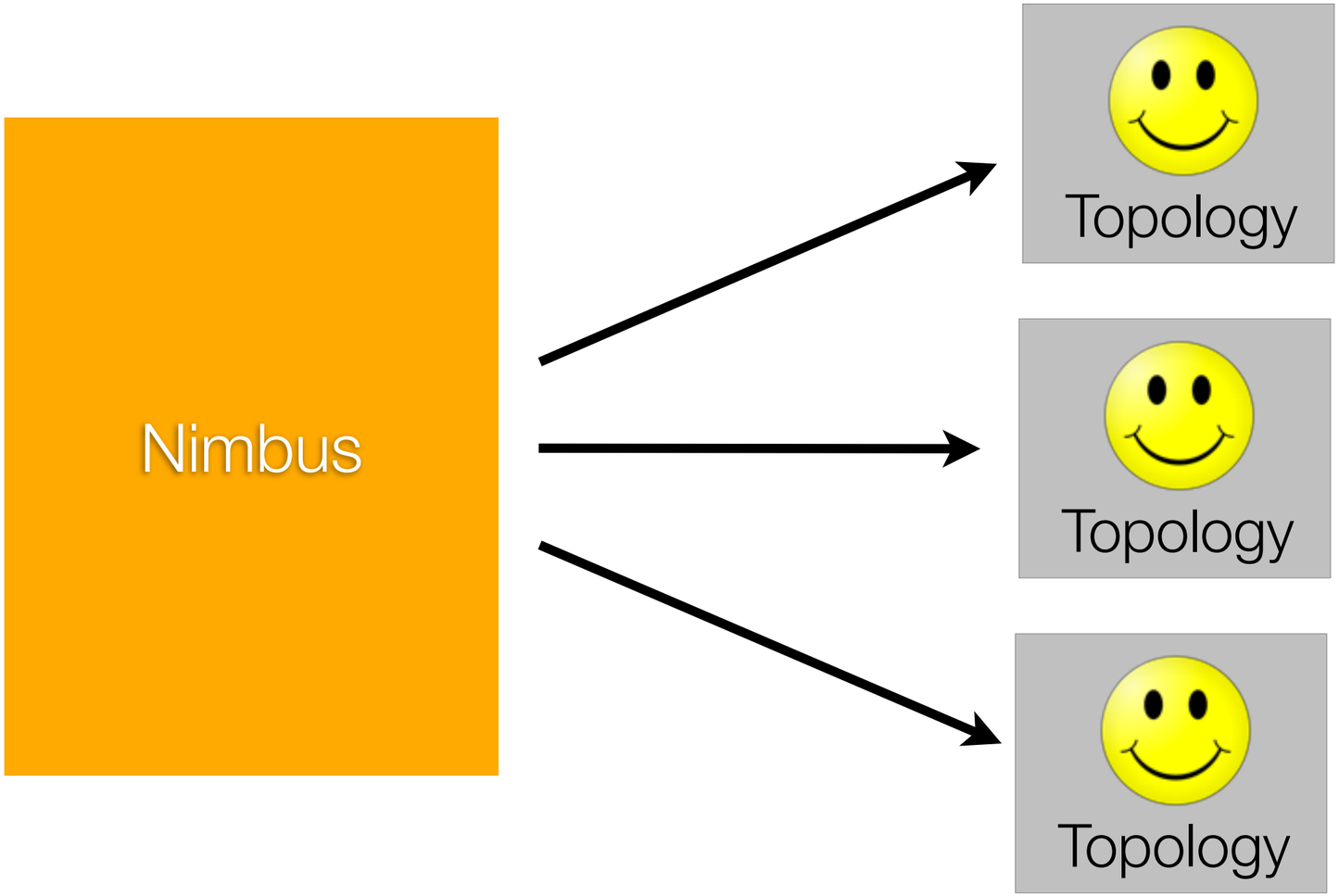


Your code is wrong

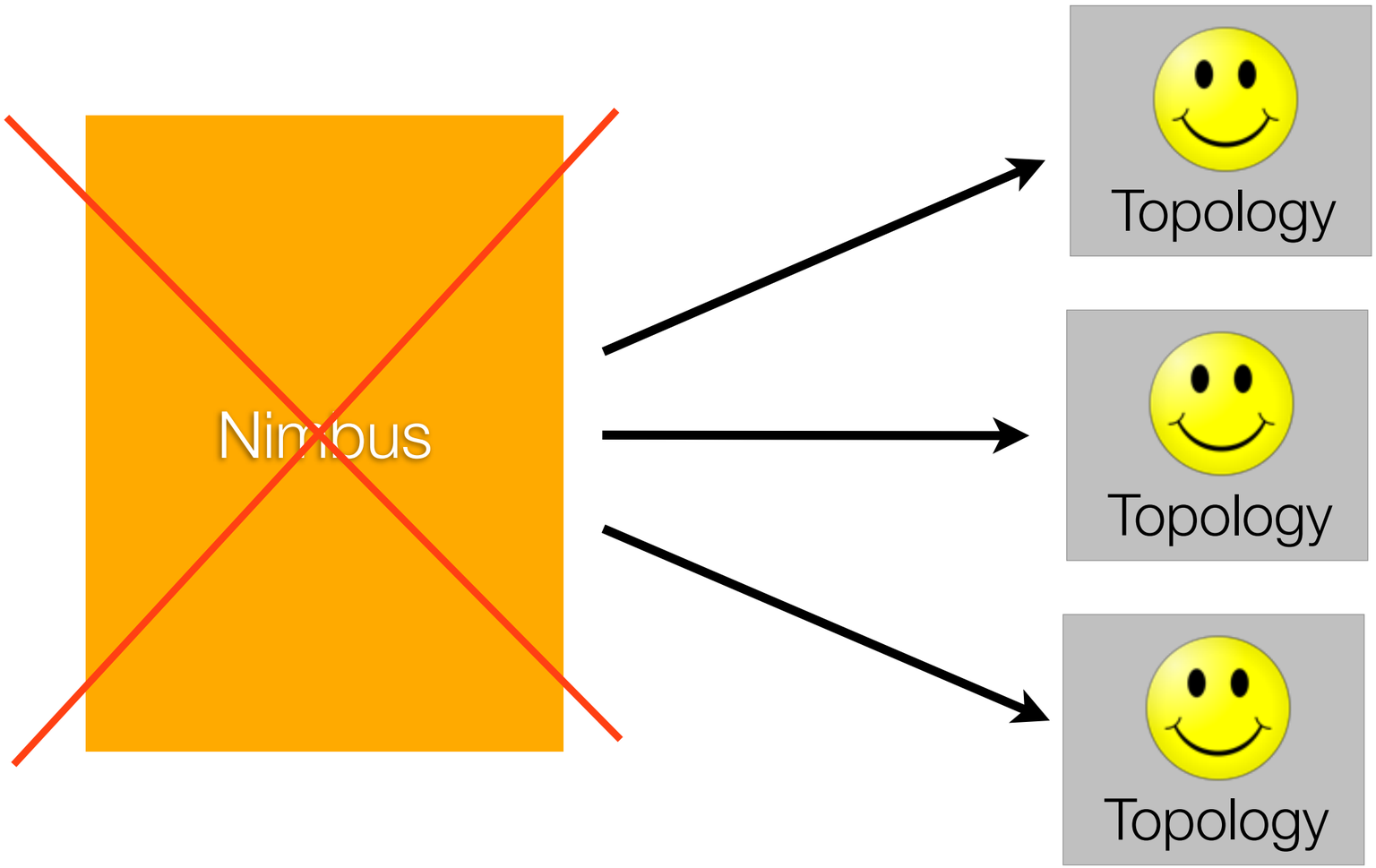
So your processes will crash

Storm’s daemons are process fault-tolerant

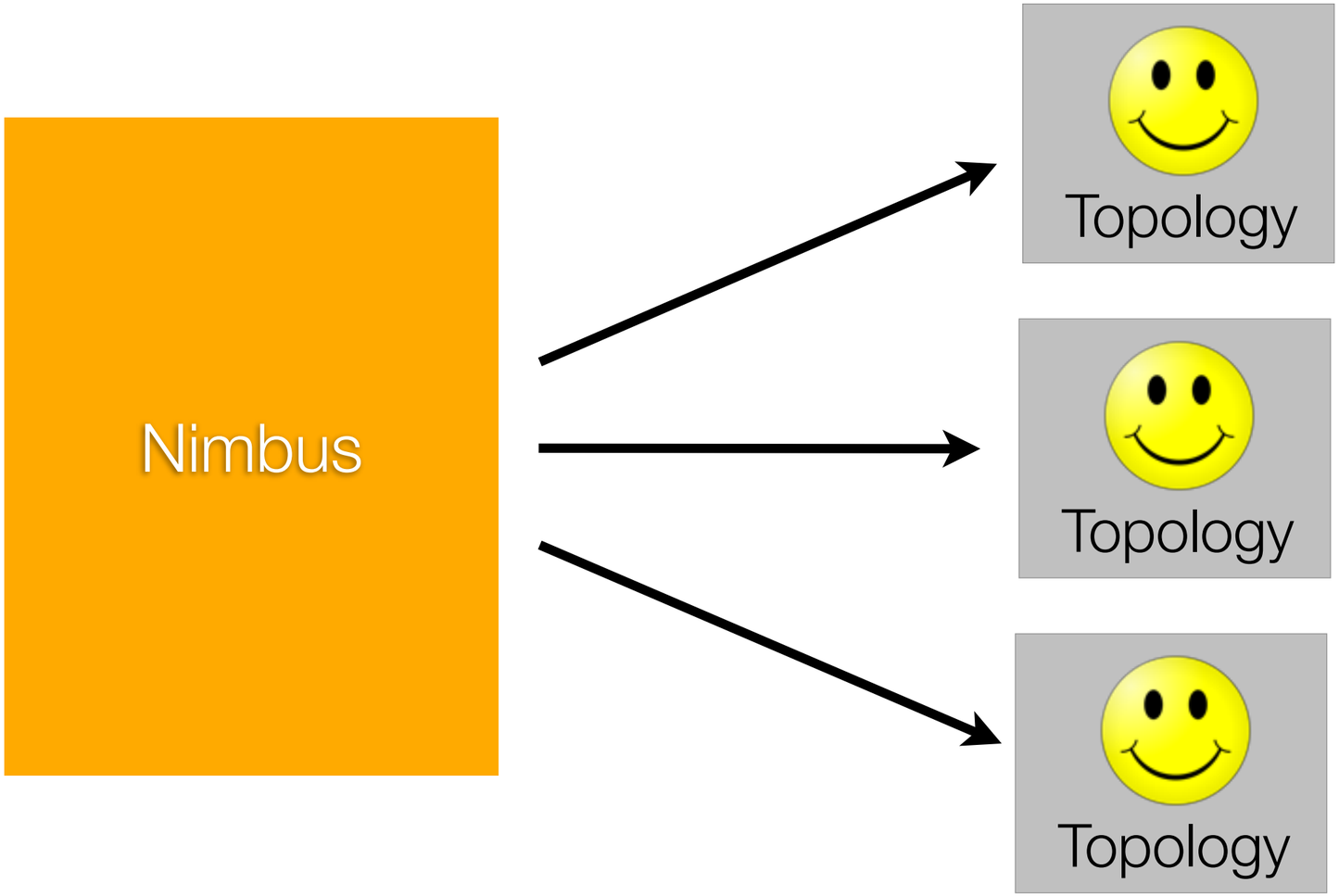
Storm



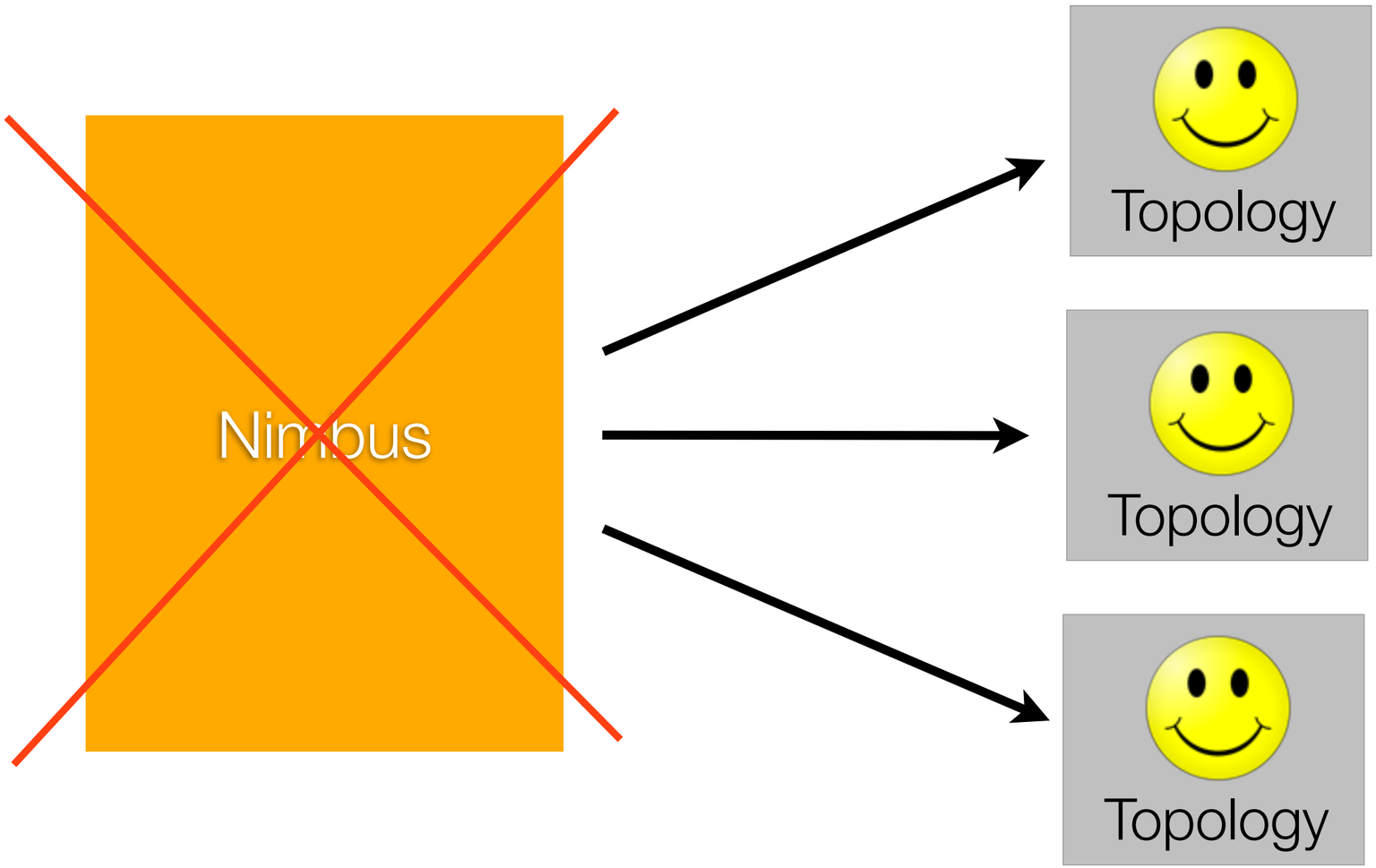
Storm



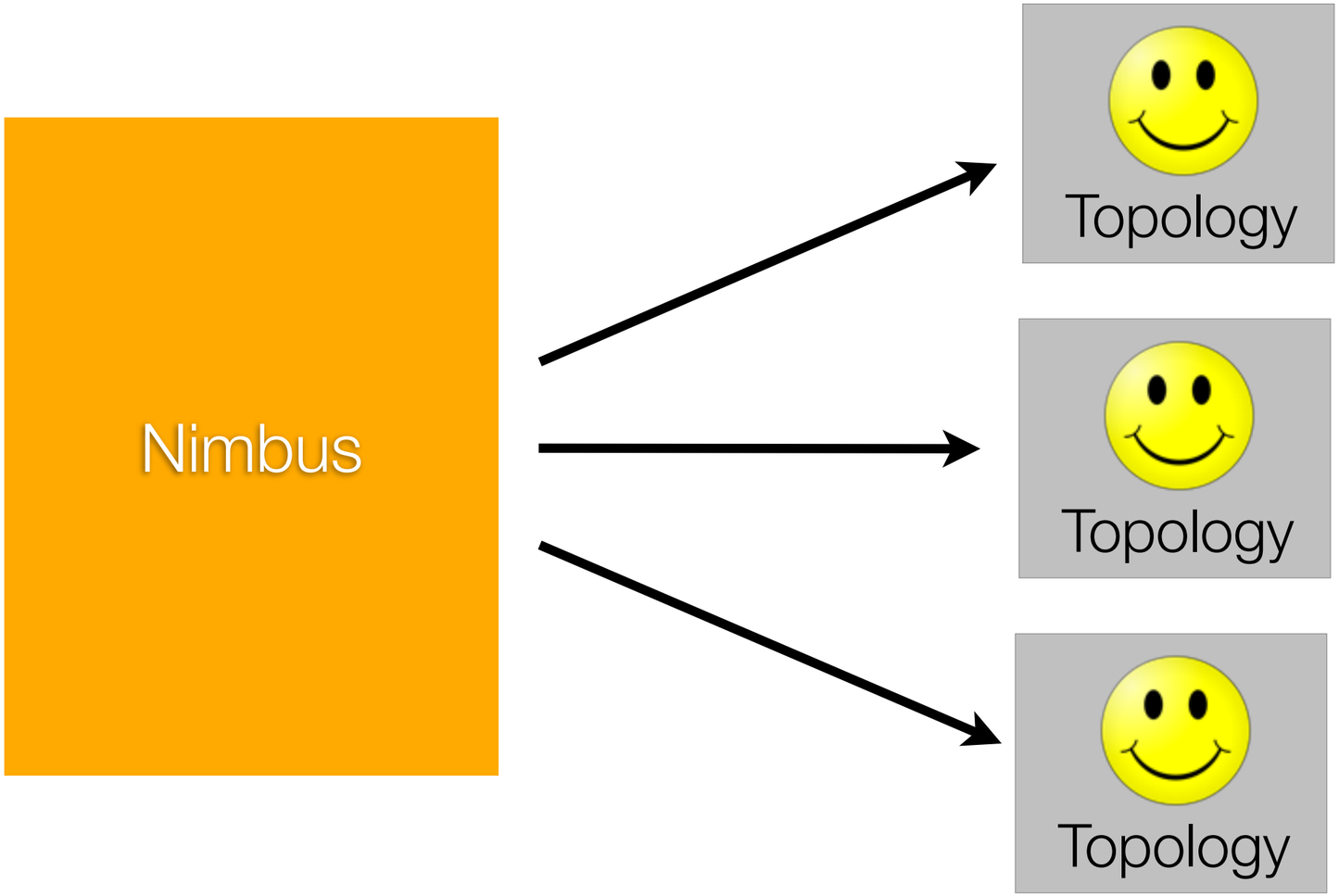
Storm

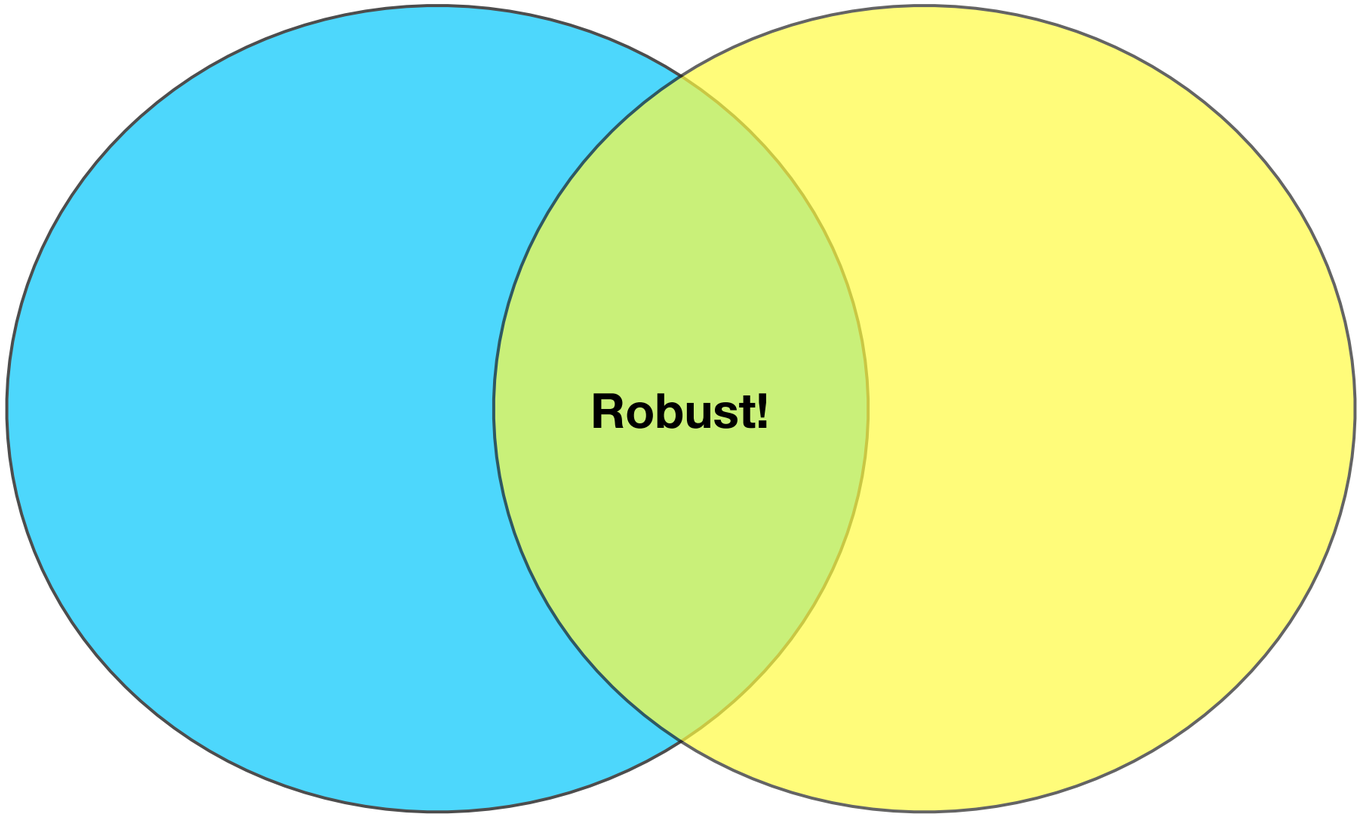


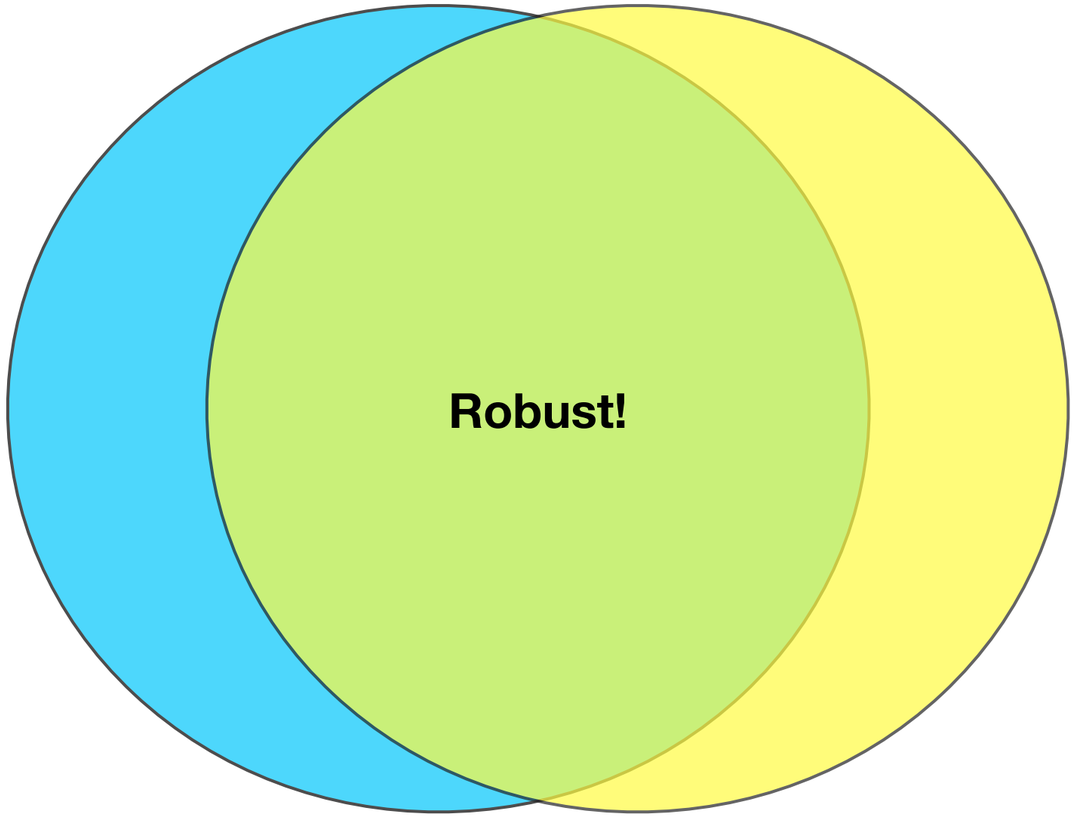
Storm



Storm




Robust!
Designed input space
Actual input space



Designed input space

Actual input space

Reasoning is fundamentally hard

So program in ways that require less of it

```
public int foo(int a, Object b) {
    int c = this.bar.bar(a);
    if(c>10 && this.dug.helper(b)) {
        return c*2;
    } else {
        return c;
    }
}
```

```
public int fib(int n) {
    if(n==0 || n==1) return 1;
    else return fib(n-1) + fib(n-2);
}
```

Pure function

Mutability is hard to reason about

Minimize state mutation

Functional programming

Clojure

skepticism(skepticism)


perfect software

Thank you