Objects, Anomalies, and Actors: The Next Revolution

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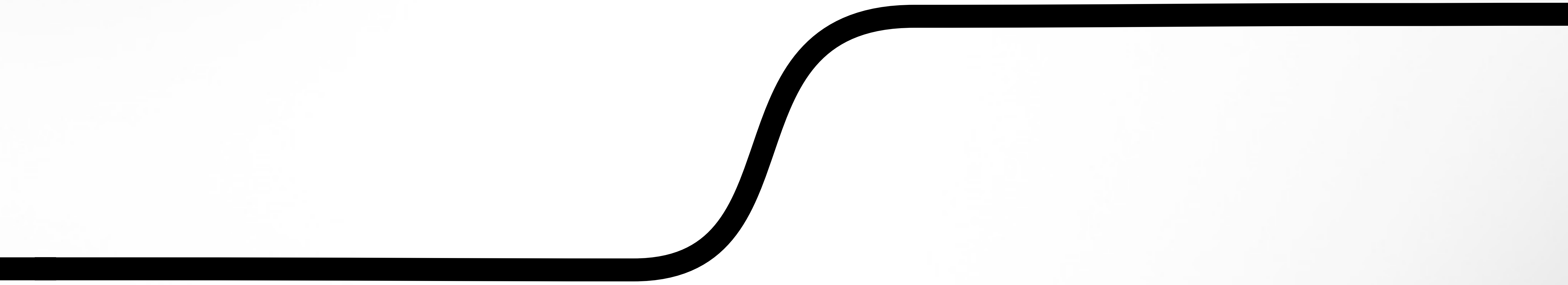
- This is actually Kresten Krab Thorup's talk, but he couldn't attend the conference
  - he's CTO of Trifork
  - and an important part of the team behind the QCon and GOTO conferences

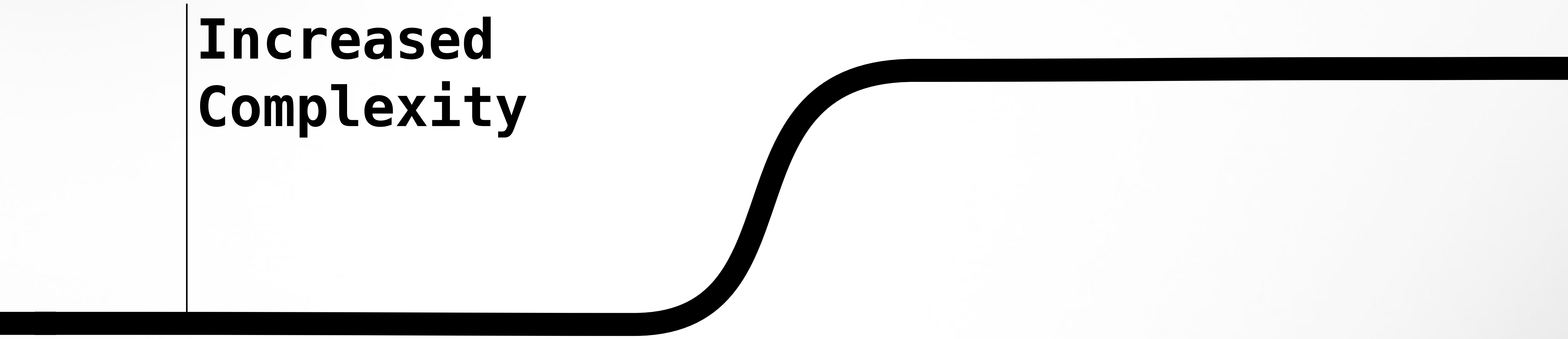
- I'm covering for him here, giving my interpretation of his material
- These are (mostly) his slides, I've changed a few and inserted some of my own

basho

'90s Object Revolution



’90s Object Revolution



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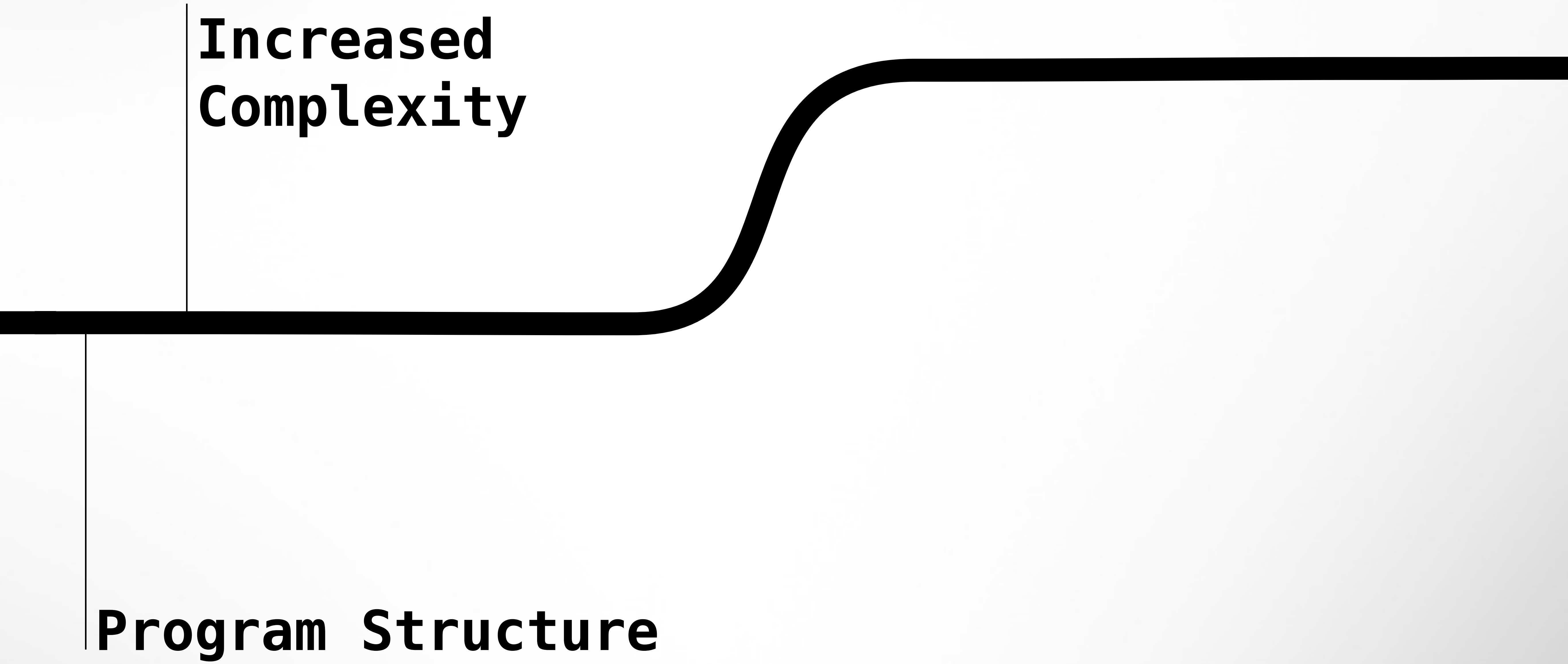
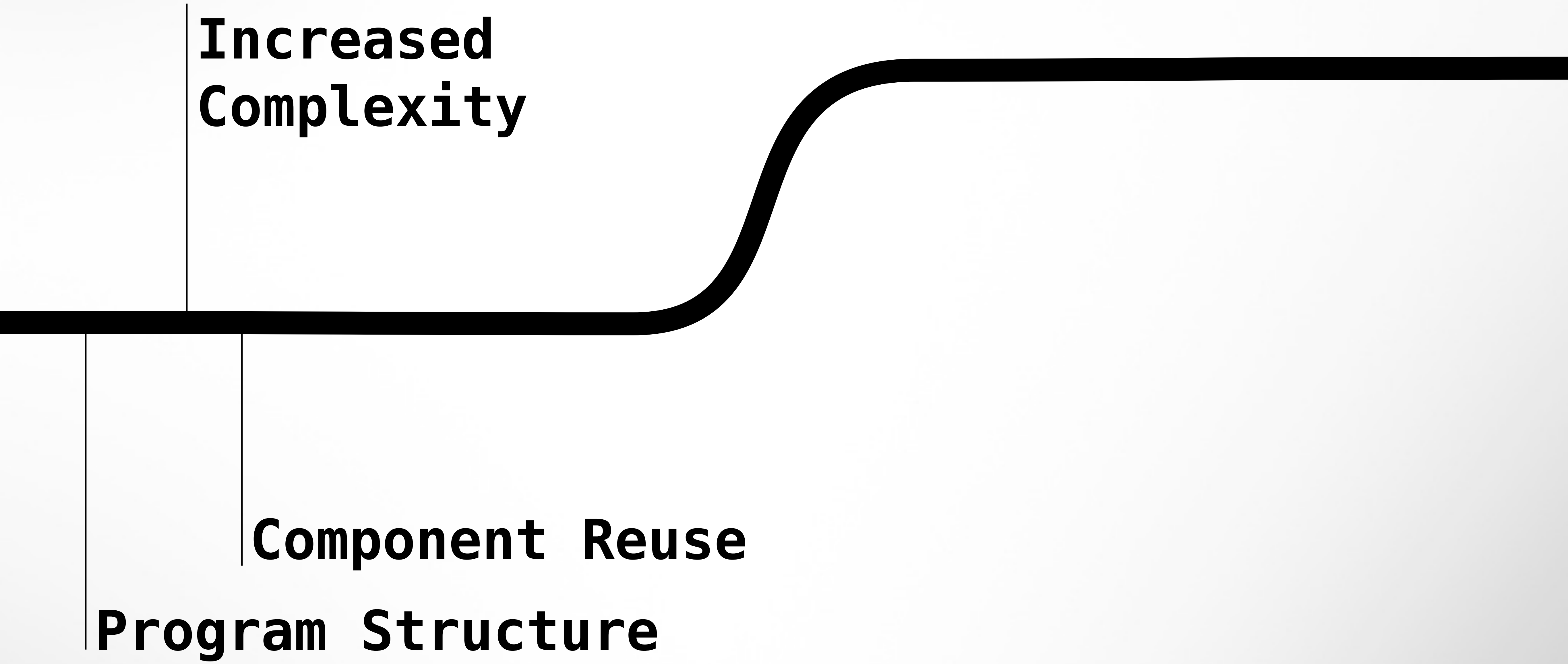
'90s Object Revolution



'90s Object Revolution



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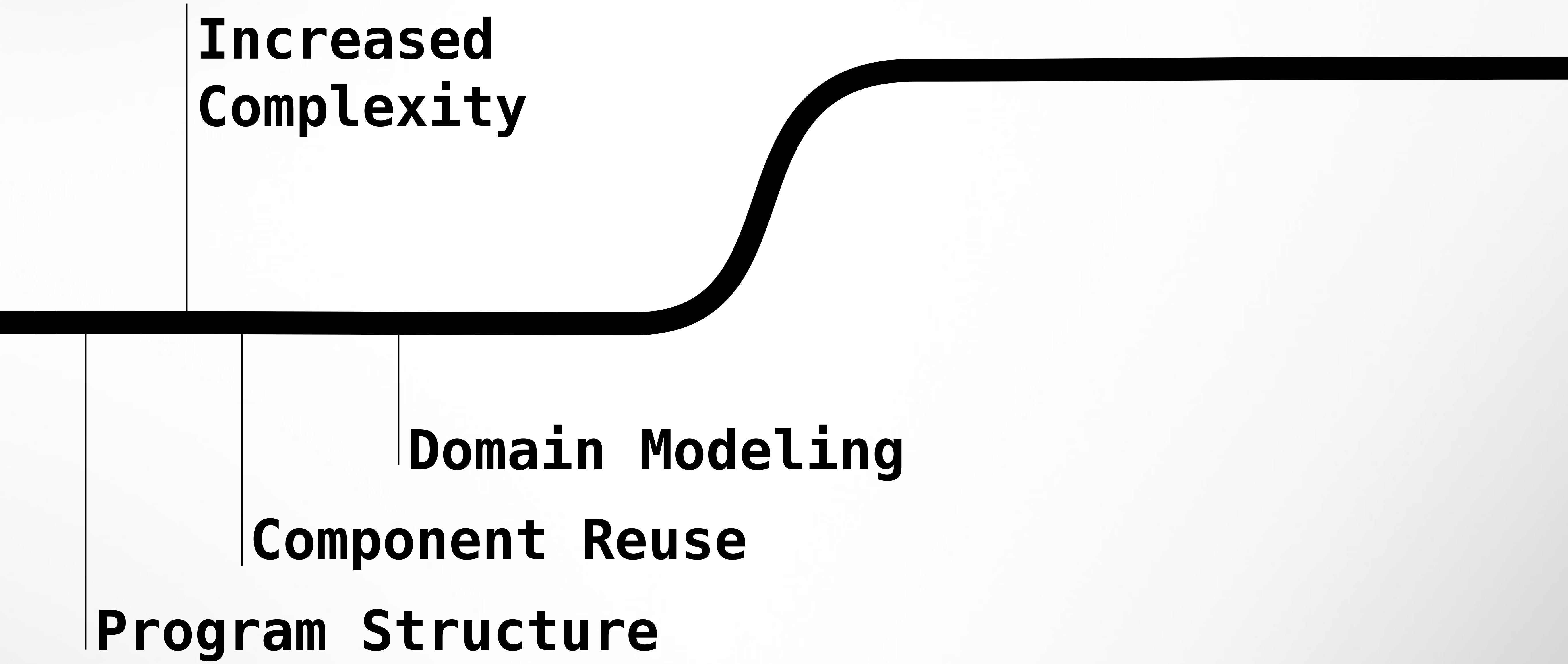
'90s Object Revolution



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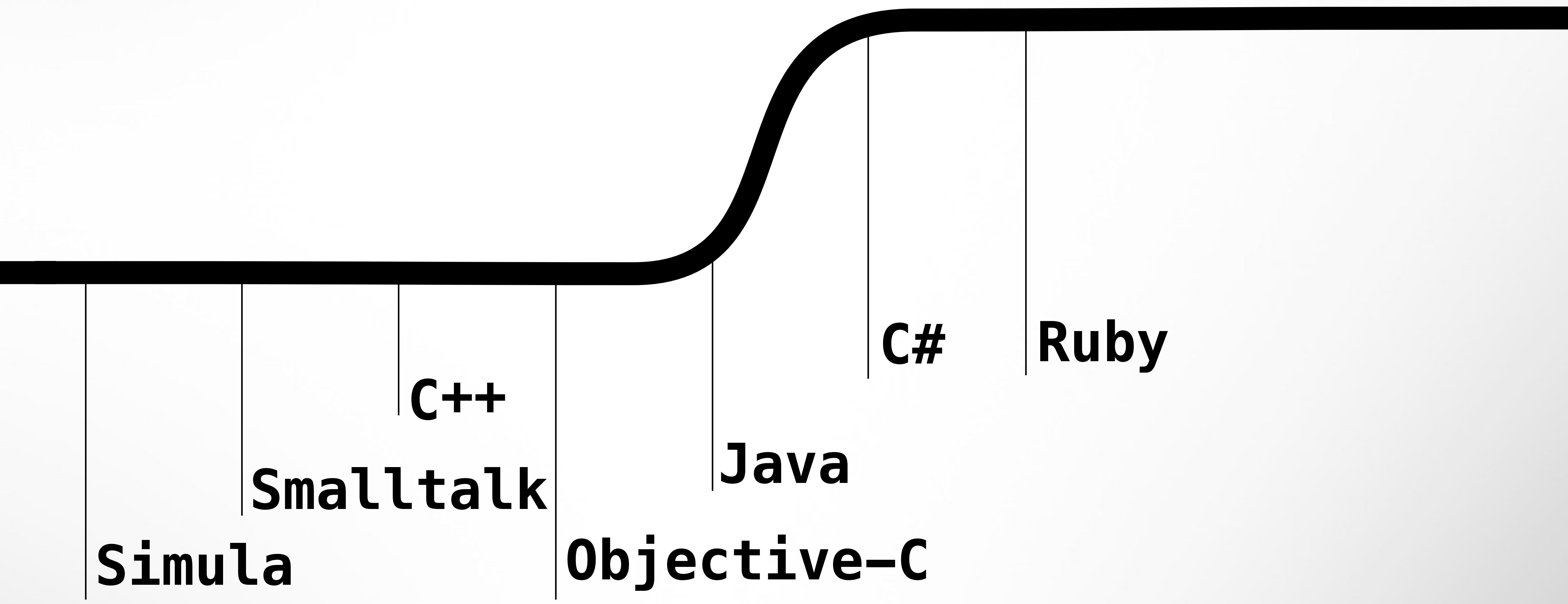
Languages



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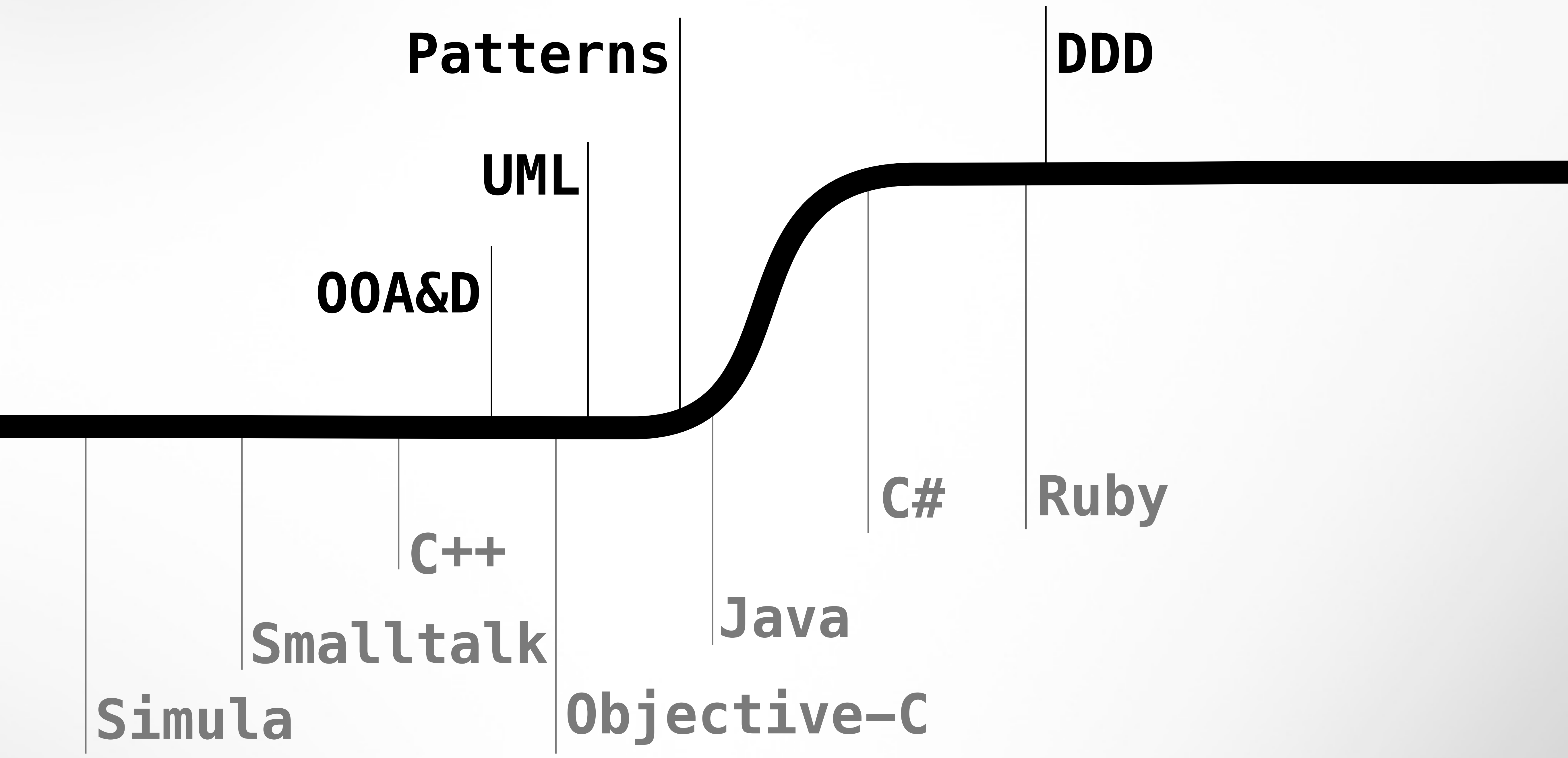
Thinking Tools



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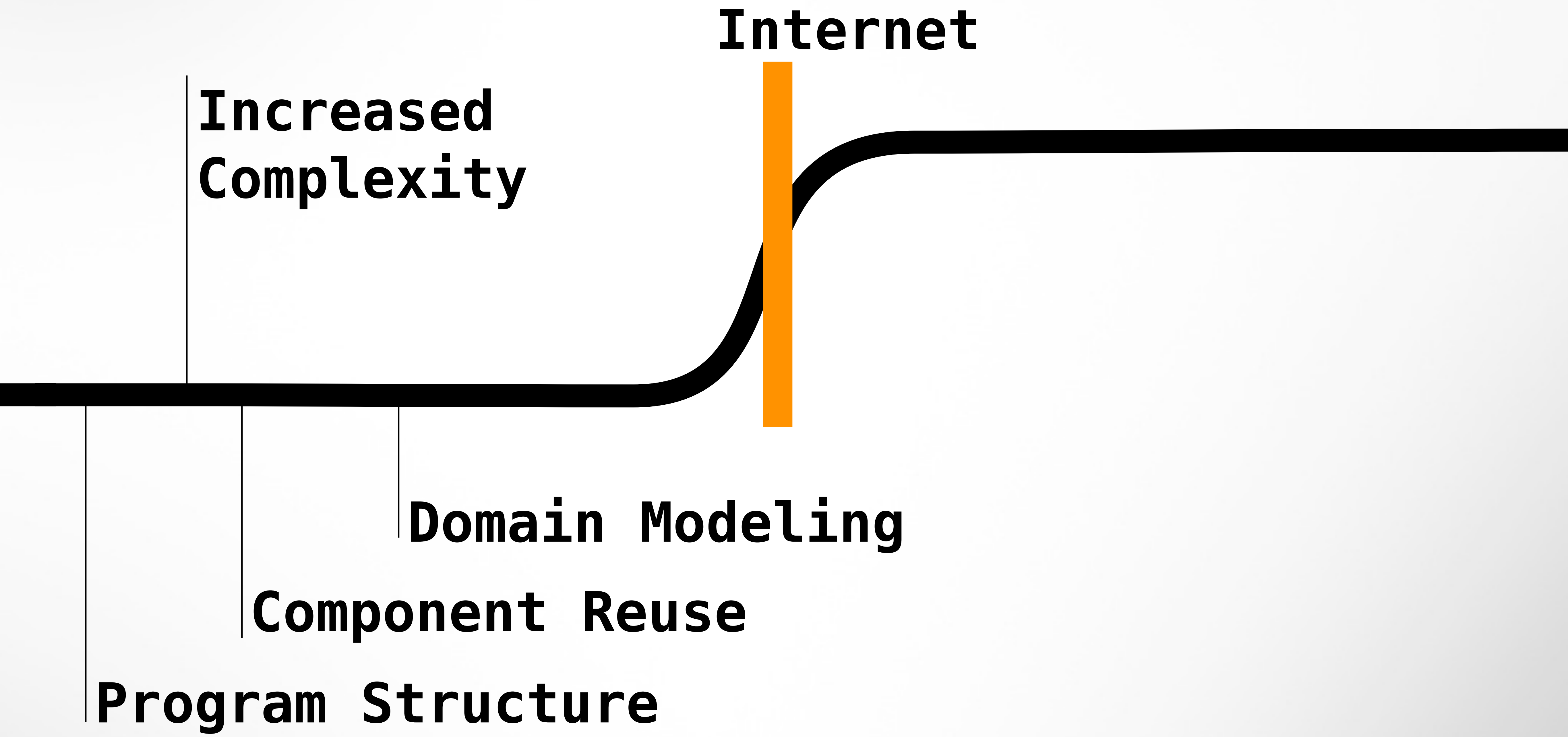
Internet
Increased Complexity
Domain Modeling
Component Reuse
Program Structure

More Complexity

Infrastructure made of Software

More Complexity

Infrastructure made of Software

More Complexity

Infrastructure made of Software

Fault Tolerance, Availability, QoS

More Complexity

Infrastructure made of Software

Integration, Coordination

Fault Tolerance, Availability, QoS

More Complexity

Infrastructure made of Software

Cloud, Multi-Core

Integration, Coordination

Fault Tolerance, Availability, QoS

More Complexity

Infrastructure m

We're struggling to handle these with an object mindset!

Cloud, Multi-Core

Integration, Coordination

Fault Tolerance, Availability, QoS

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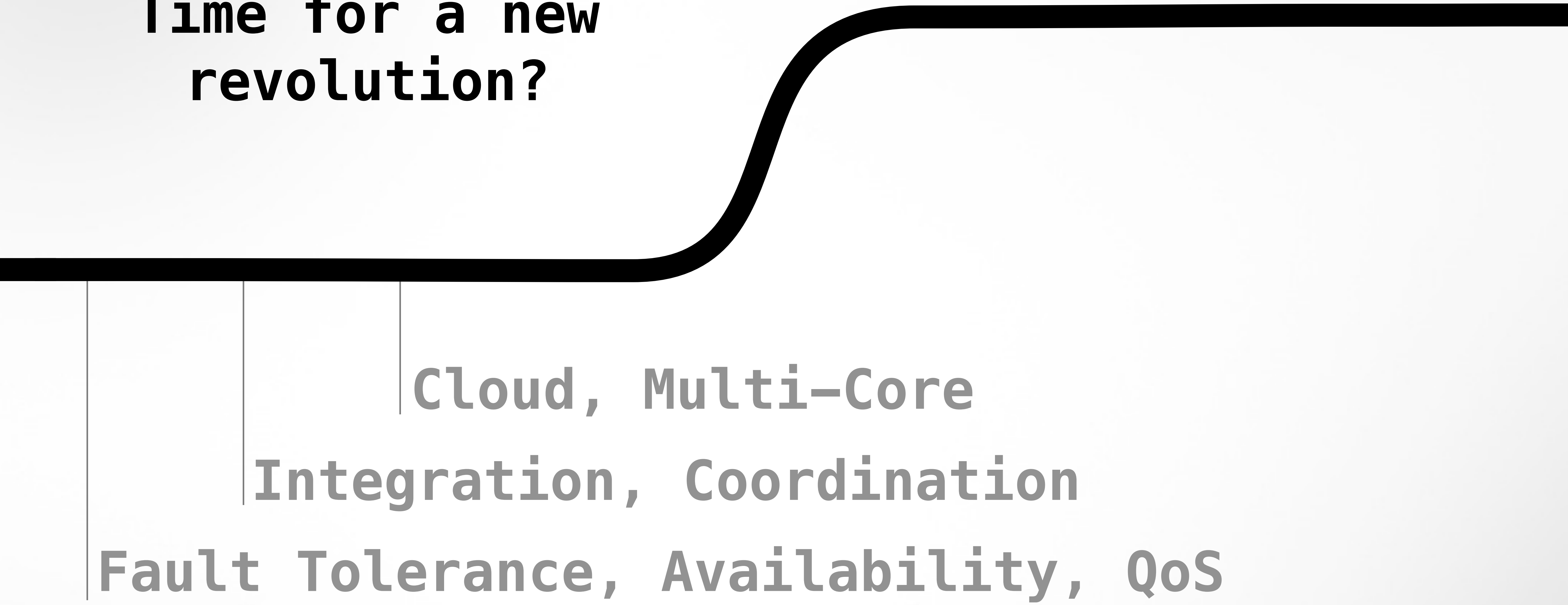
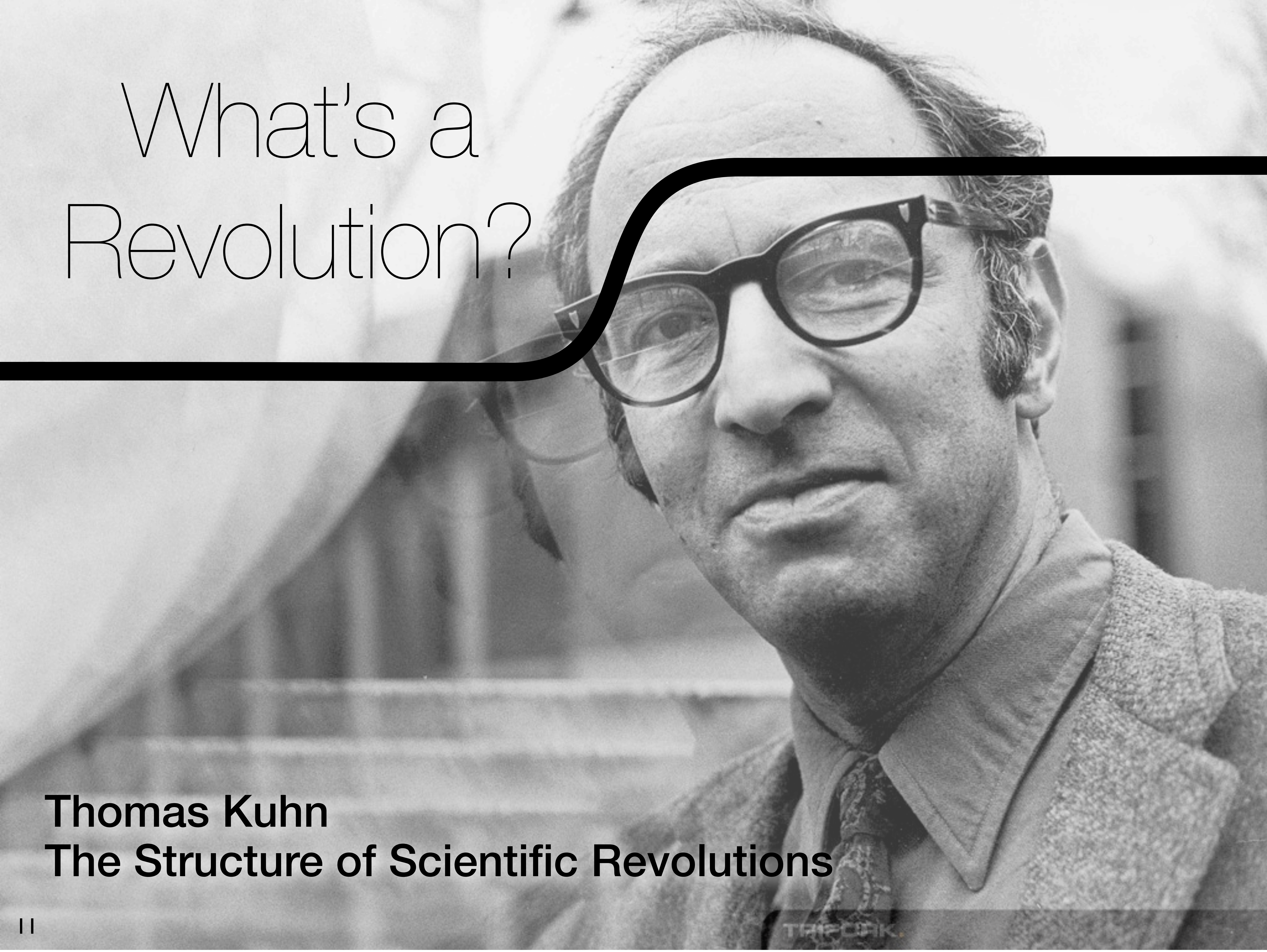
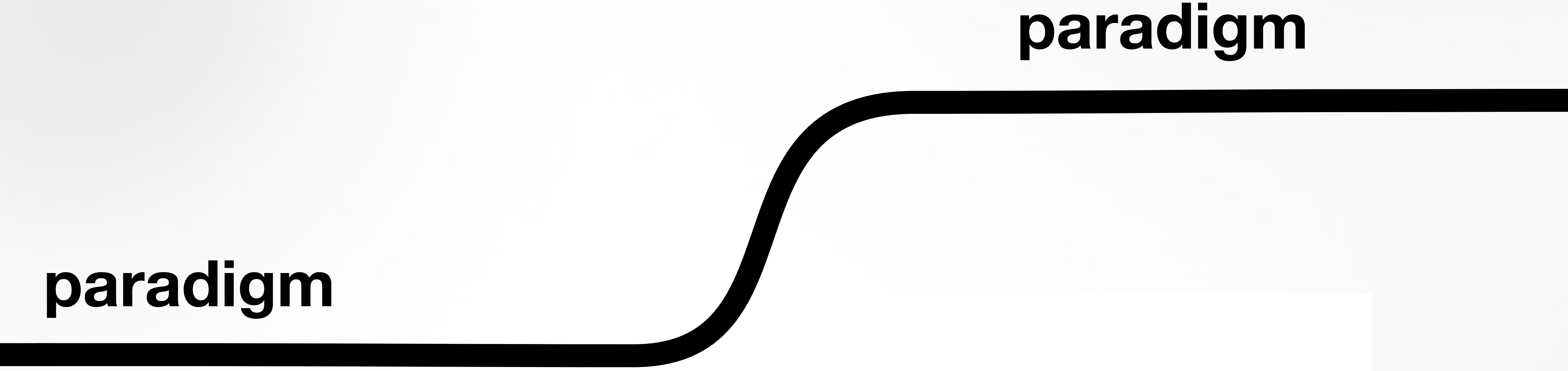
Time for a new revolution?





What's a Revolution?

Thomas Kuhn
The Structure of Scientific Revolutions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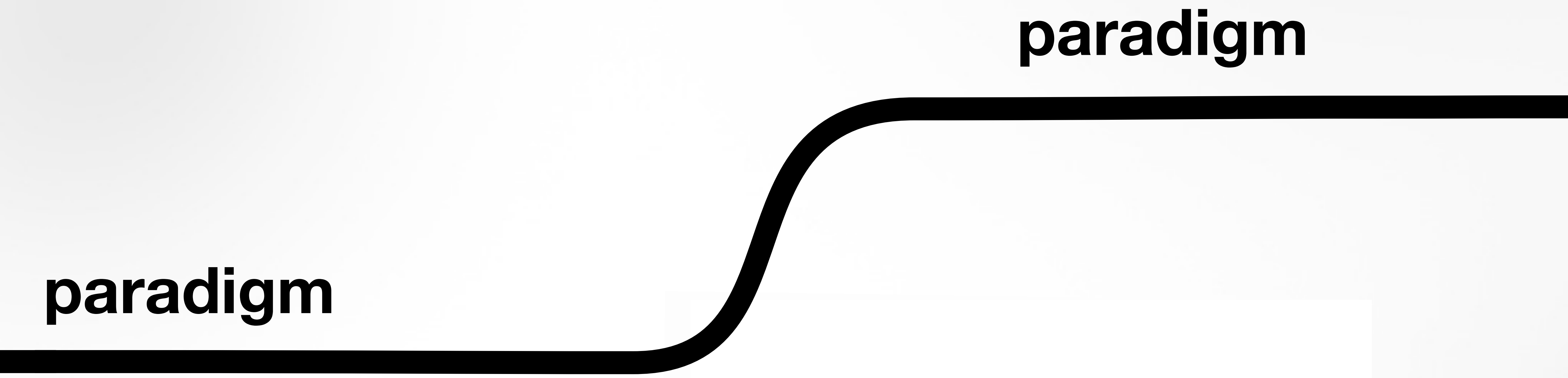
paradigm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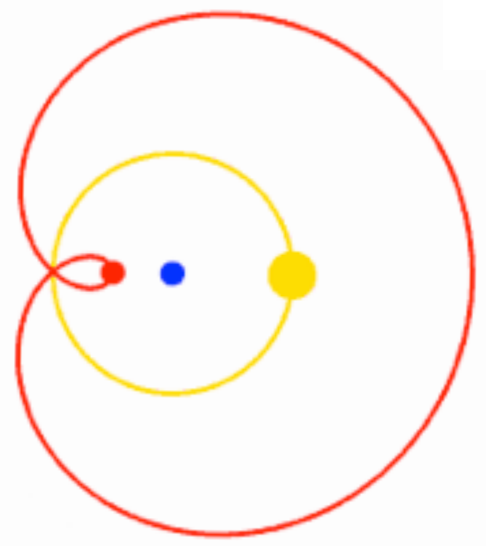
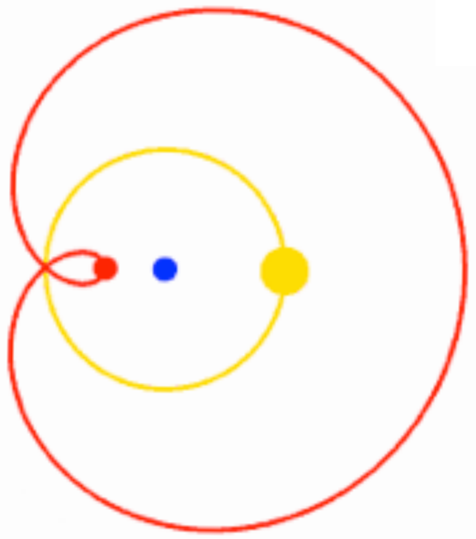


paradigm

paradigm

normal science



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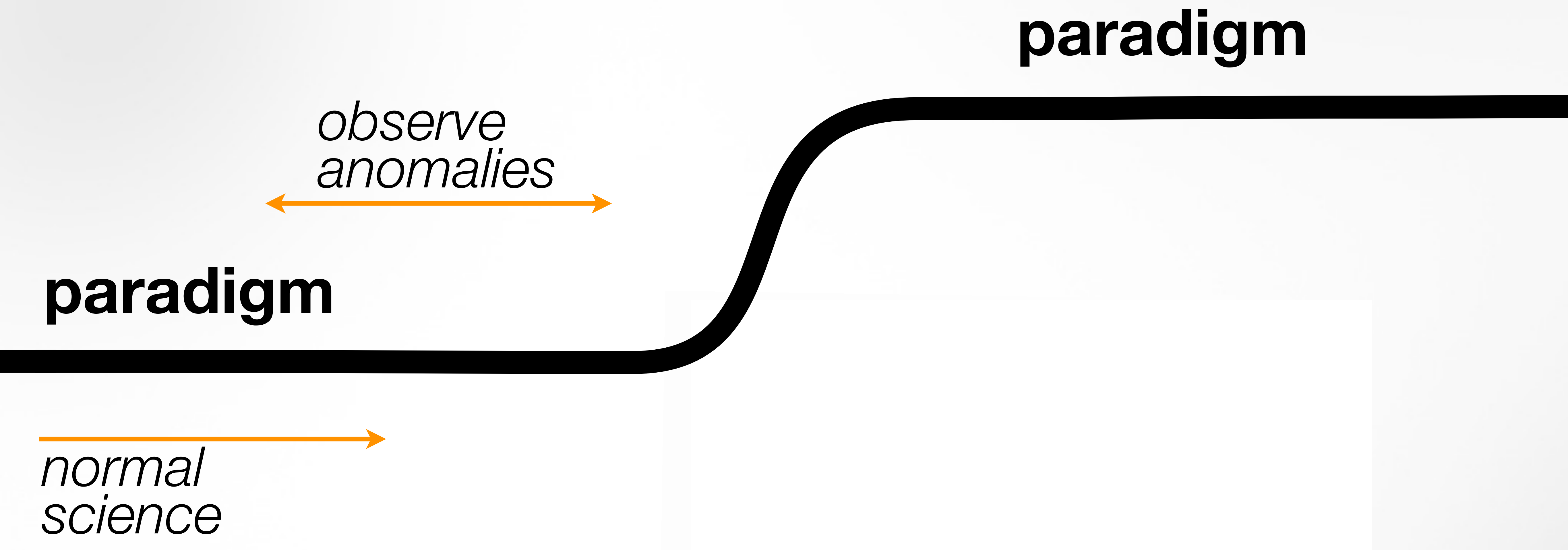

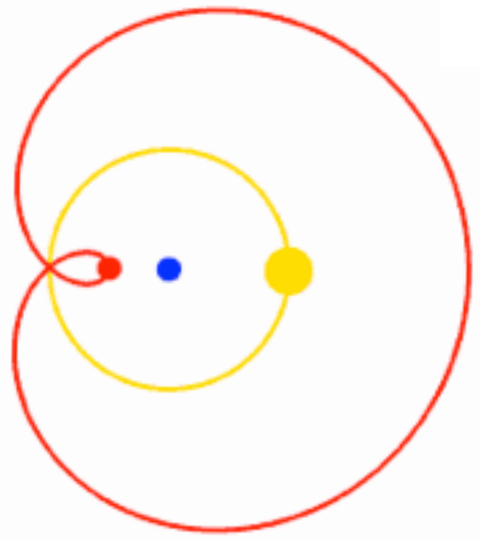

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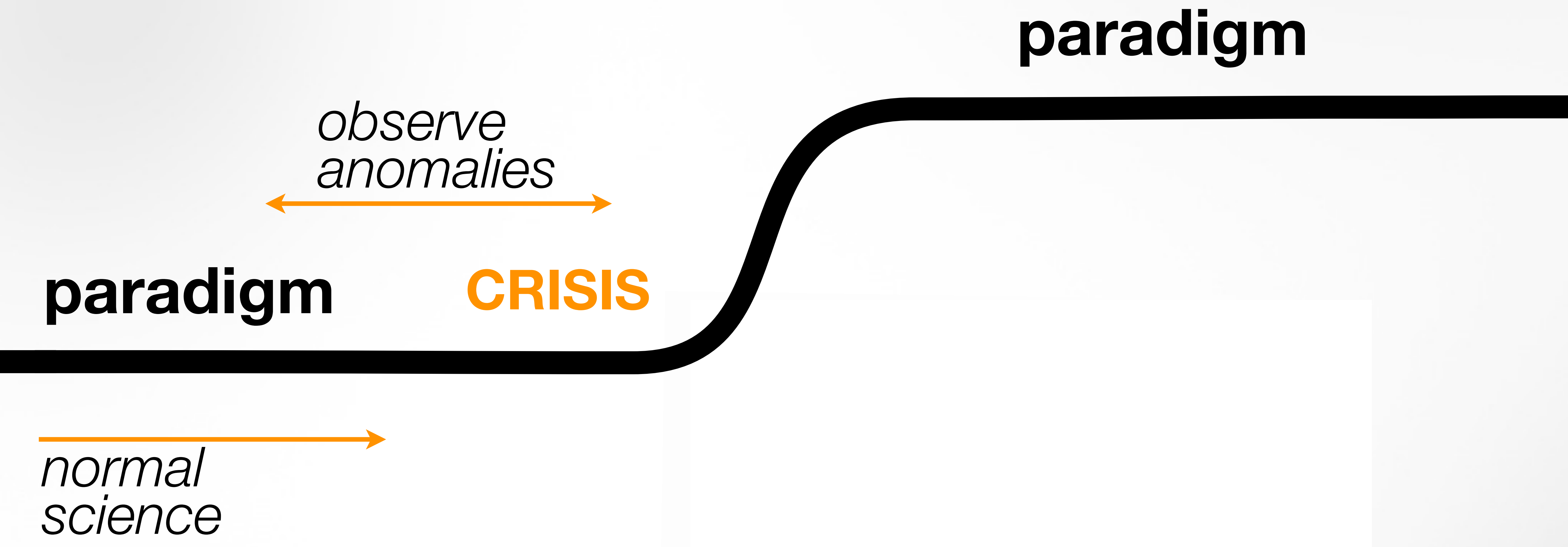
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observe anomalies
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CRISIS
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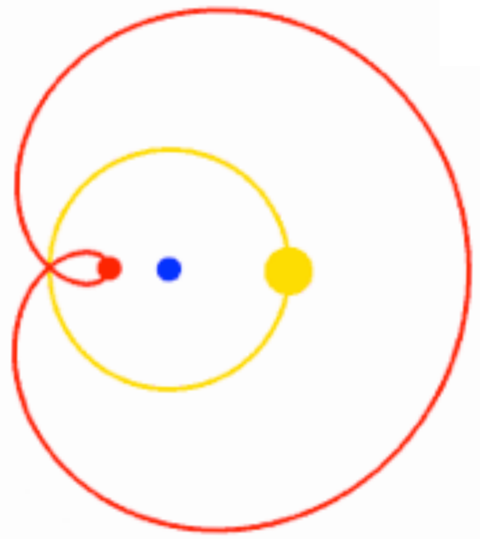

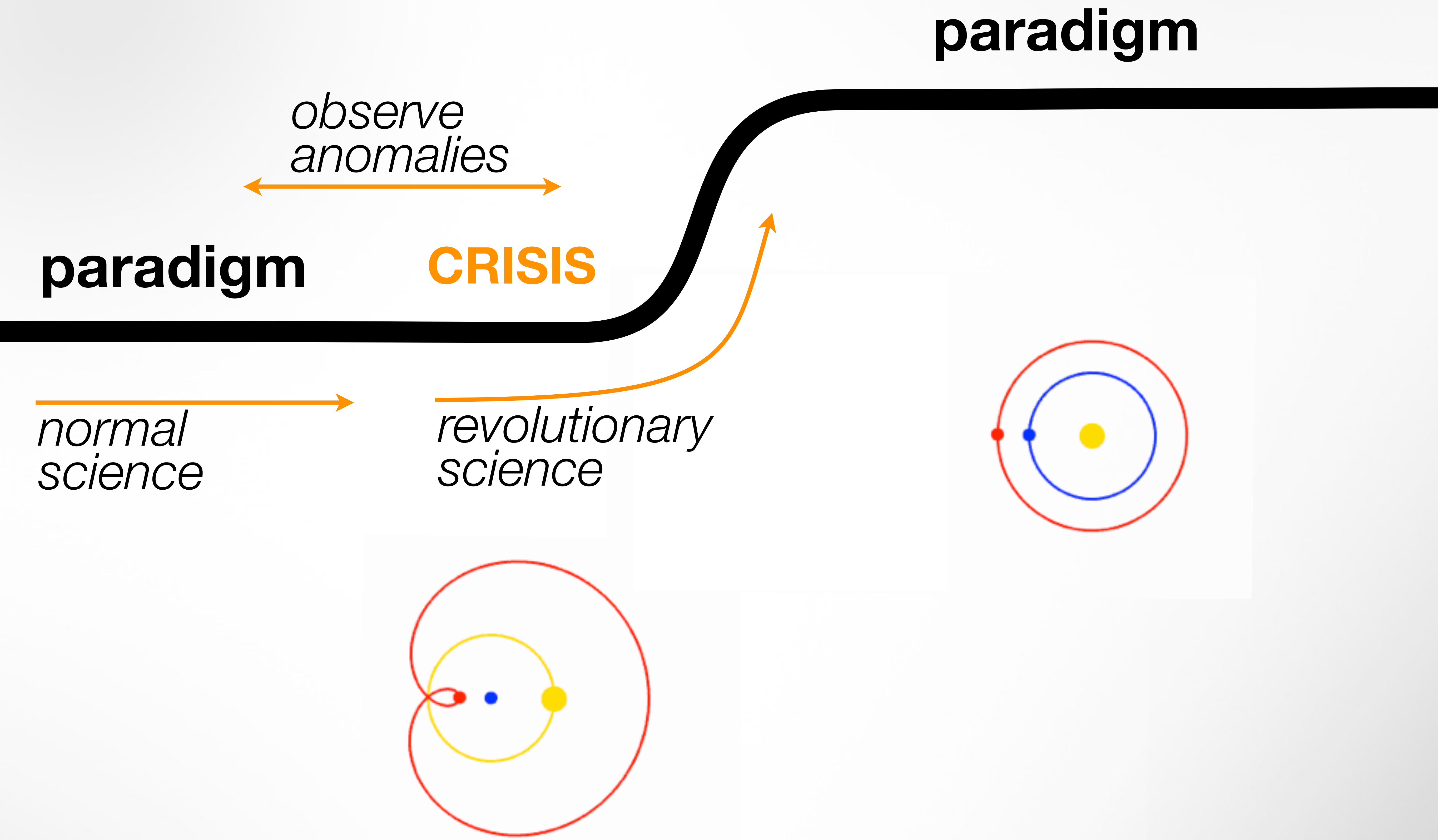
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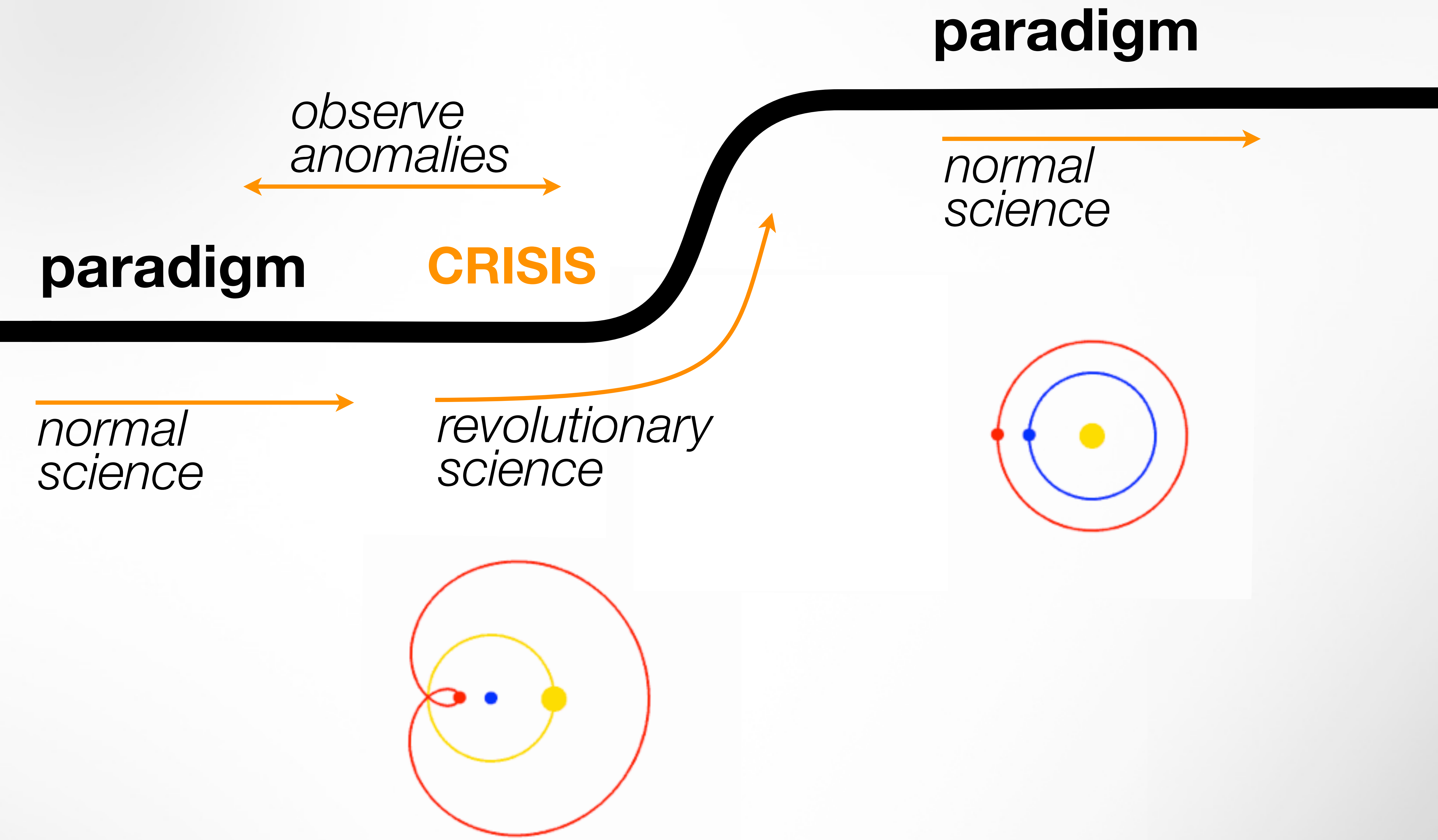
revolutionary science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observe anomalies
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CRISIS
normal science
revolutionary science
normal science

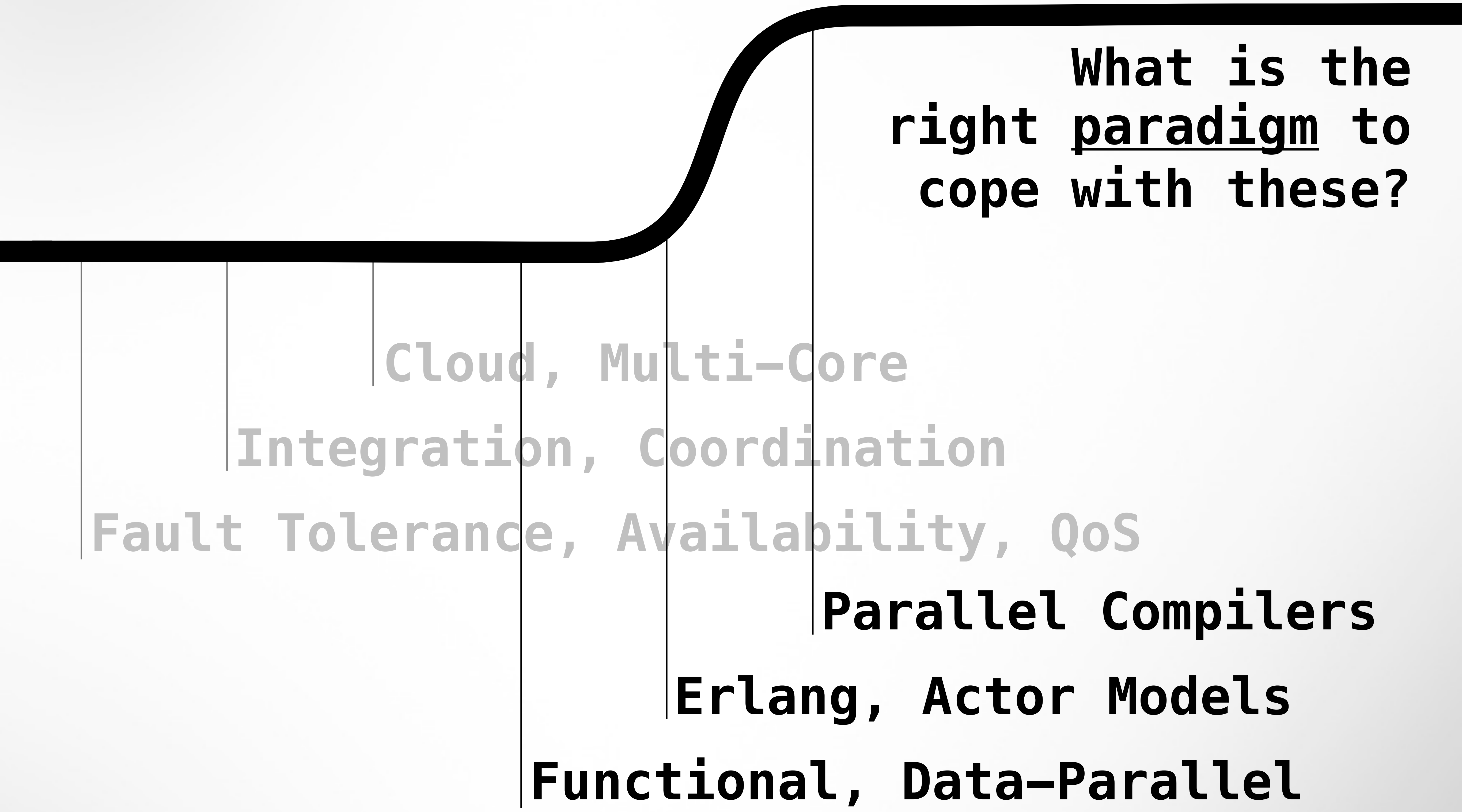
What is the right <u>paradigm</u> to cope with these?

Cloud, Multi-Core

Integration, Coordination

Fault Tolerance, Availability, QoS

What is the right paradigm to cope with these?



Cloud, Multi-Core

Integration, Coordination

Fault Tolerance, Availability, QoS

Parallel Compilers

Erlang, Actor Models

Functional, Data-Parallel

Ralph Johnson's blog
"Erlang, the Next Java"

... Erlang is going to be a very important language ... Its main advantage is that it is perfectly suited for the multi-core, web services future. In fact, it is the ONLY mature, rock-solid language that is suitable for writing highly scalable systems to run on multicore machines.

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these?

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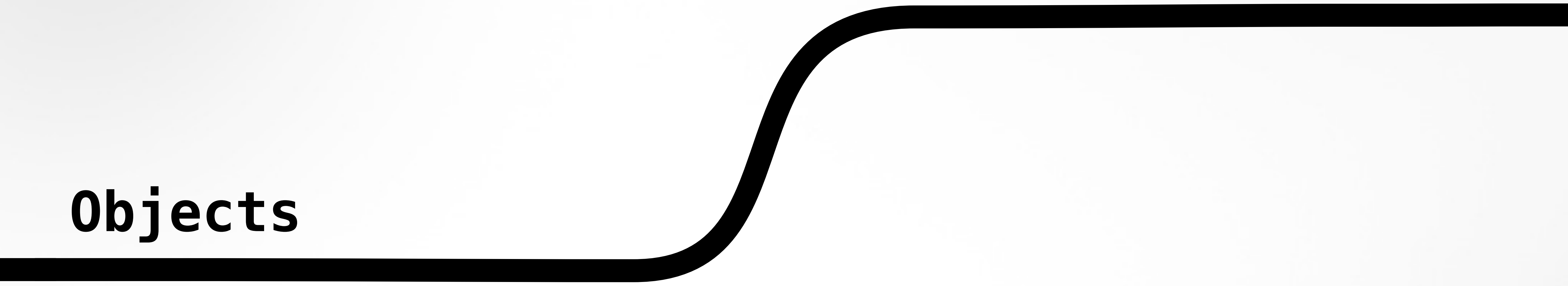
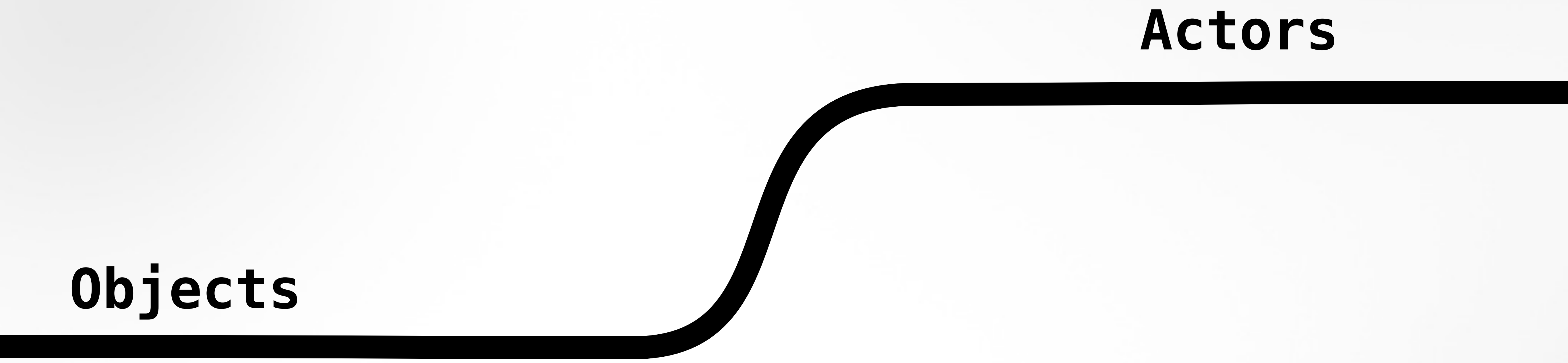
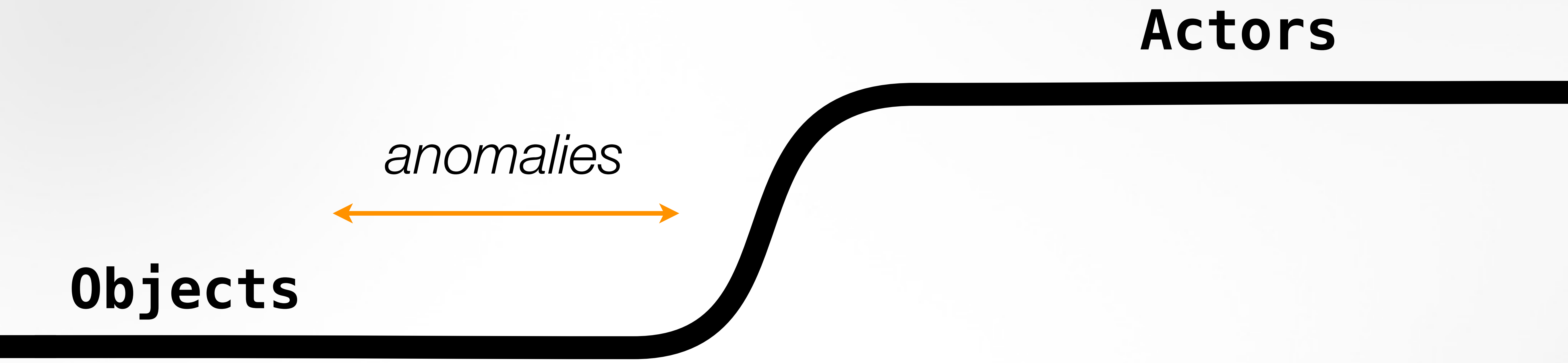
Data-Parallel


Objects
Actors

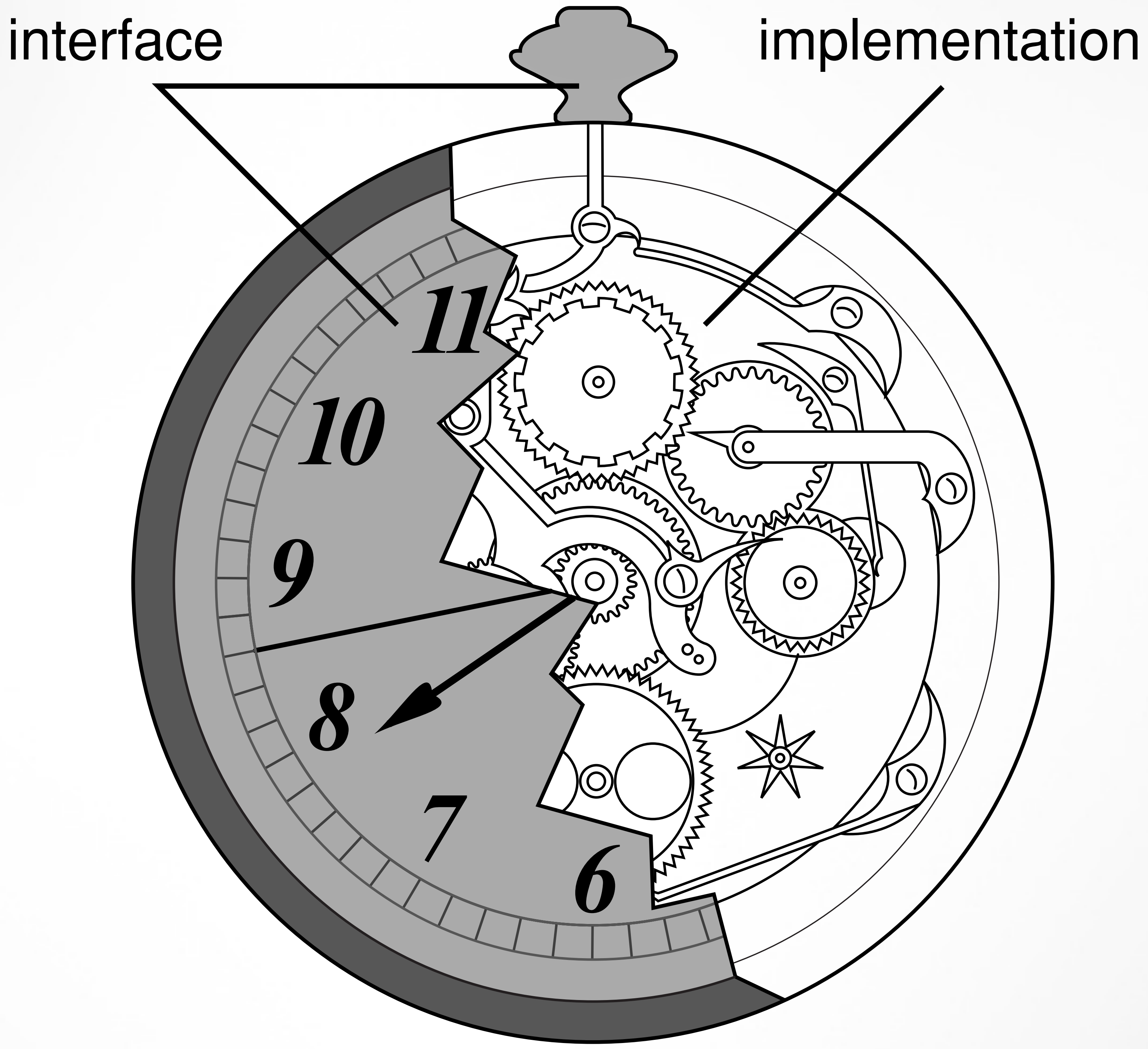

Actors
Objects


Actors
anomalies
Objects

Obj

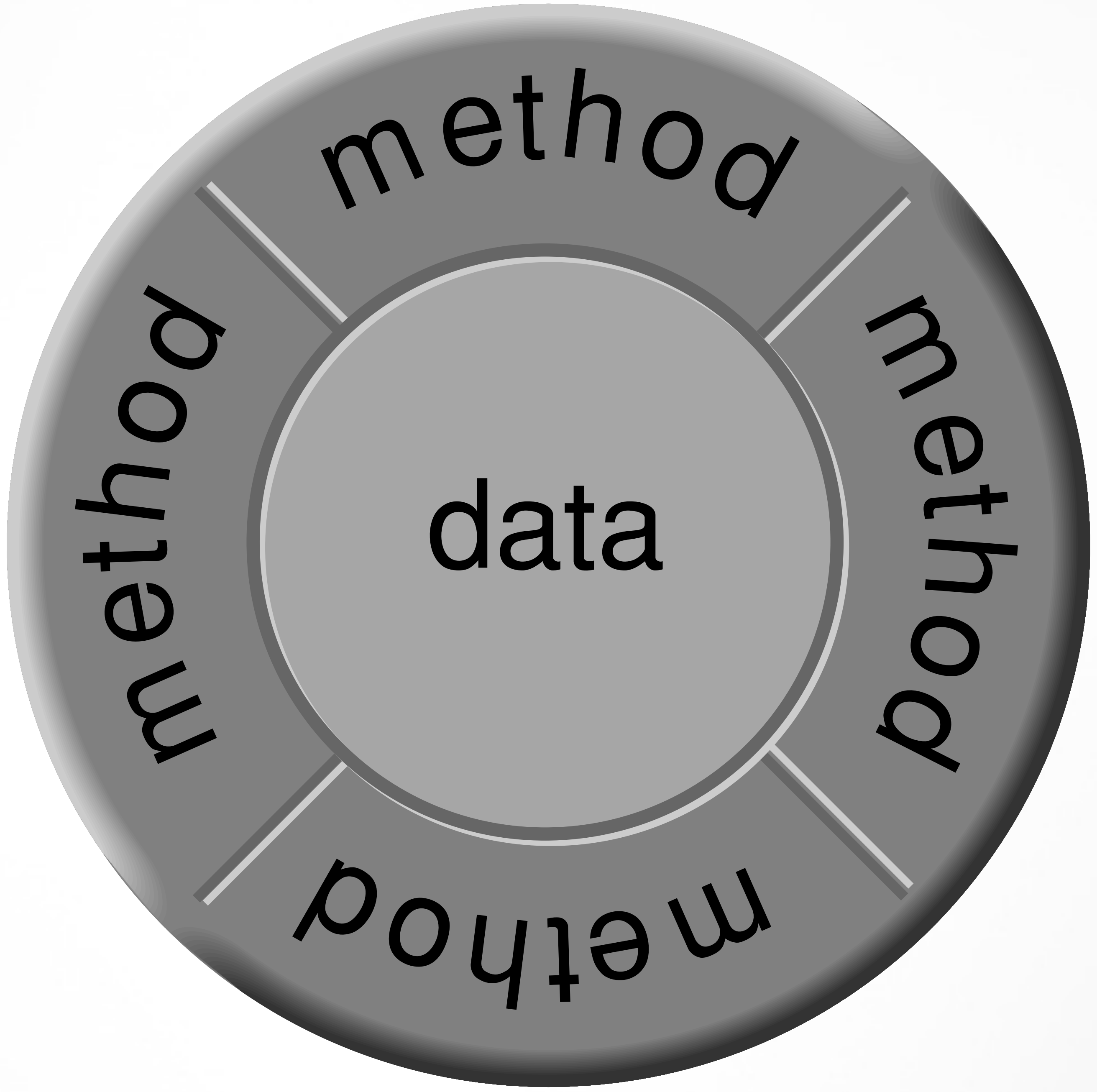
If Actor-Programming is the new Paradigm, What are the anomalies we should see now?

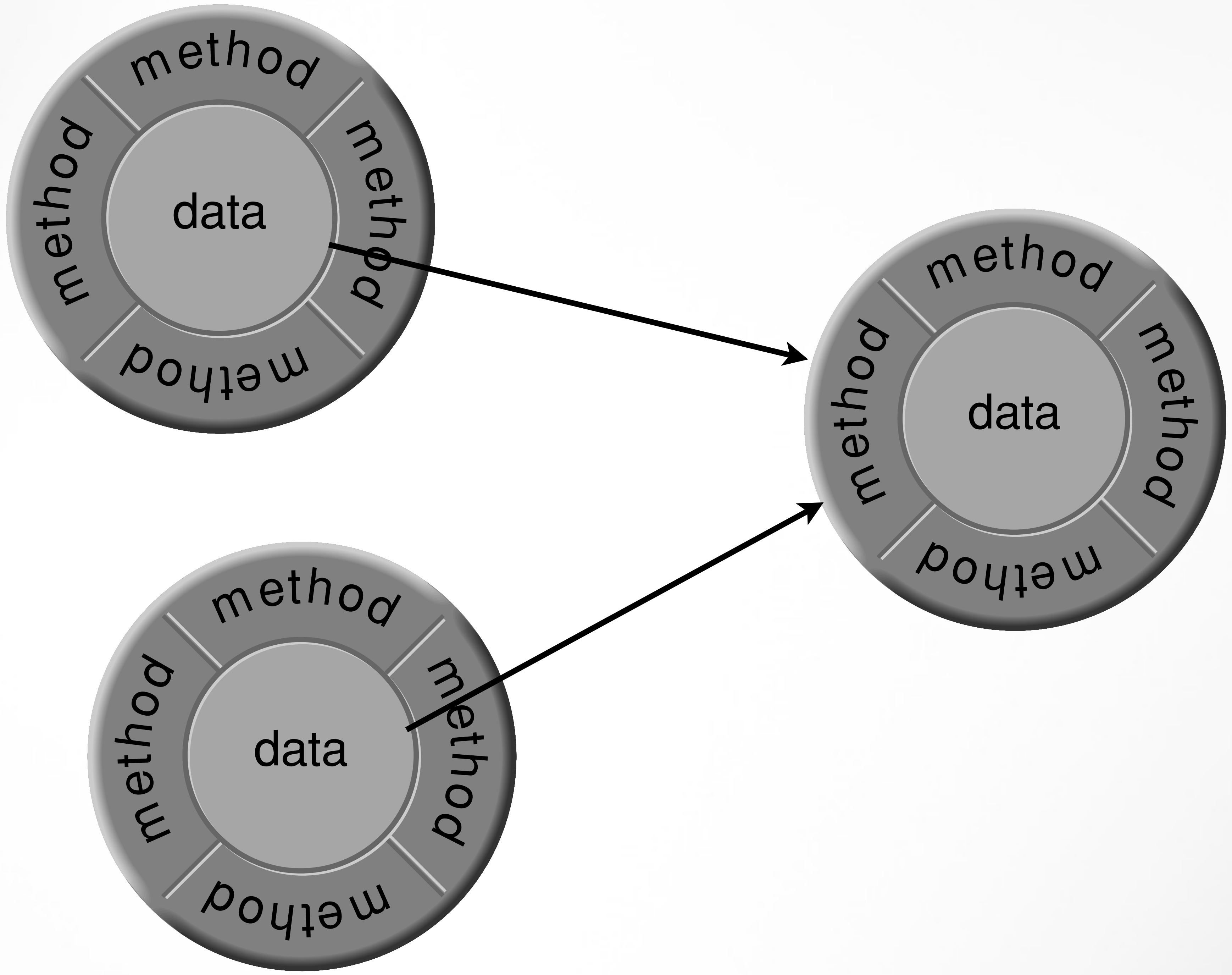
Anomalies in the object-oriented world view



Graphics from *Object-Oriented Programming with Objective C*, Apple, 2011

Encapsulation

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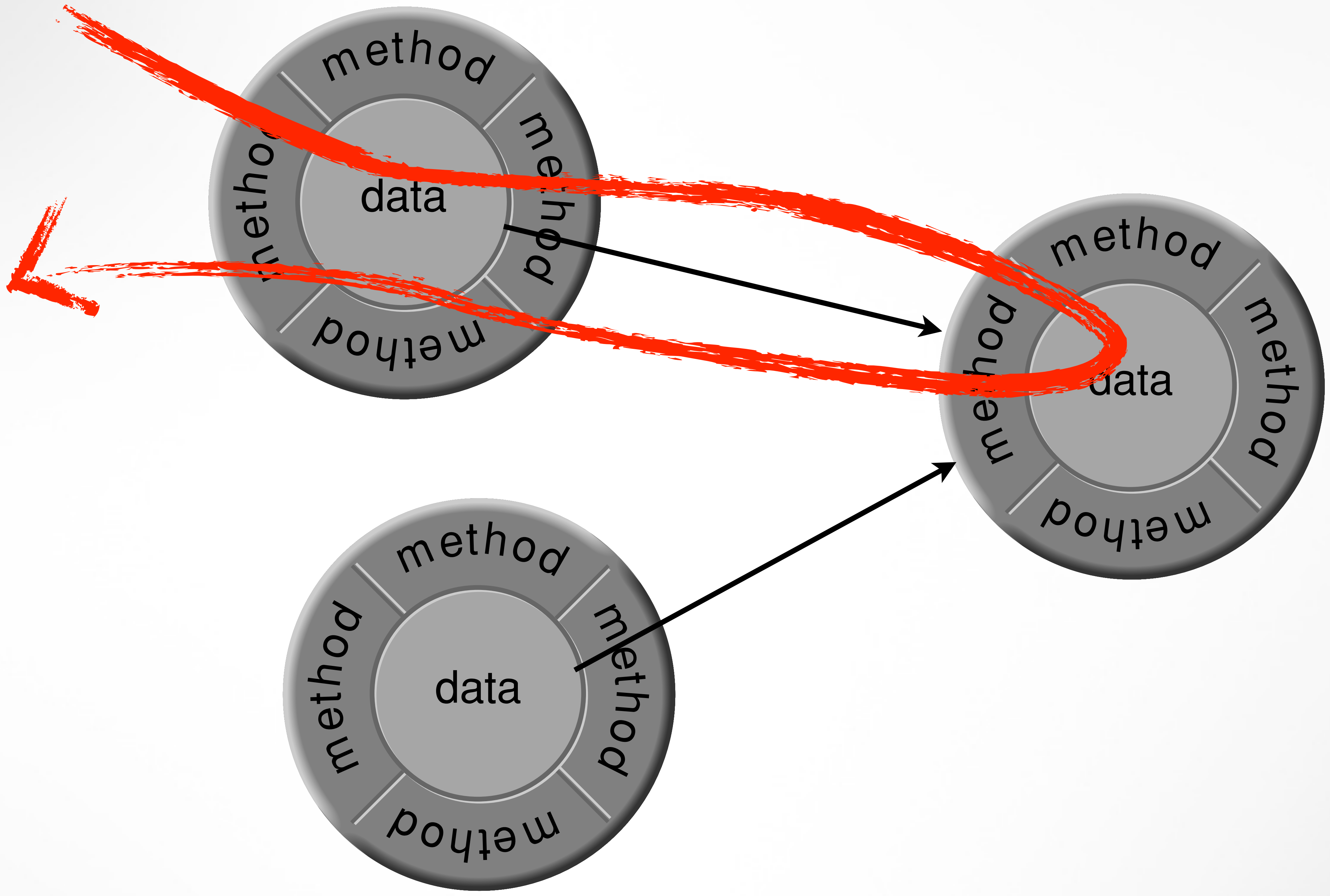
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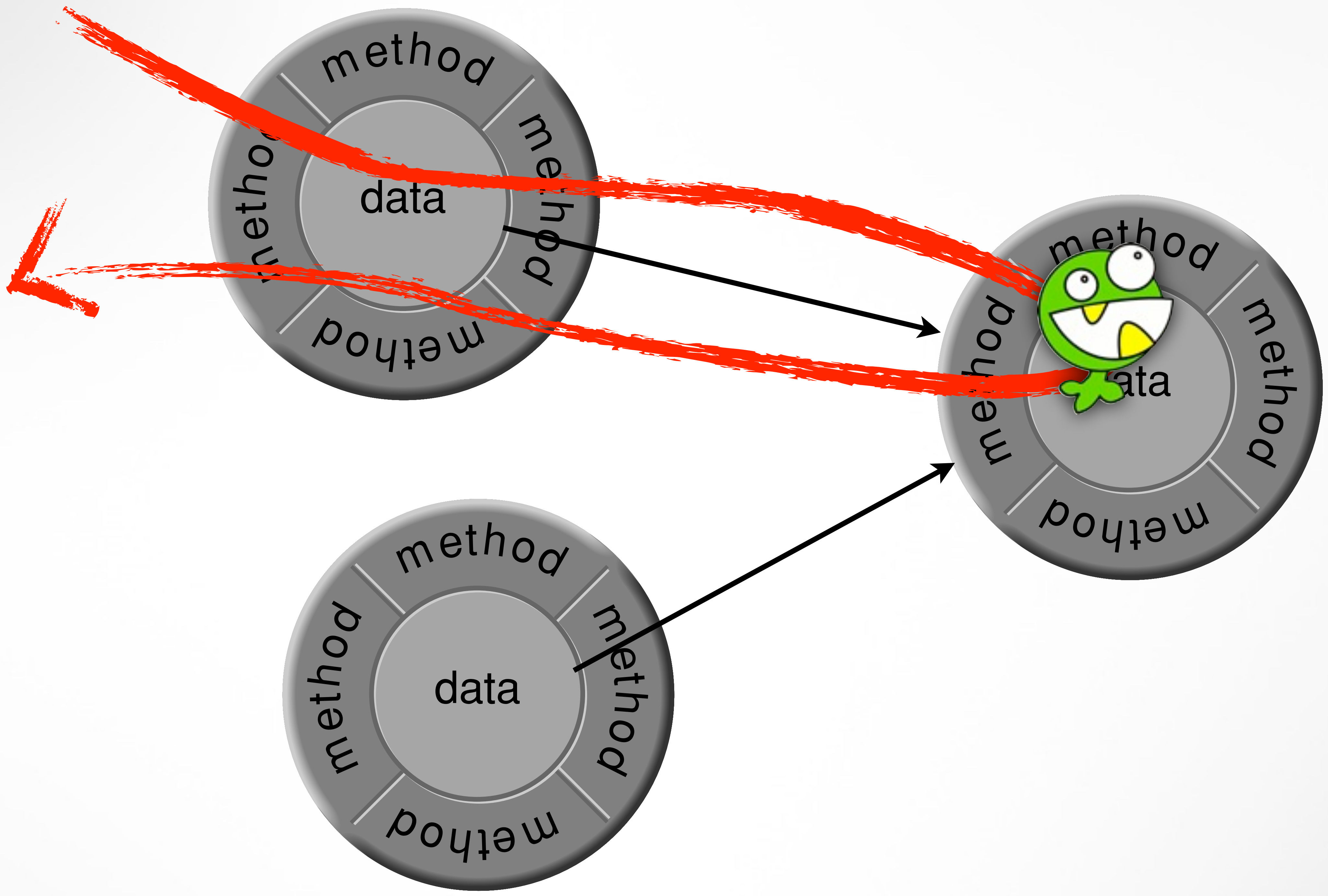
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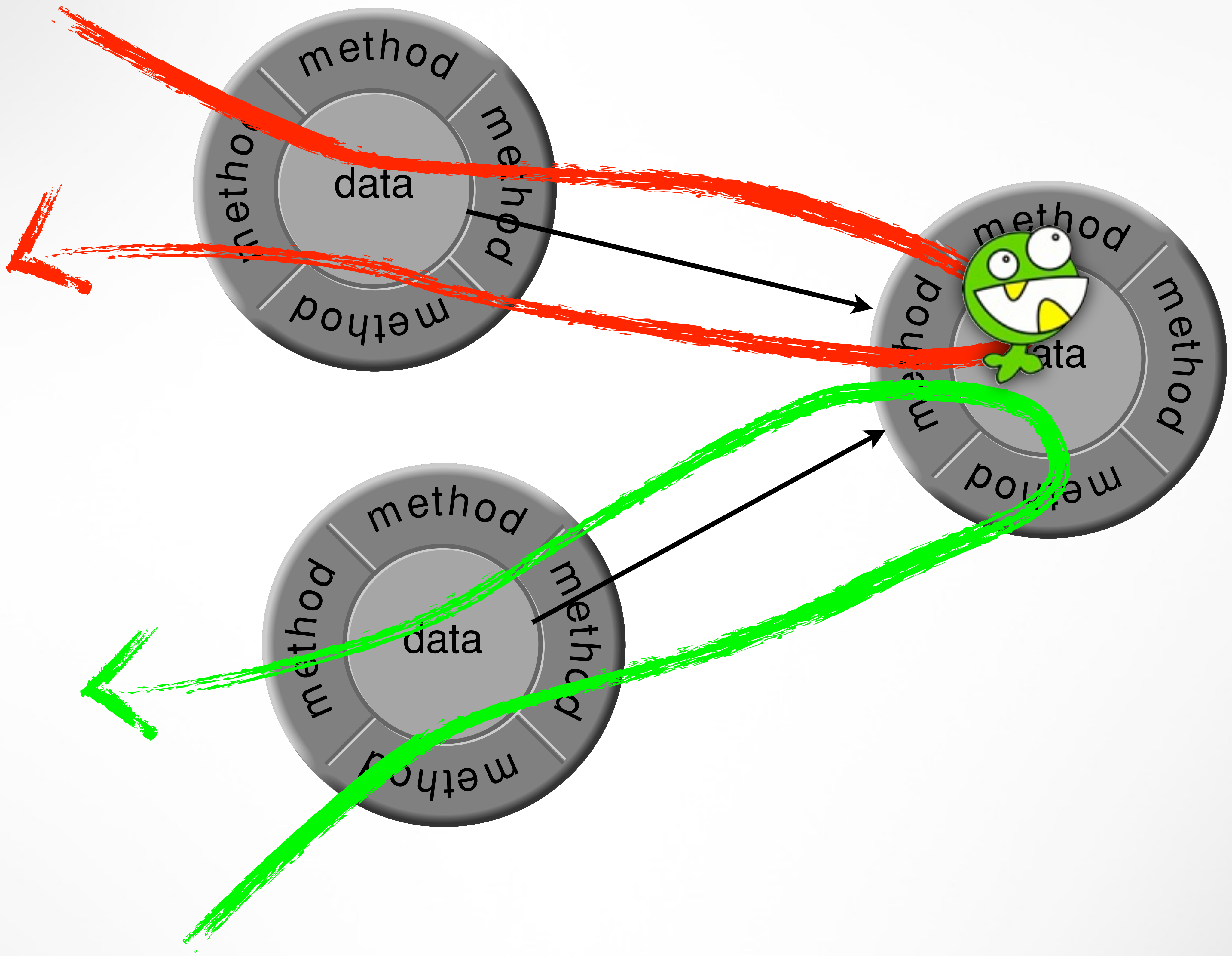
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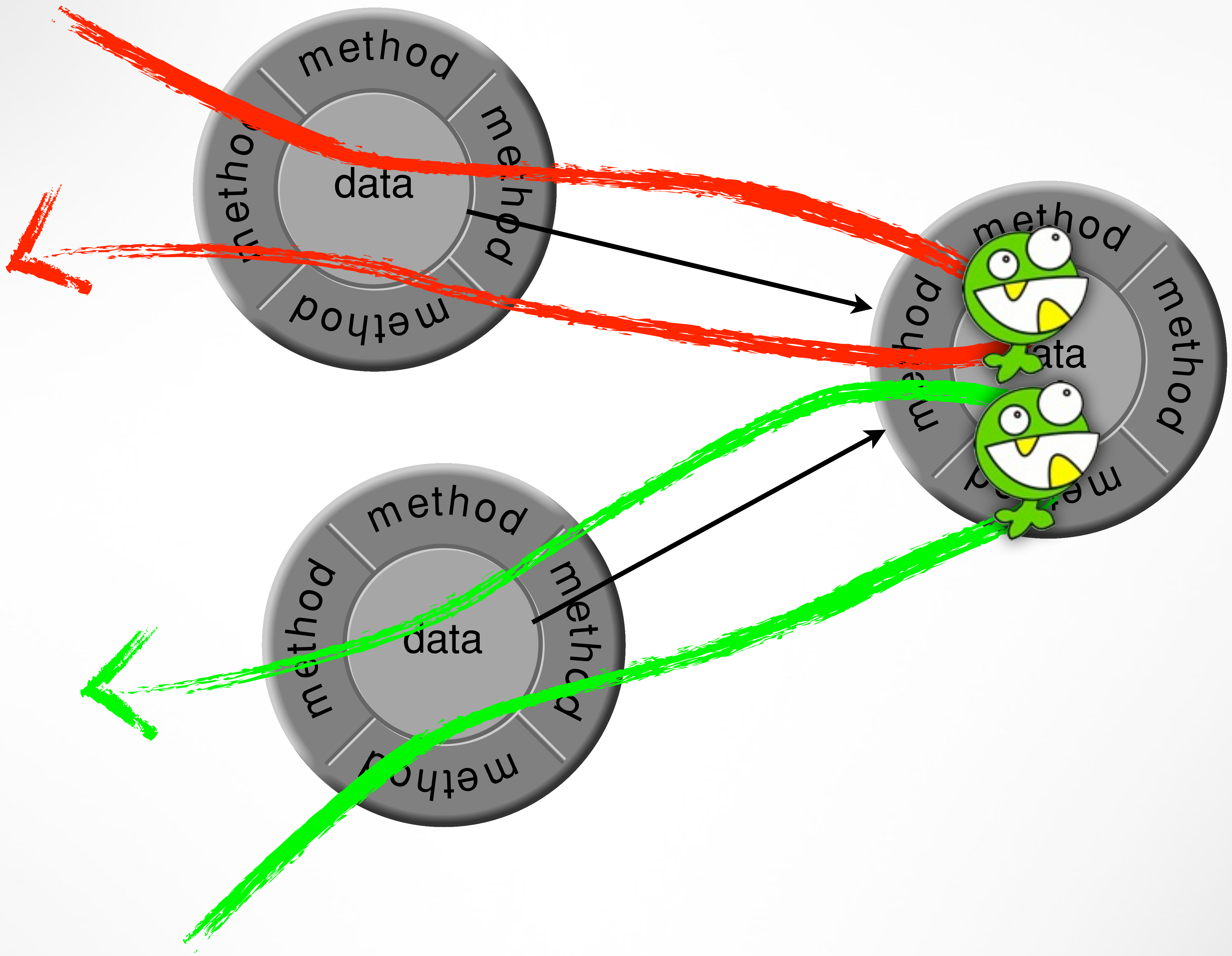
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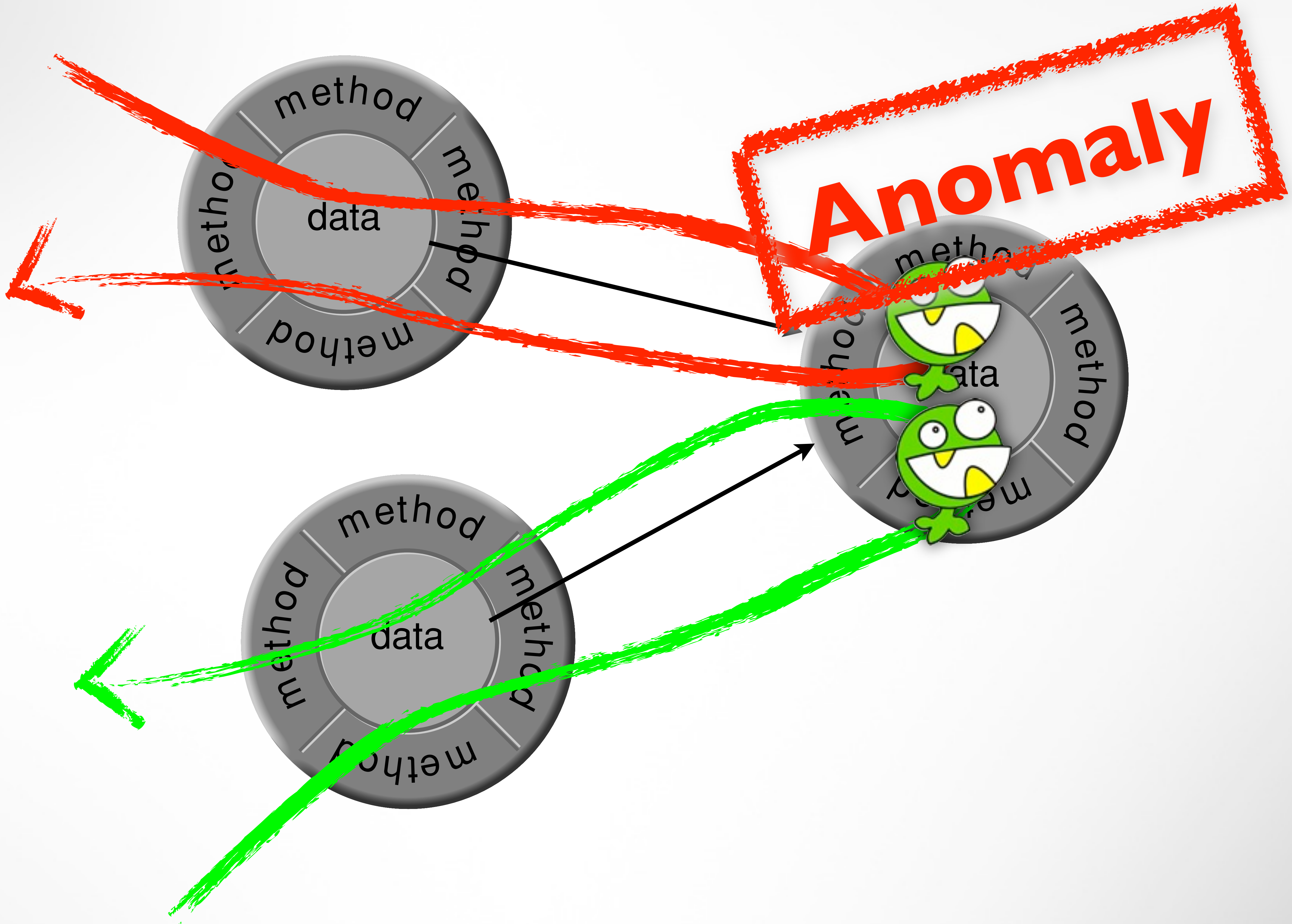
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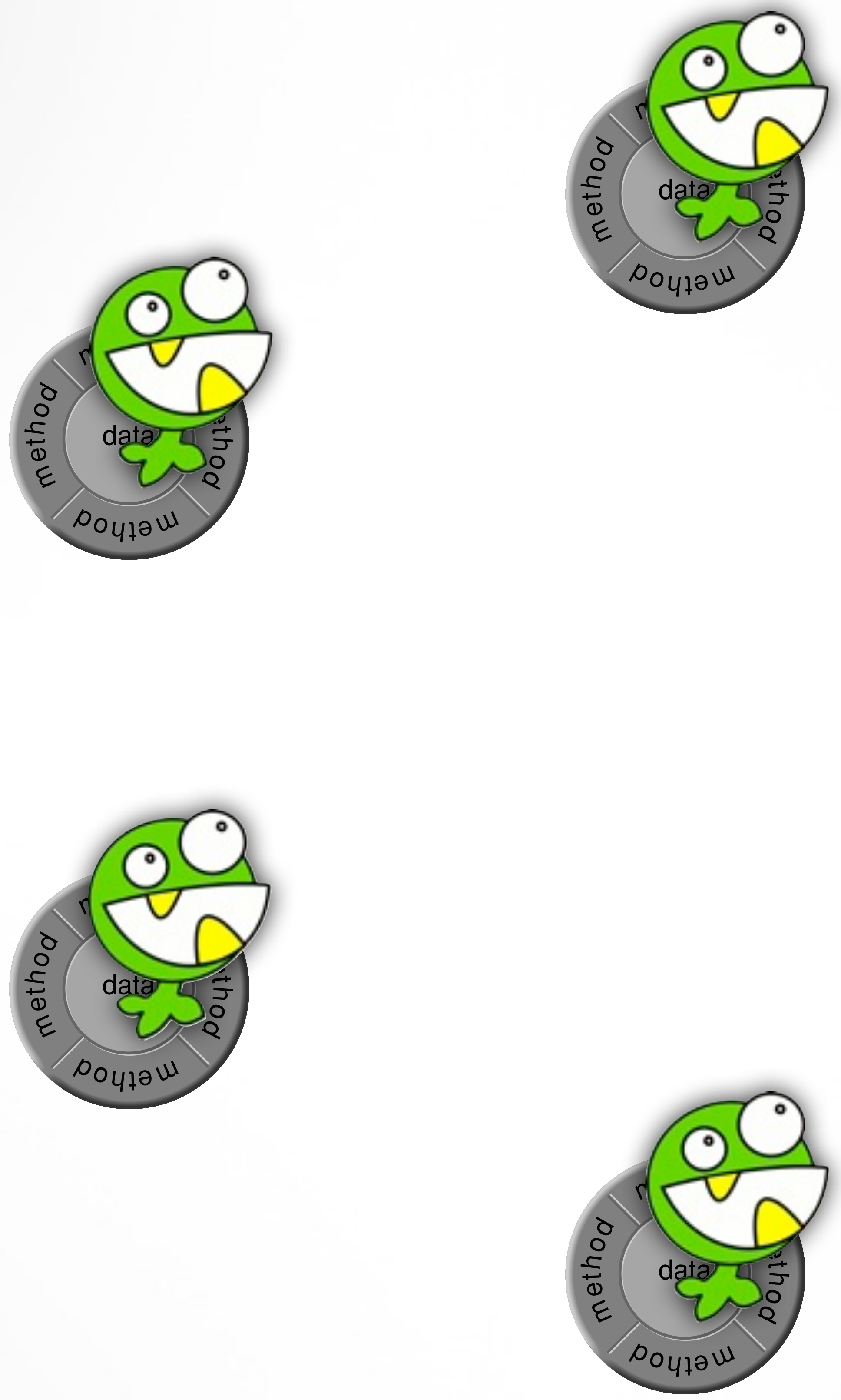
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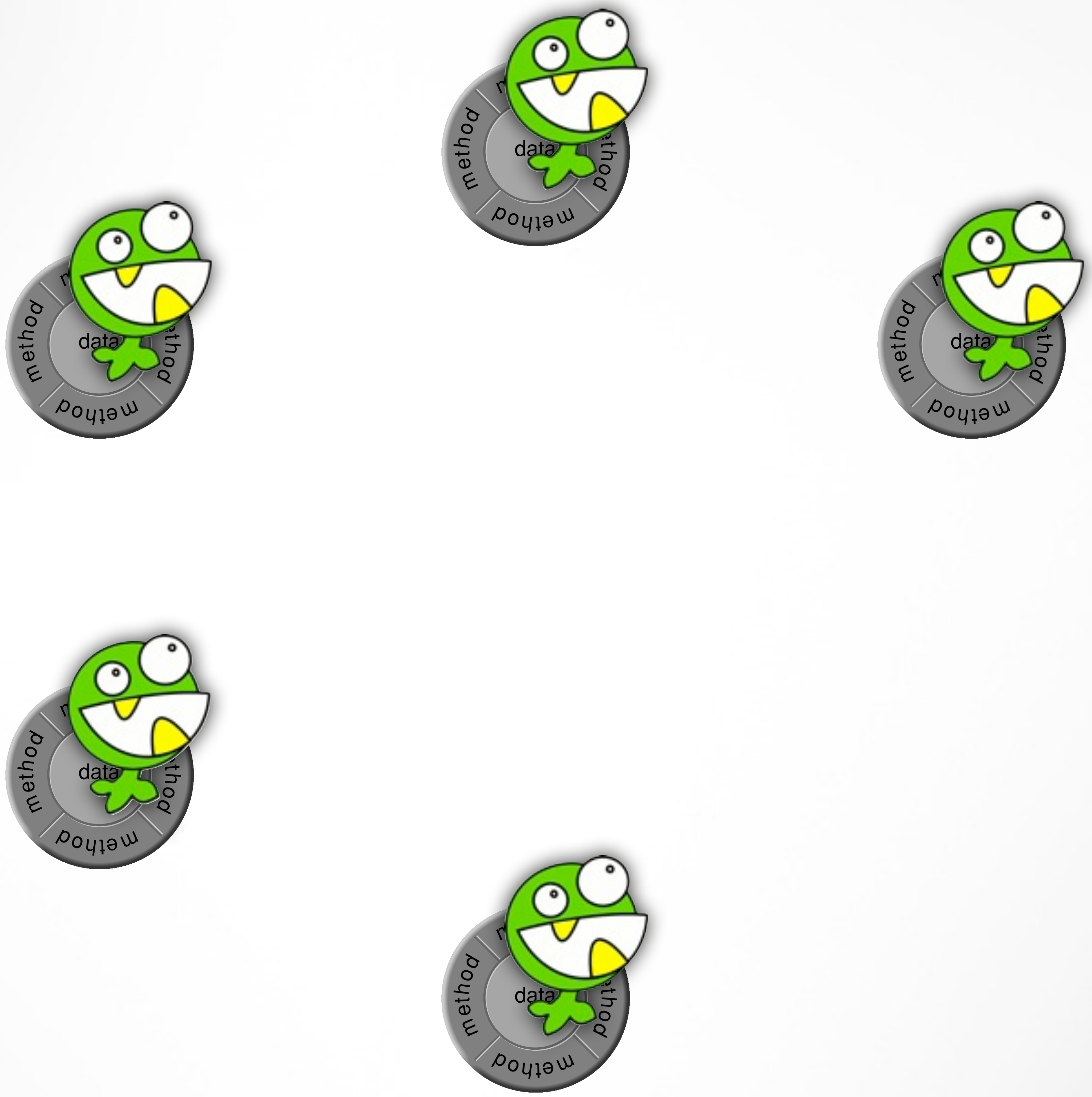
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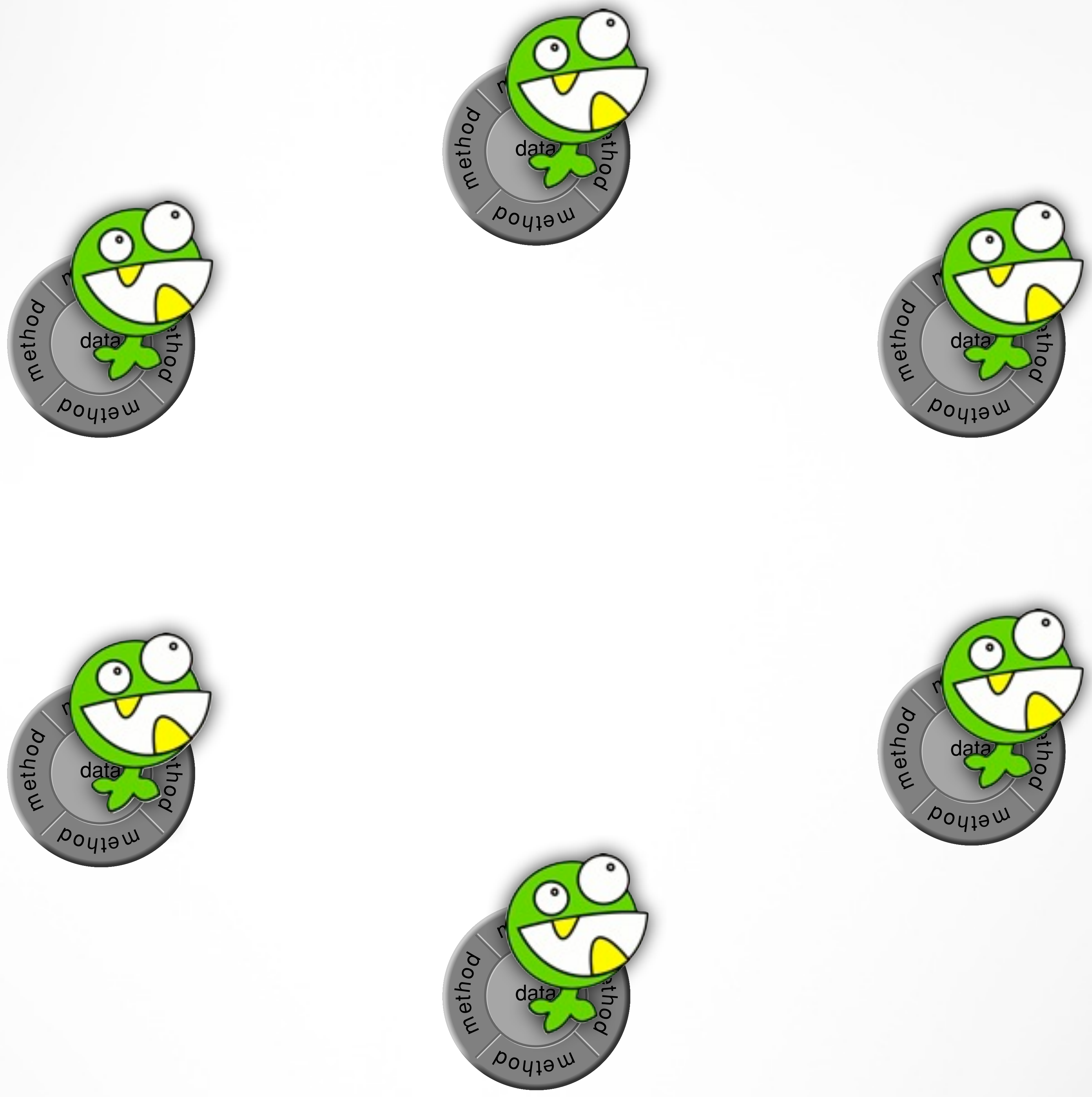
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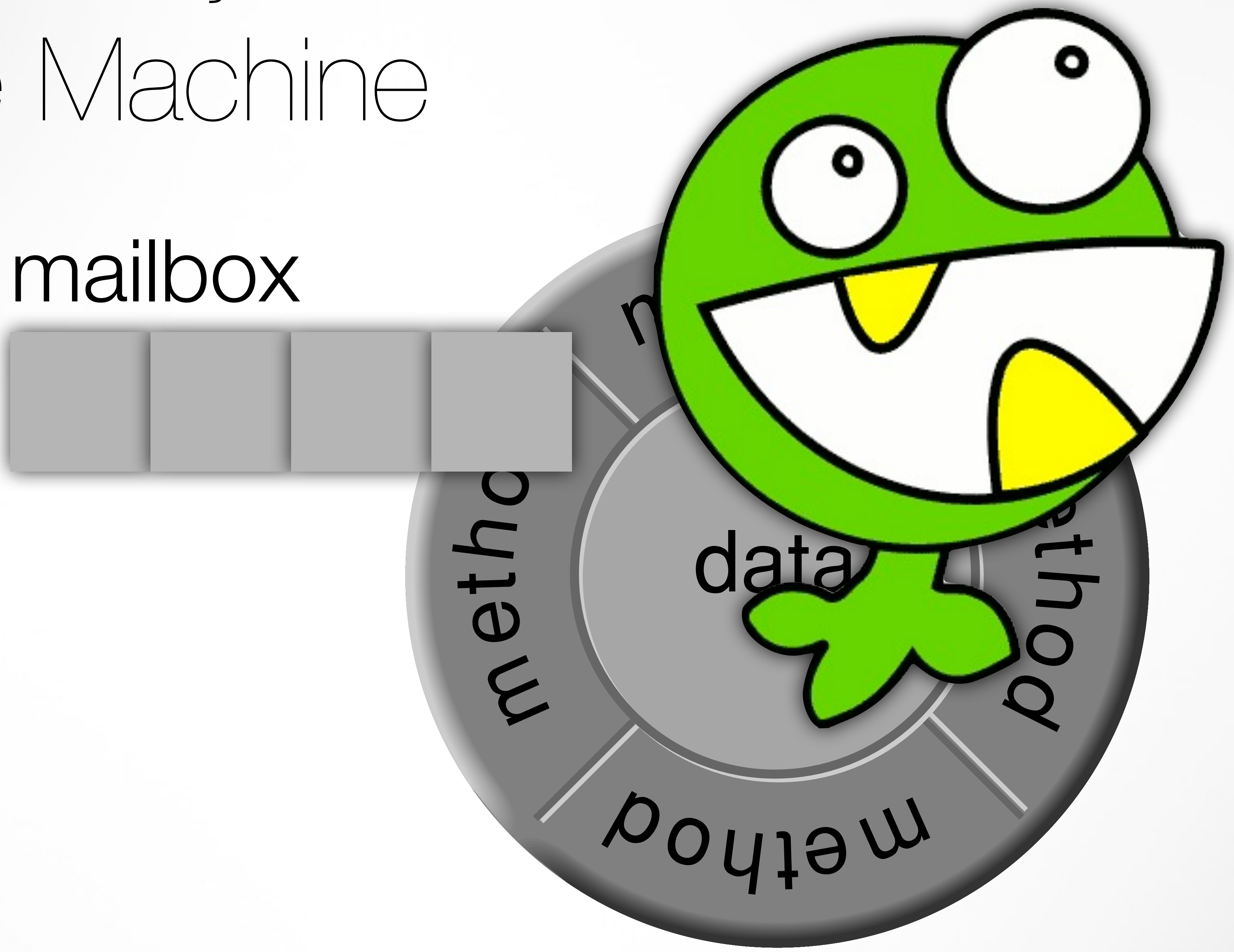
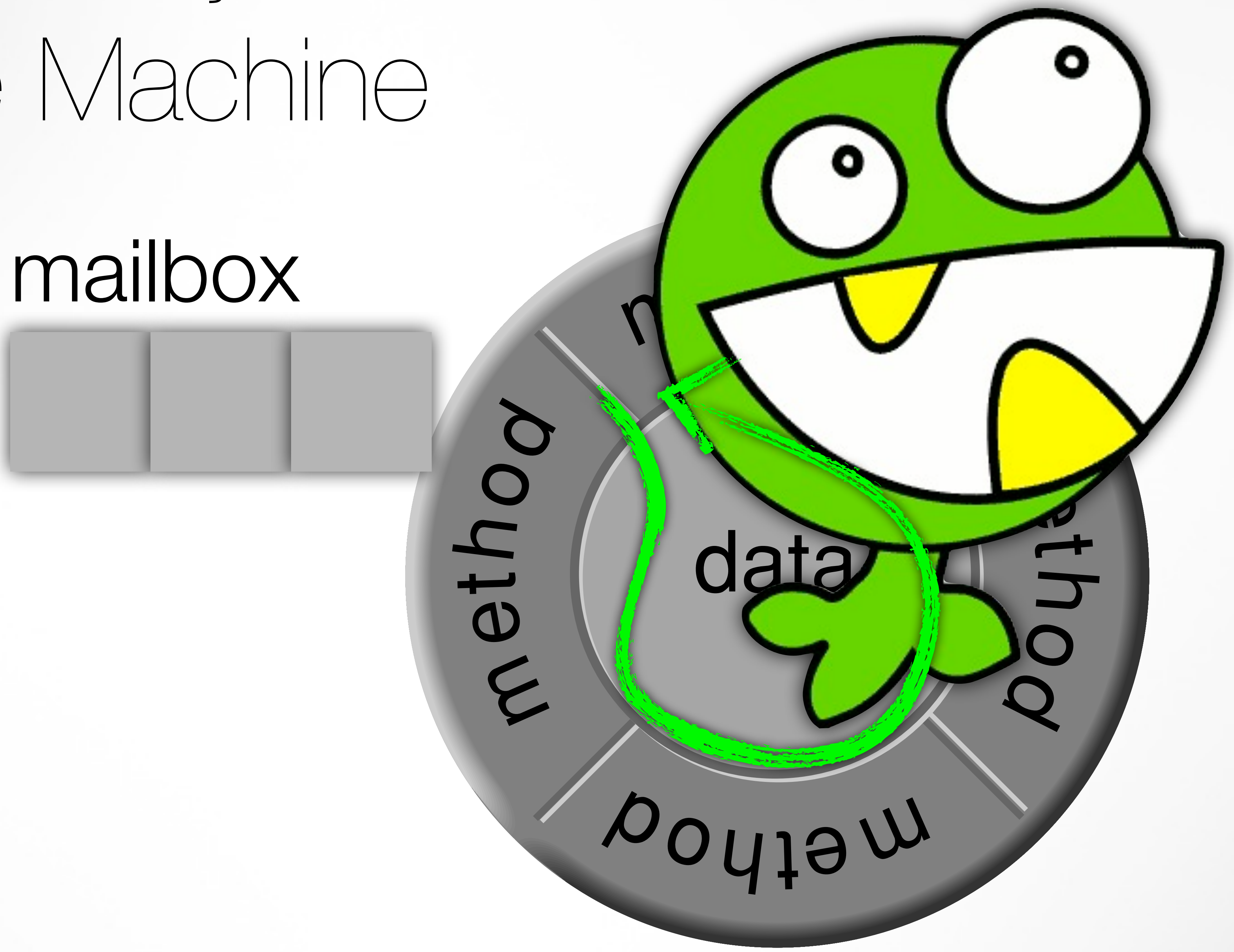
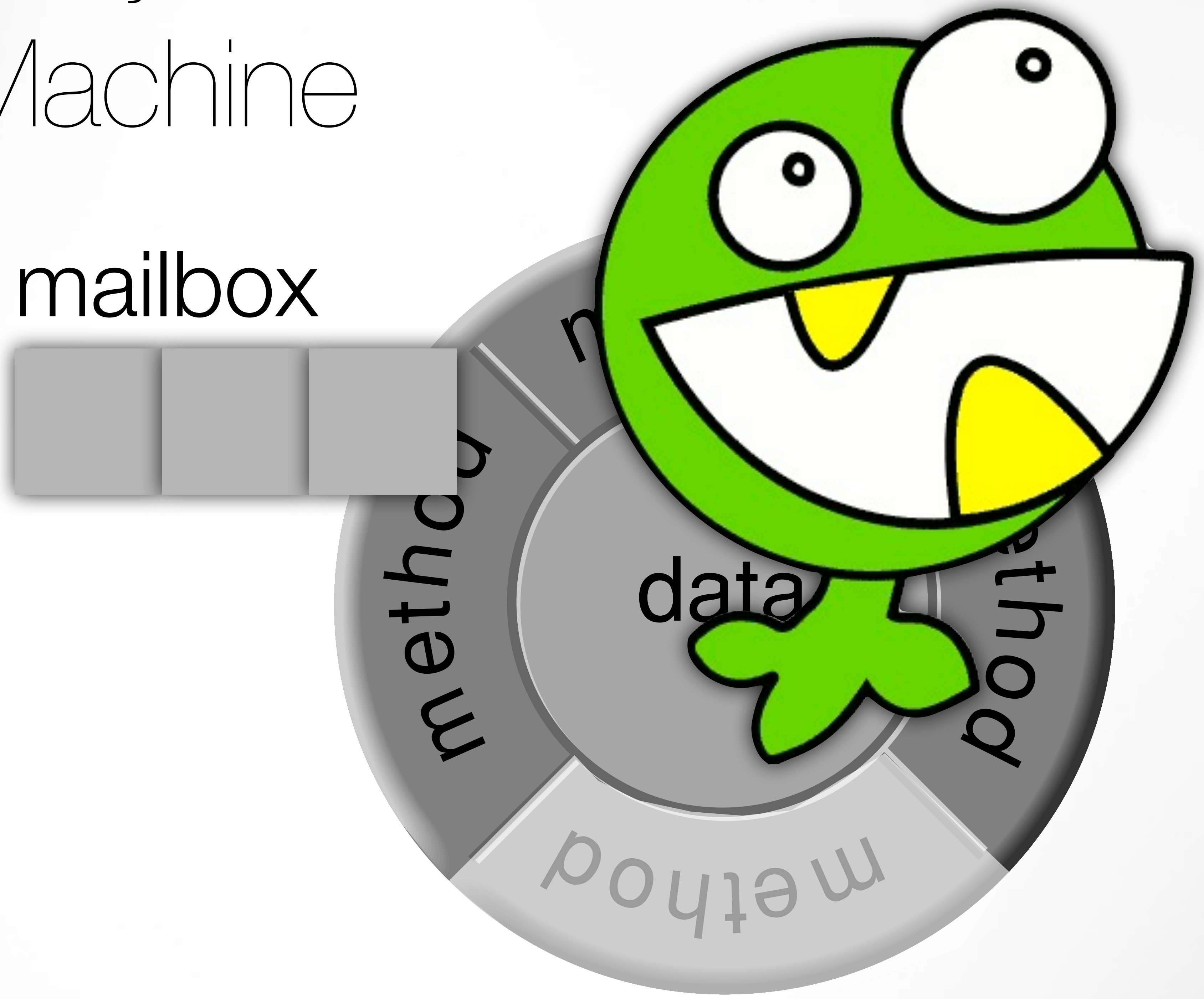
Active Object + State Machine



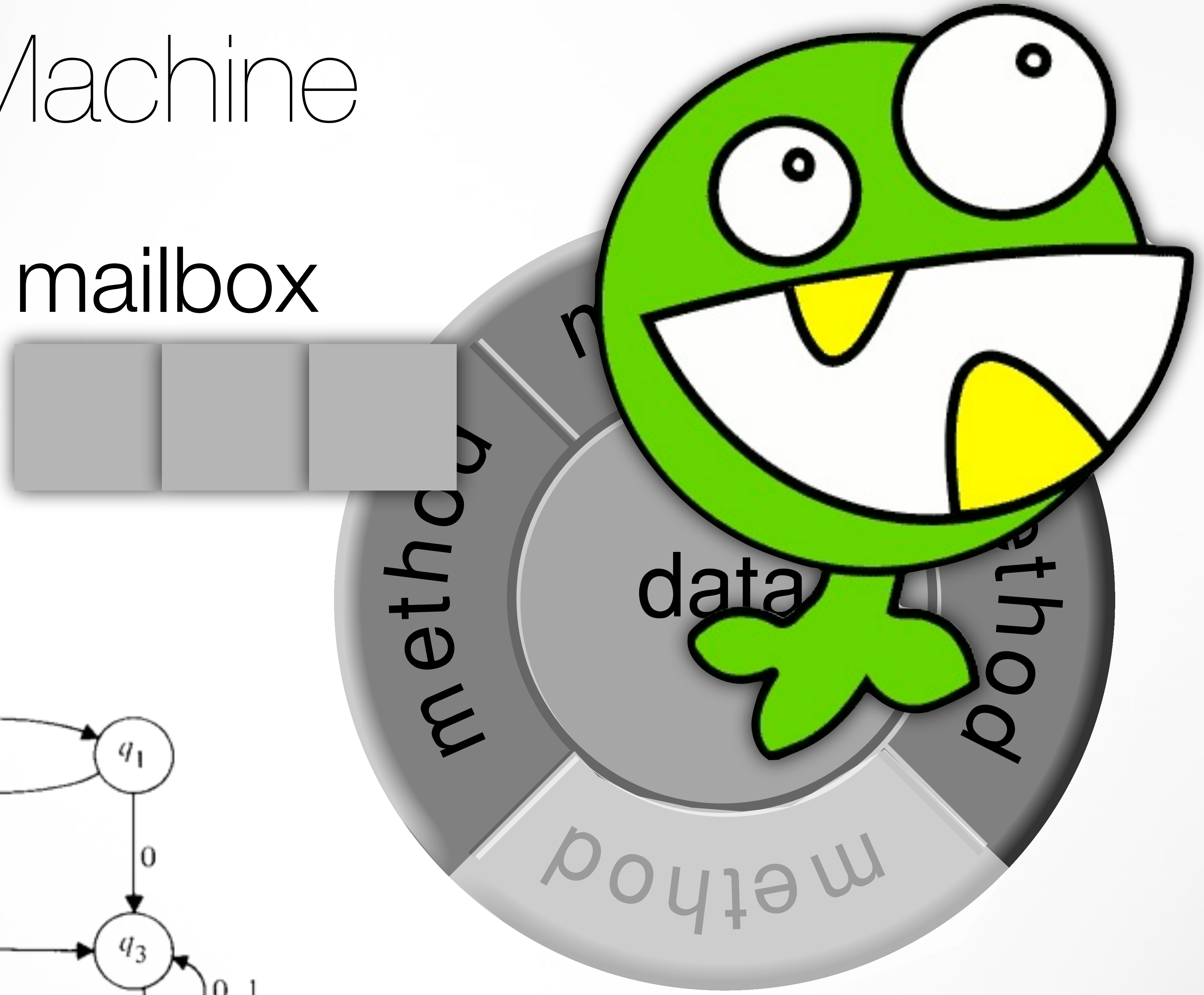
Active Object + State Machine

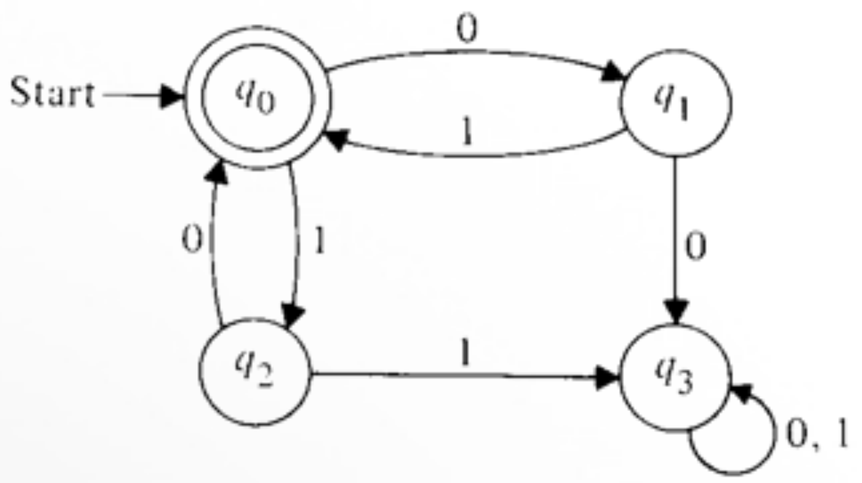


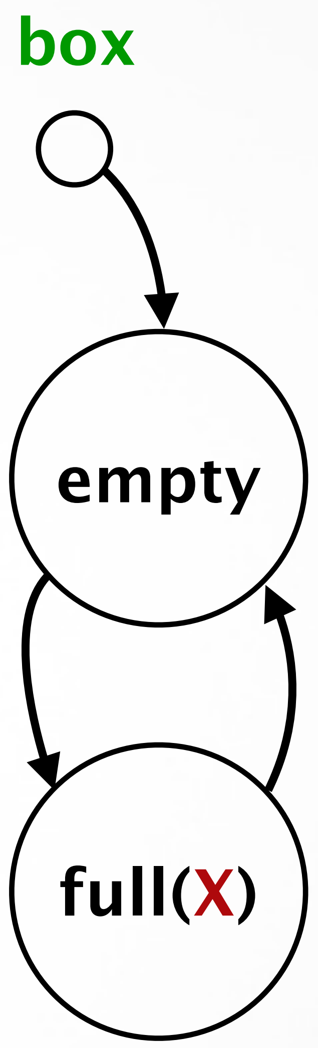
Active Object + State Machine

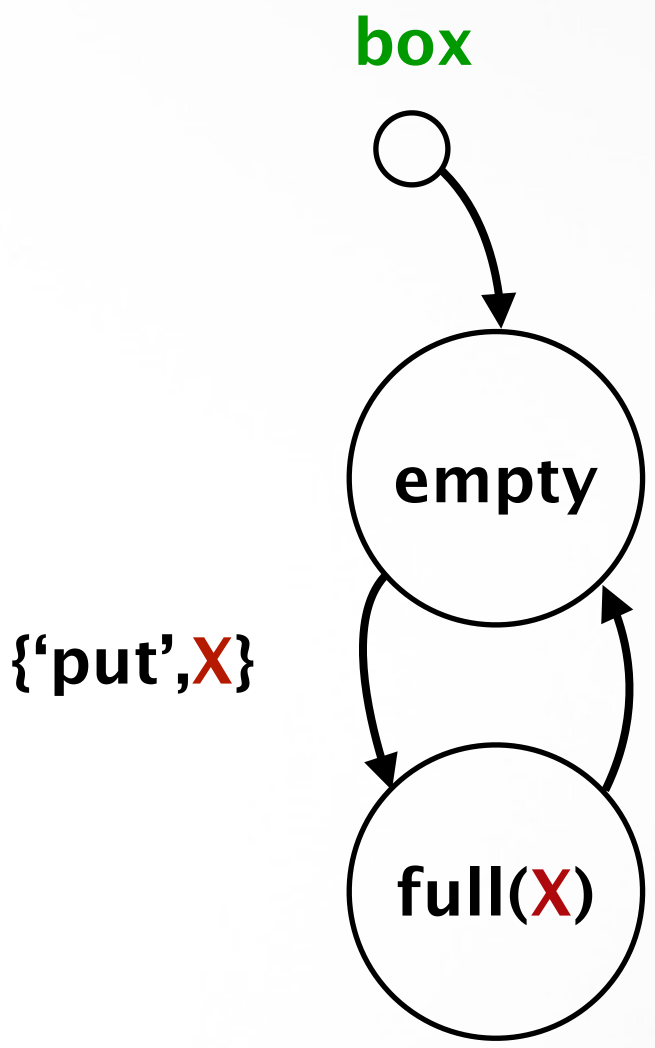


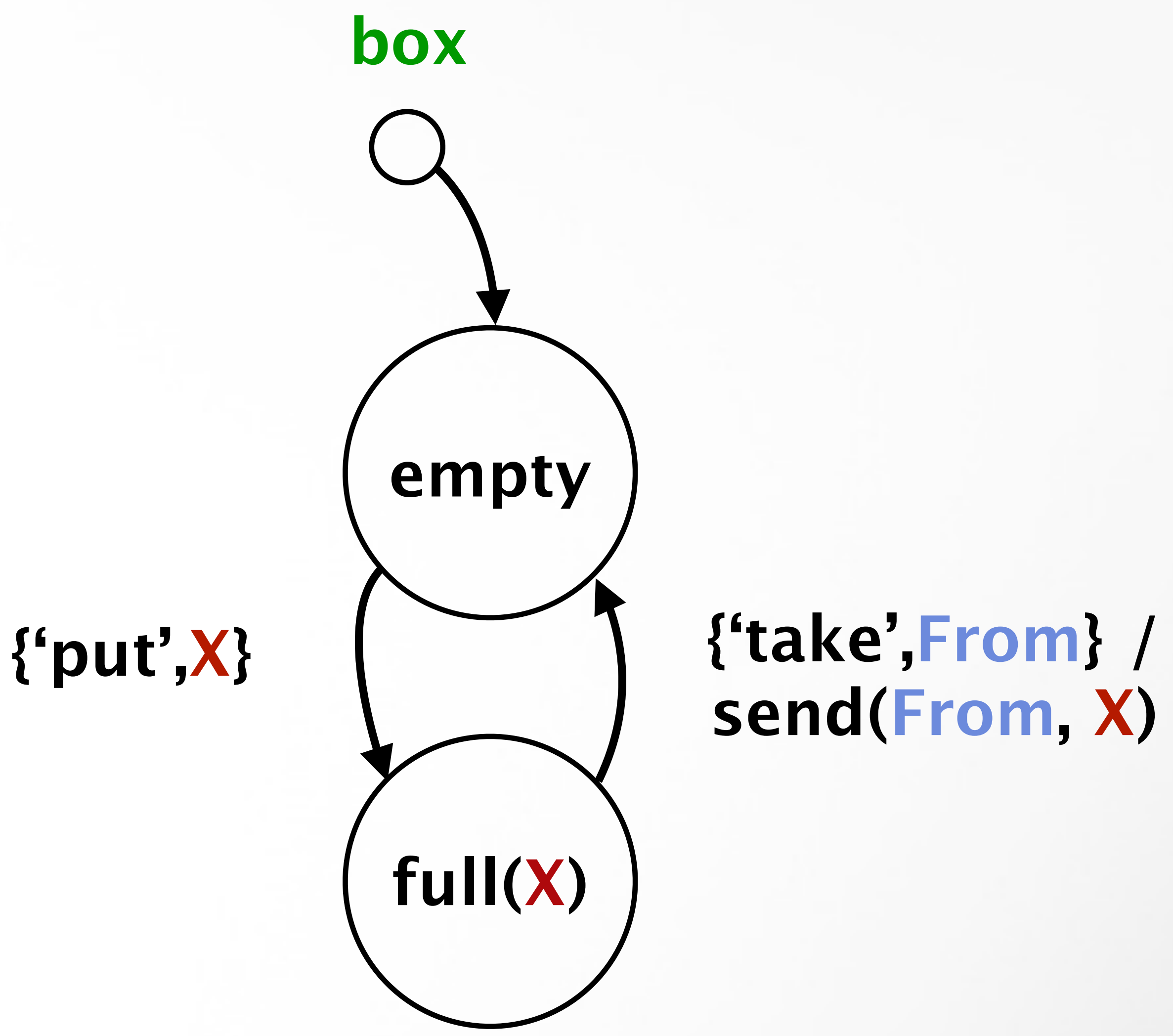
Active Object + State Machine






box
empty
full(X)

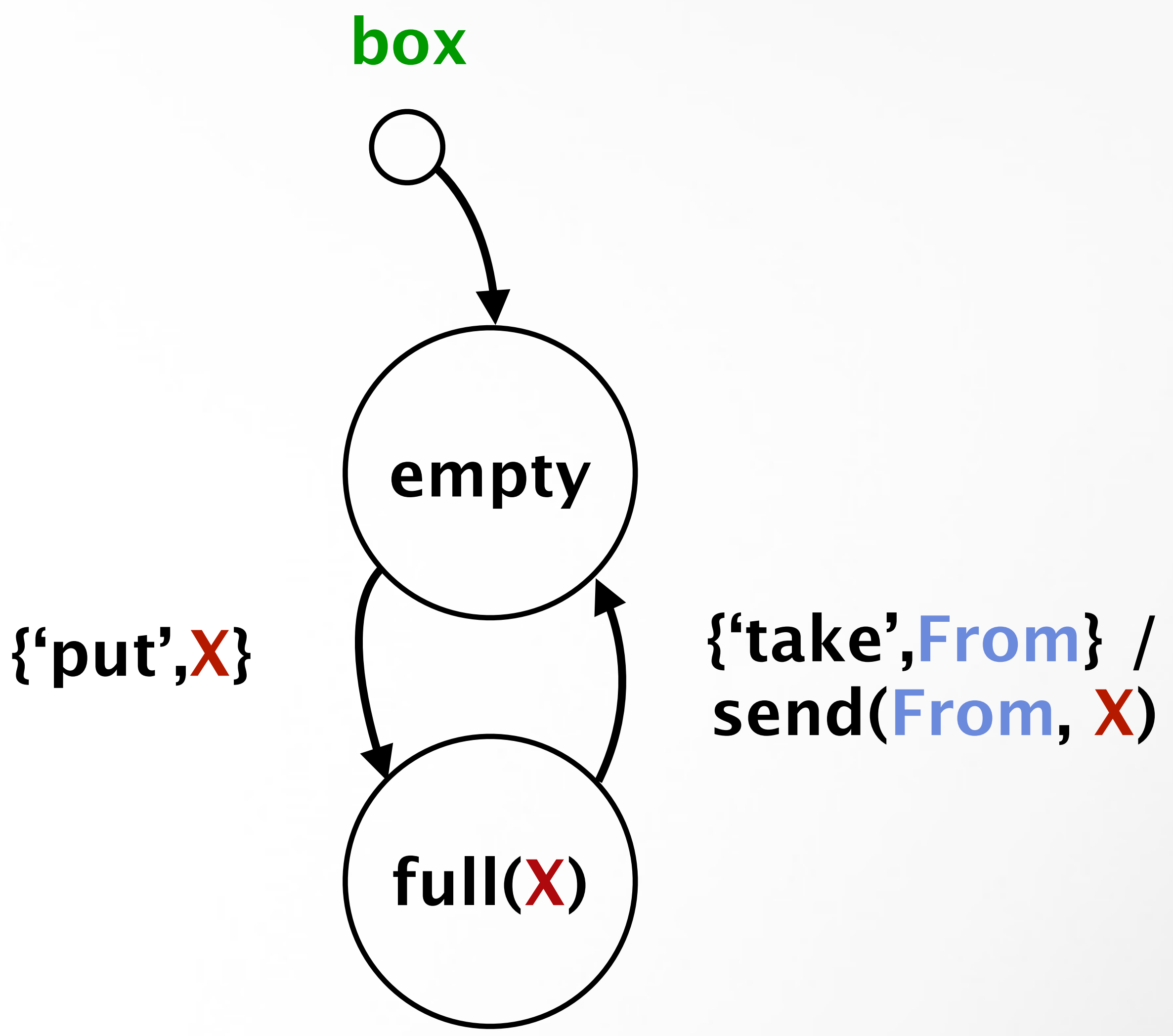

box
empty
{'put',X}
full(X)


box
empty
full(X)
{'put',X}
{'take',From} /
send(From, X)

```
box() → empty().

empty() →
  receive
   {'put', X} →
         full(X)
  end.

full(X) →
  receive
   {'take', From} →
         From ! X,
         empty()
  end.
```



```
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empty() →
  receive
   {'put', X} →
        full(X)
  end.

full(X) →
  receive
   {'take', From} →
        From ! X,
        empty()
  end.
```
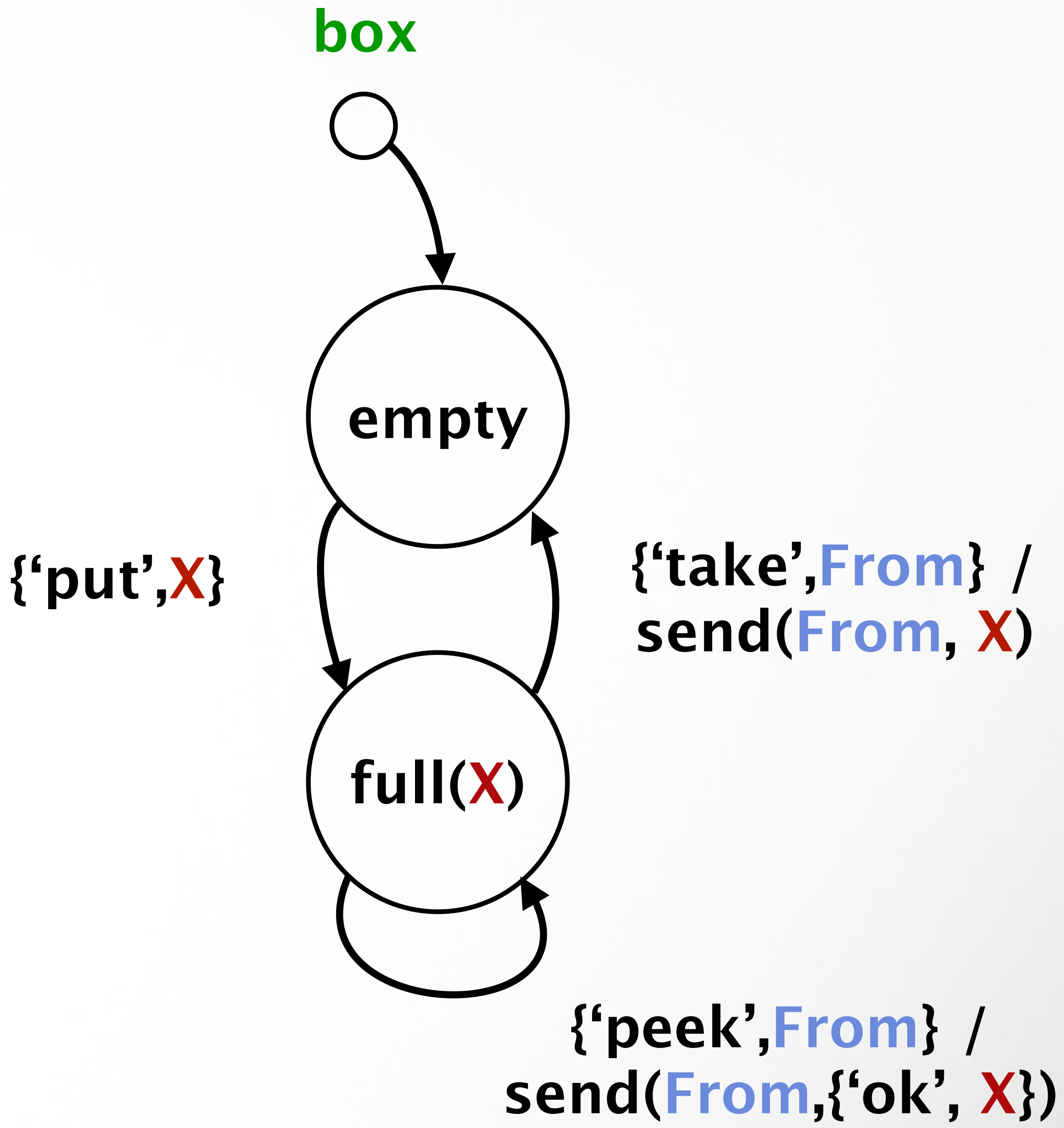
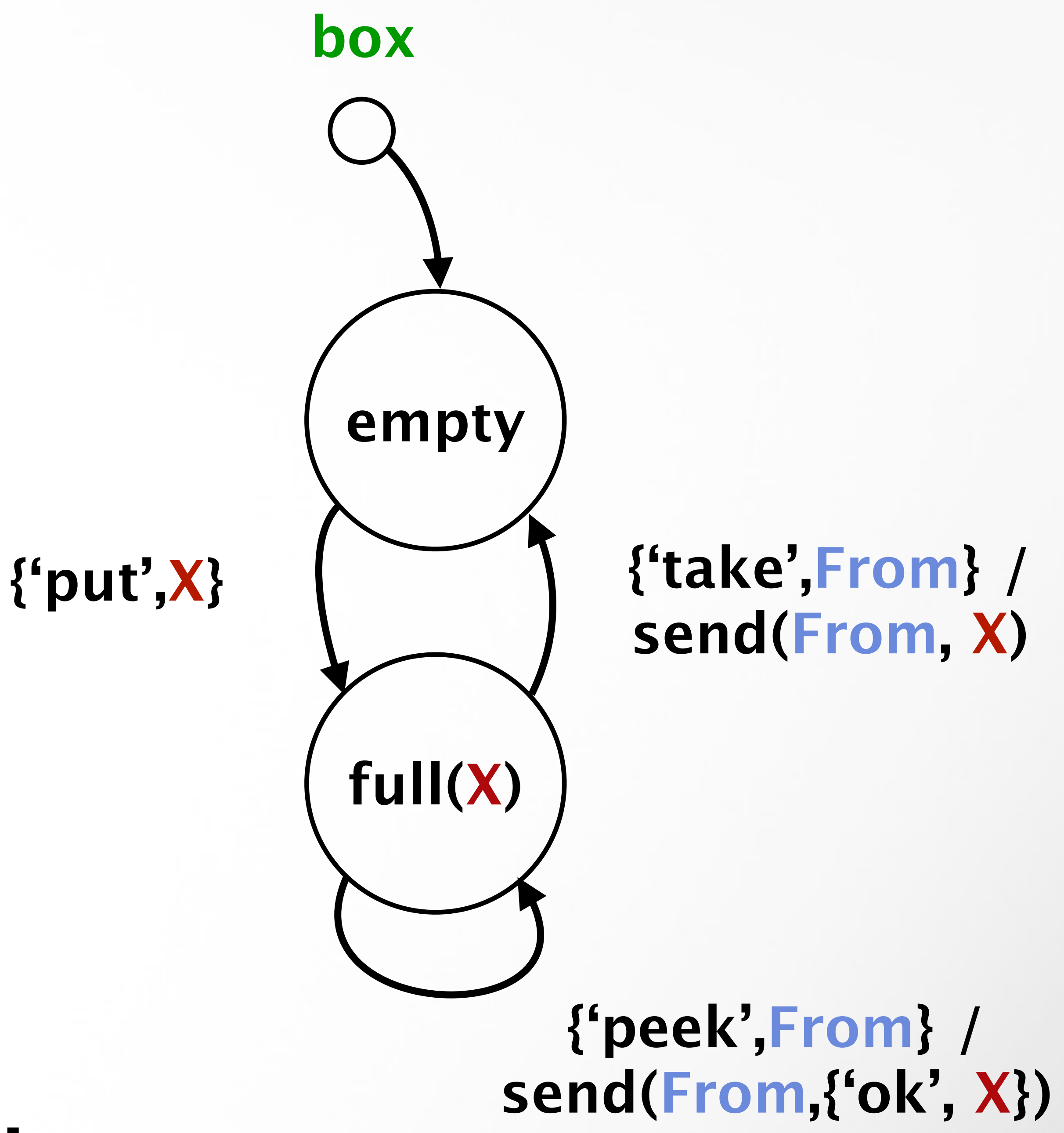


box
empty
{'put',X}
{'take',From} / send(From, X)
full(X)
{'peek',From} / send(From,{'ok', X})

```
box() → empty().

empty() →
   receive
    {‘put’, X} →
          full(X)
   end.

full(X) →
   receive
    {‘take’, From} →
          From ! X,
          empty();
    {‘peek’, From} →
          From ! {‘ok’, X},
          full(X)
   end.
```



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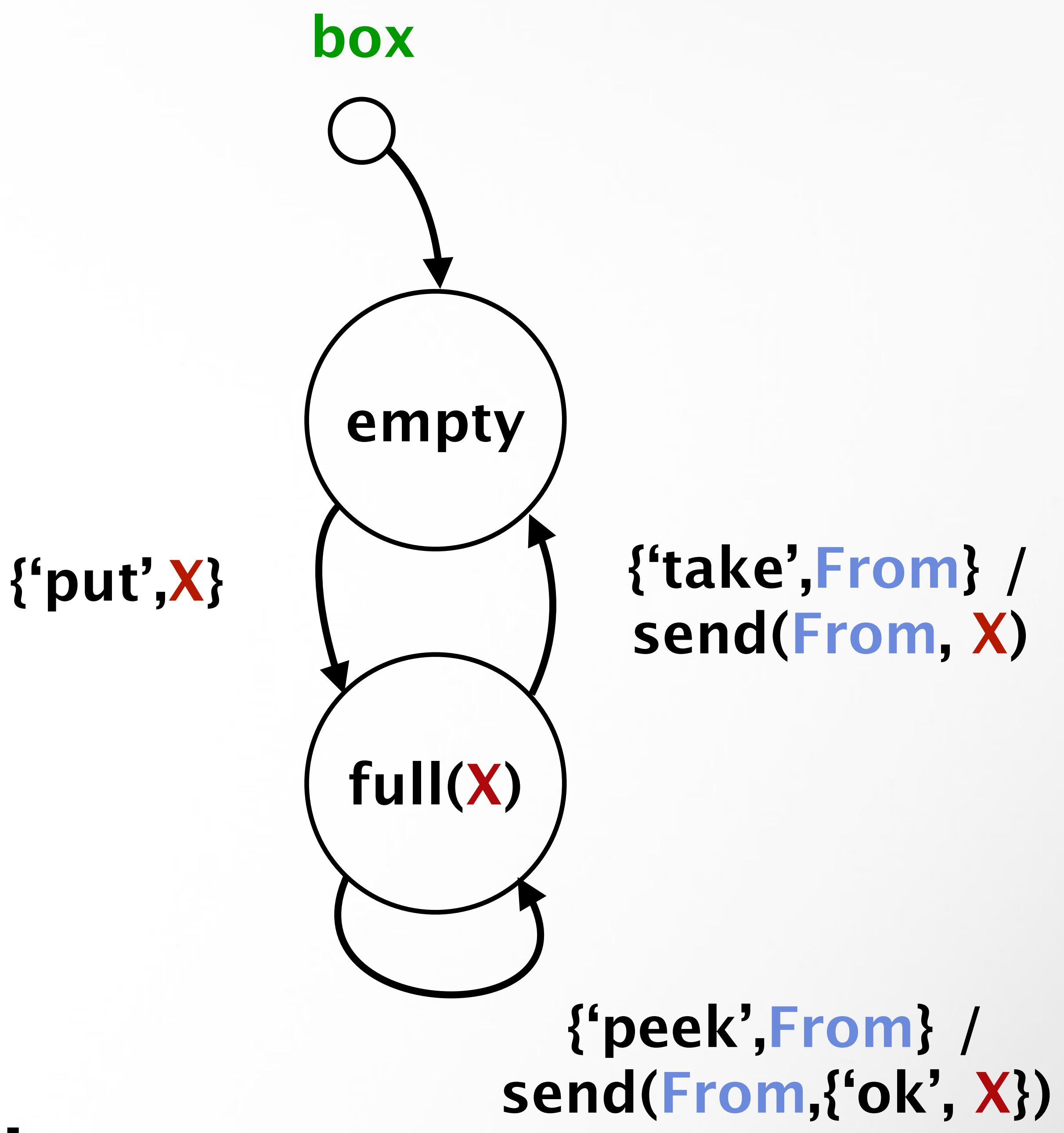
  end.

full(X) →
  receive
   {'take', From} →
          From ! X,
          empty();
   {'peek', From} →
          From ! {'ok', X},
          full(X)
  end.
```



box
empty
full(X)
{'put',X}
{'take',From} / send(From, X)
{'peek',From} / send(From,{'ok', X})

```
box() → empty().

empty() →
  receive
   {‘put’, X} →
        full(X)
  end.

full(X) →
  receive
   {‘take’, From} →
        From ! X,
        empty();
   {‘peek’, From} →
        From ! {‘ok’, X},
        full(X)
  end.
```

```
box() → empty().                Box = spawn(fun box/0),

empty() →
   receive
    {‘put’, X} →
          full(X)
   end.

full(X) →
   receive
    {‘take’, From} →
          From ! X,
          empty();
    {‘peek’, From} →
          From ! {‘ok’, X},
          full(X)
   end.
```

TRIFORK.

```
box() → empty().

empty() →
   receive
    {‘put’, X} →
         full(X)
   end.

full(X) →
   receive
    {‘take’, From} →
         From ! X,
         empty();
    {‘peek’, From} →
         From ! {‘ok’, X},
         full(X)
   end.
```

```
Box = spawn(fun box/0),

Box ! {‘put’, 27},
```

TRIFORK.

```
box() → empty().

empty() →
   receive
    {‘put’, X} →
         full(X)
   end.

full(X) →
   receive
    {‘take’, From} →
         From ! X,
         empty();
    {‘peek’, From} →
         From ! {‘ok’, X},
         full(X)
   end.
```

```
Box = spawn(fun box/0),

Box ! {‘put’, 27},

Box ! {‘take’, self()},
receive
  Value → print(Value)
end
```

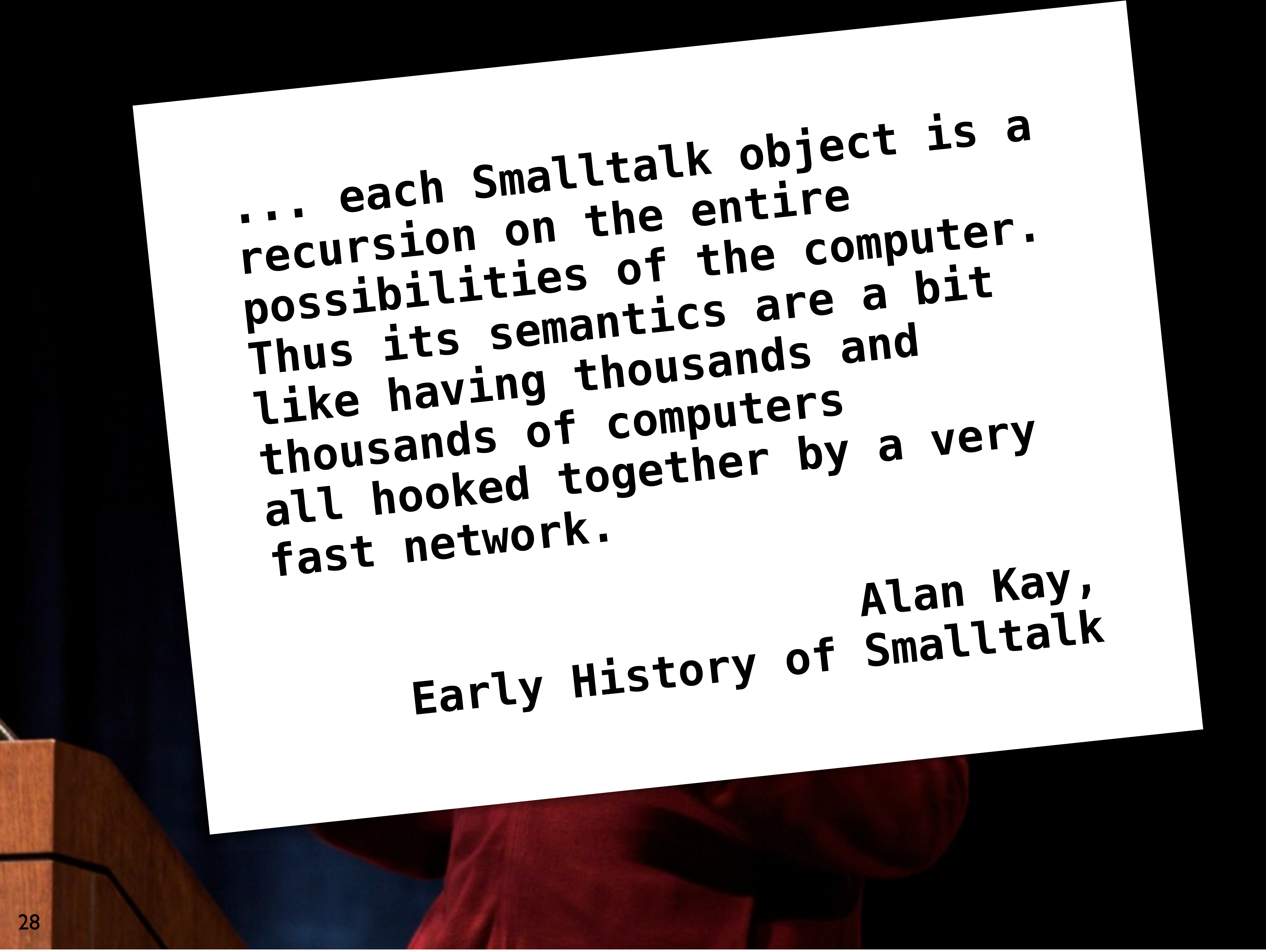
TRIFORK.

Objects	**Interface** Fixed API
Actors	**Protocol** API changes with internal state

Objects	~~**Interface**~~ Anomaly Fixed API
Actors	**Protocol** API changes with internal state

TRIFORK.

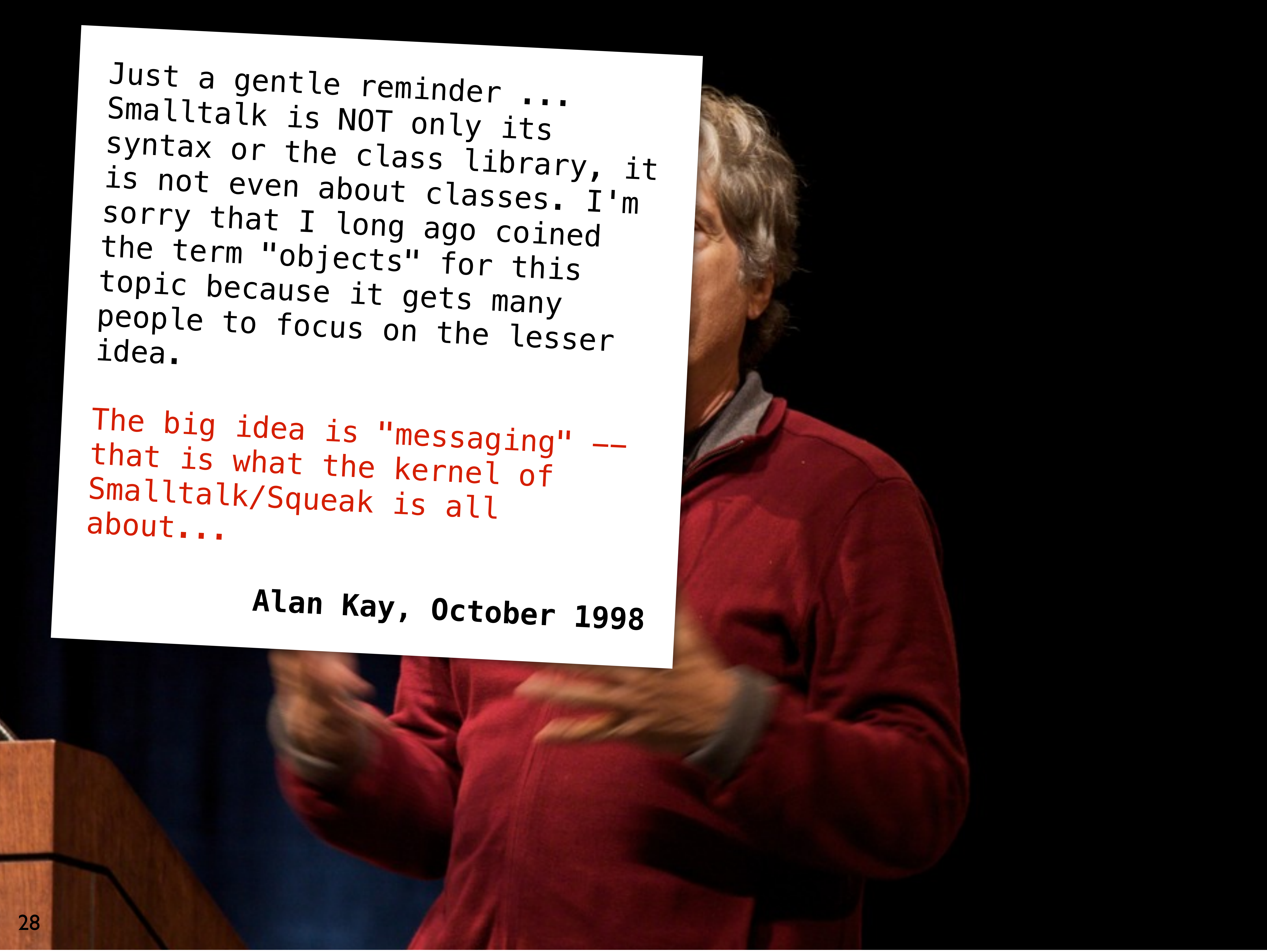
28



... each Smalltalk object is a recursion on the entire possibilities of the computer. Thus its semantics are a bit like having thousands and thousands of computers all hooked together by a very fast network.

Alan Kay,

Early History of Smalltalk



Just a gentle reminder ... Smalltalk is NOT only its syntax or the class library, it is not even about classes. I'm sorry that I long ago coined the term "objects" for this topic because it gets many people to focus on the lesser idea.

The big idea is "messaging" -- that is what the kernel of Smalltalk/Squeak is all about...

Alan Kay, October 1998

But isn't this expensive?

But isn’t this expensive?

... heard in the ‘90s

But isn't this expensive?

... heard in the '90s

Use Objects!

100.000's of objects,
are you crazy?

But isn't this expensive?

... heard yesterday

Use Actors!

100.000's of processes, silly you!

“What if the OOP parts of other languages (Java, C++, Ruby, etc.) had the same behavior as their concurrency support? What if you were limited to only creating 500 objects total for an application because any more would make the app unstable and almost certainly crash it in hard-to-debug ways? What if these objects behaved differently on different platforms?”

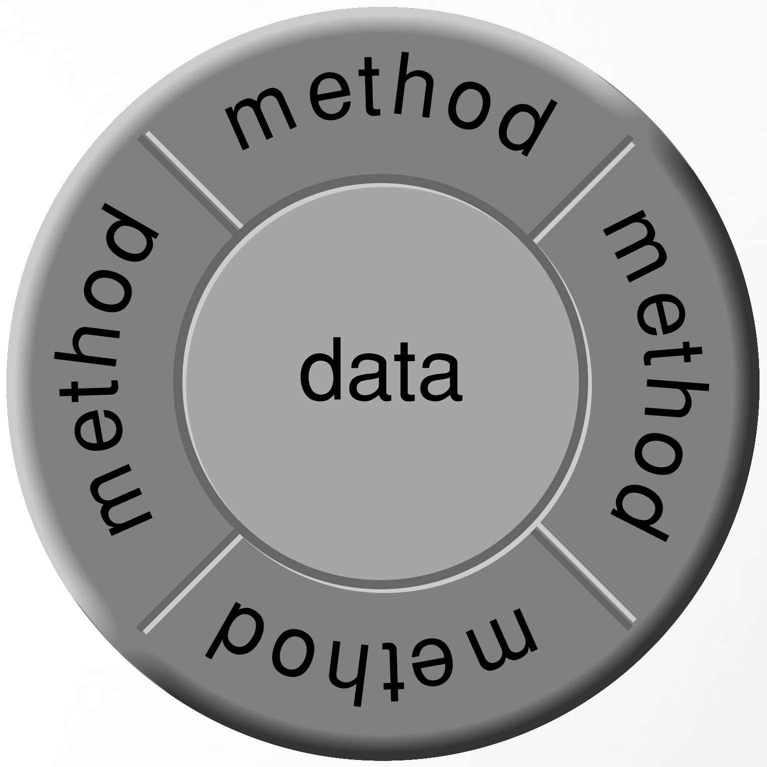
Joe Armstrong, creator of Erlang

as quoted in

http://weblog.hypotheticalabs.com/?p=217

Effect Containment

- Functional languages *disallow effects*
- Many object-oriented styles *encourage side effects*.
- Actors *confine effects*



TRIFORK.

From C++ to Java	Garbage Collection
From Java to Erlang	**State Containment**

Threads and Locks don’t compose well

- Threaded programs are error prone (we already knew that).
- Good thread design requires global knowledge.

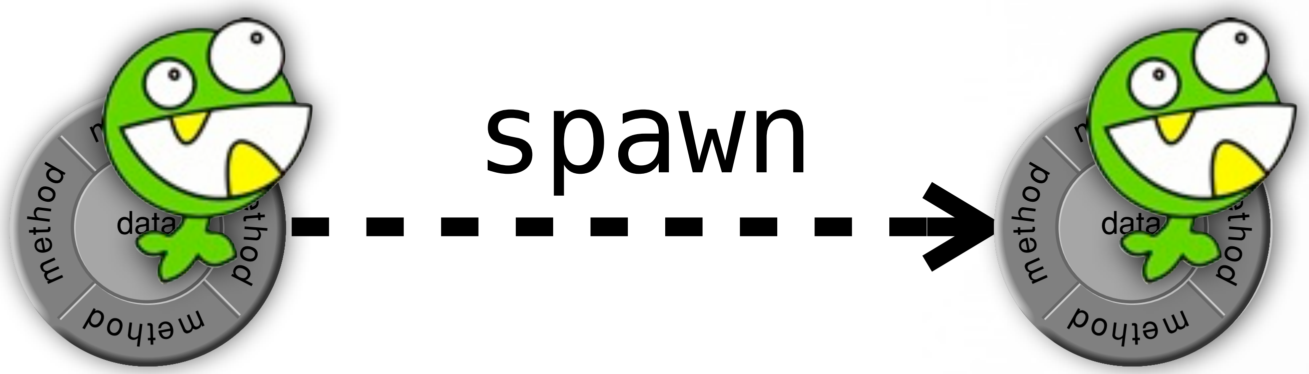
TRIFORK.

Threads and Locks don't compose well

- Threaded programs are error prone (we already knew that).
- Good thread design requires global knowledge.

Anomaly

Activity Composition



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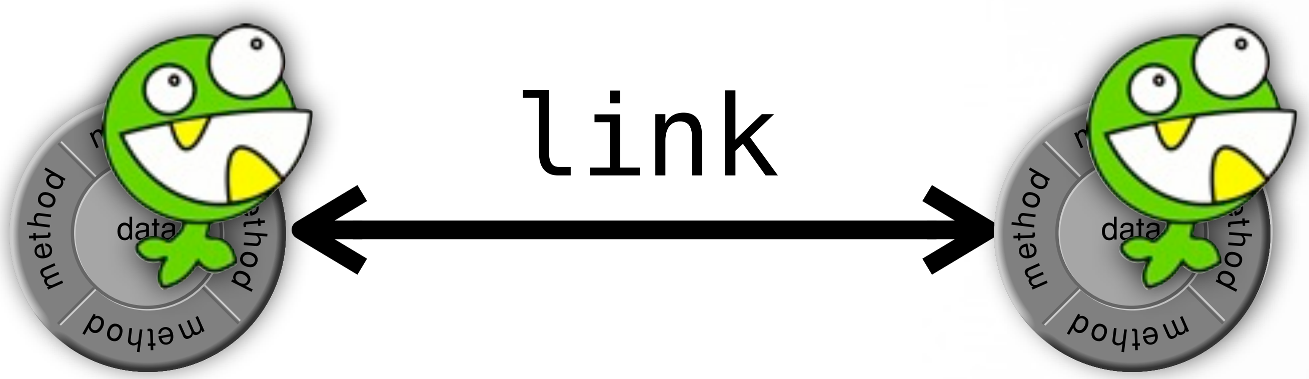

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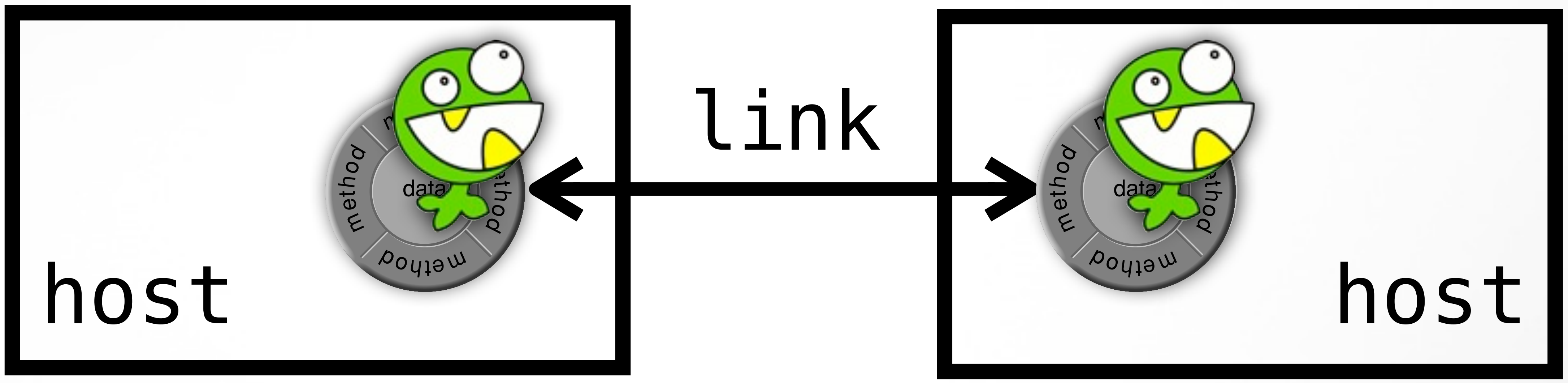
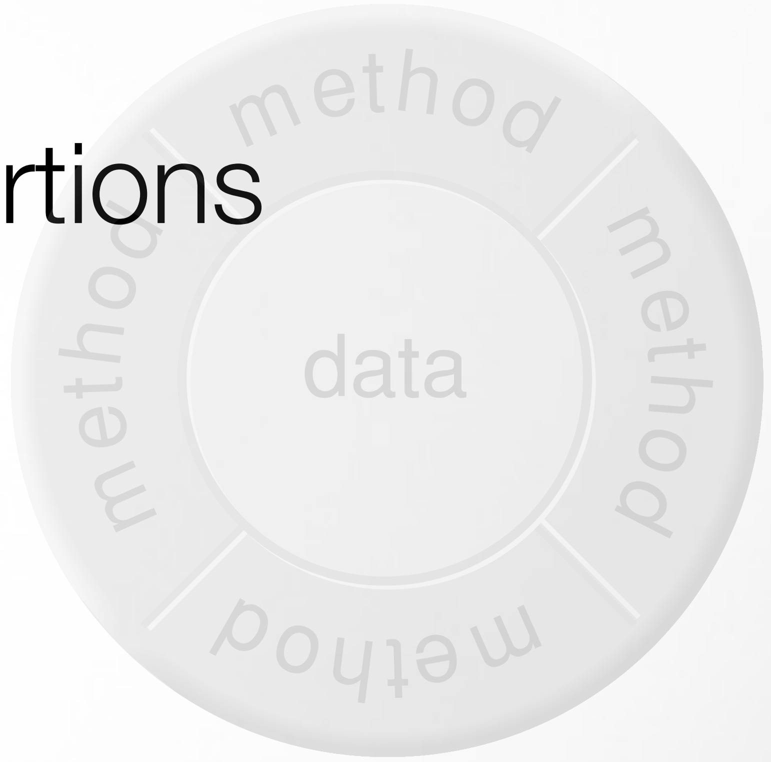


"Let it Fail" philosophy

method
method
method
method
data

“Let it Fail” philosophy

- Write code with lots of assertions



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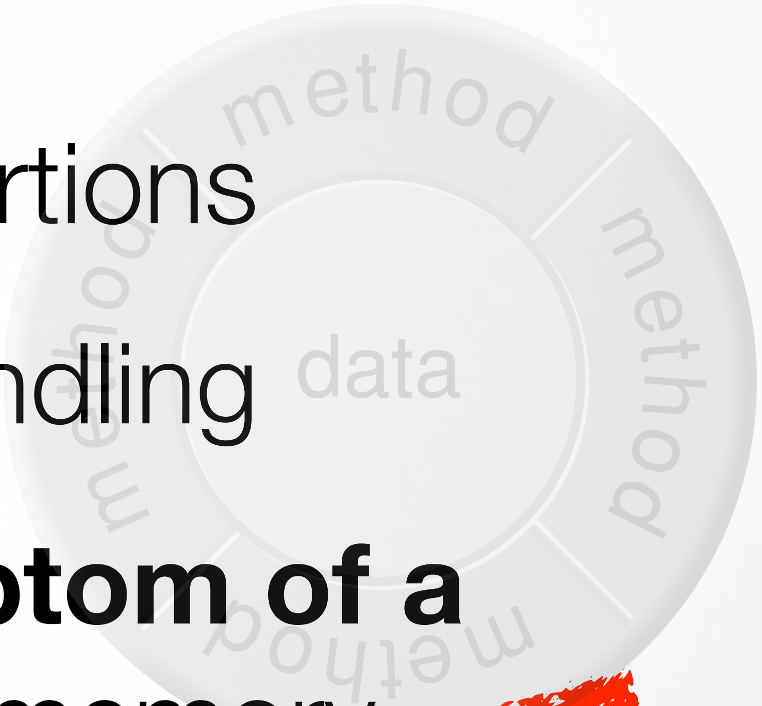
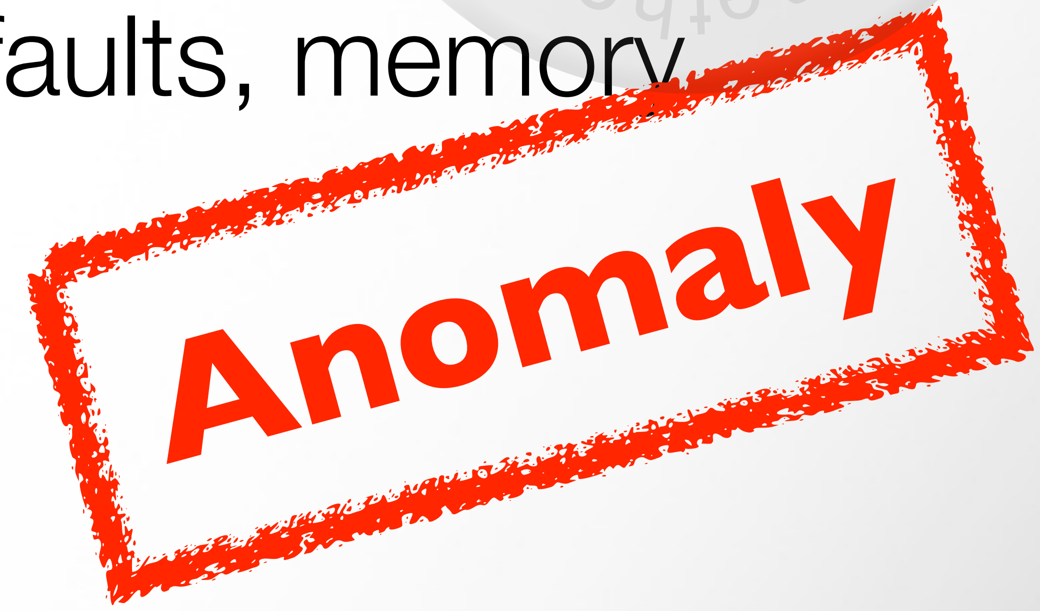
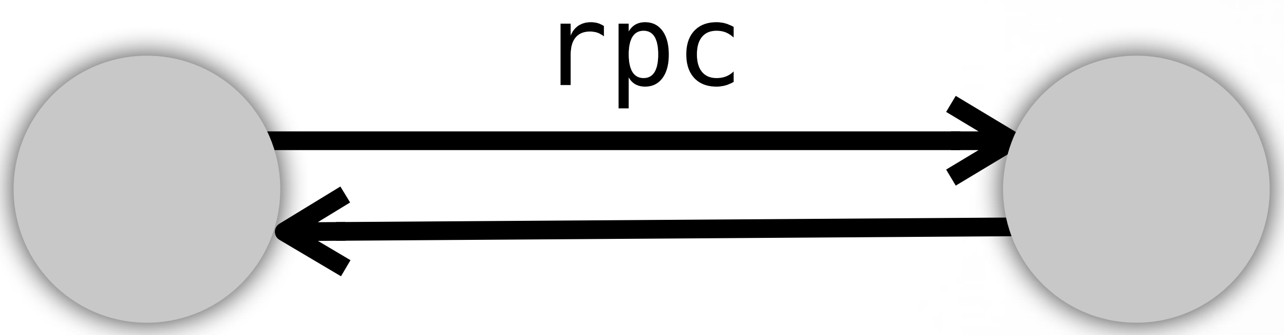




Martin Fowler's First Law of Distributed Objects Design



Starbucks doesn't use transactions

Steve Vinoski: *RPC and its Offspring: Convenient, Yet Fundamentally Flawed*

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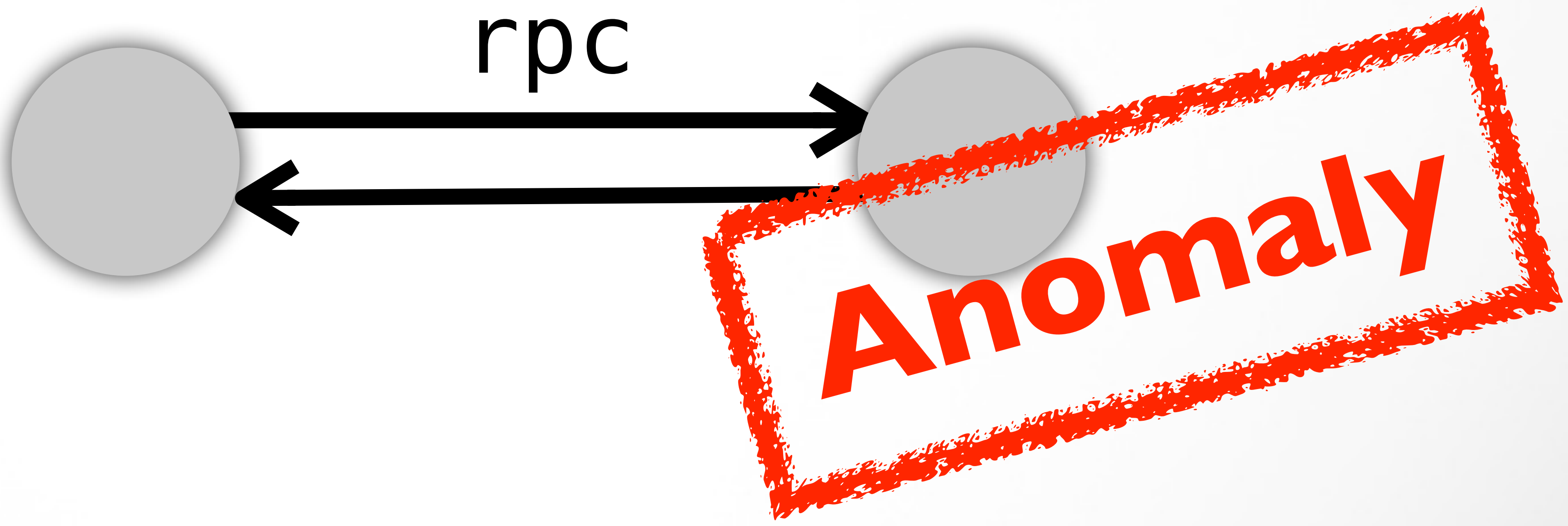

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Abstractions

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Anomaly

Simple Values

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- Tuple, List, Record, Number, String, Binary
- Pattern matching is polymorphism for values
- Erlang data stores (like Mnesia) just store values, not bytes or objects.
- Too much of my Java programs are boilerplate code.

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“Object” Model Anomalies

- Thread & Locks
- Interfaces with Fixed API
- Defensive Code
- RPC/RMI
- Boilerplate code for persistence

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Actor “Solutions”

- Processes w/ state containment
- Protocols
- Let it Fail
- Async Messaging
- Send & store simple Data

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ERLANG

Making reliable distributed control systems in the presence of errors

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Making reliable distributed control systems in the presence of errors

- The “secret weapon” for Ericsson’s market leading, real-time telephony systems.

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Making reliable distributed control systems in the presence of errors

- The “secret weapon” for Ericsson’s market leading, real-time telephony systems.
- <u>20+ years of experience</u> to learn from.

ERLANG

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Erlang/OTP

Open Telecommunications Platform

- Embedded Distributed Systems
- High Availability
- In-Production Upgrades

How to Learn Erlang

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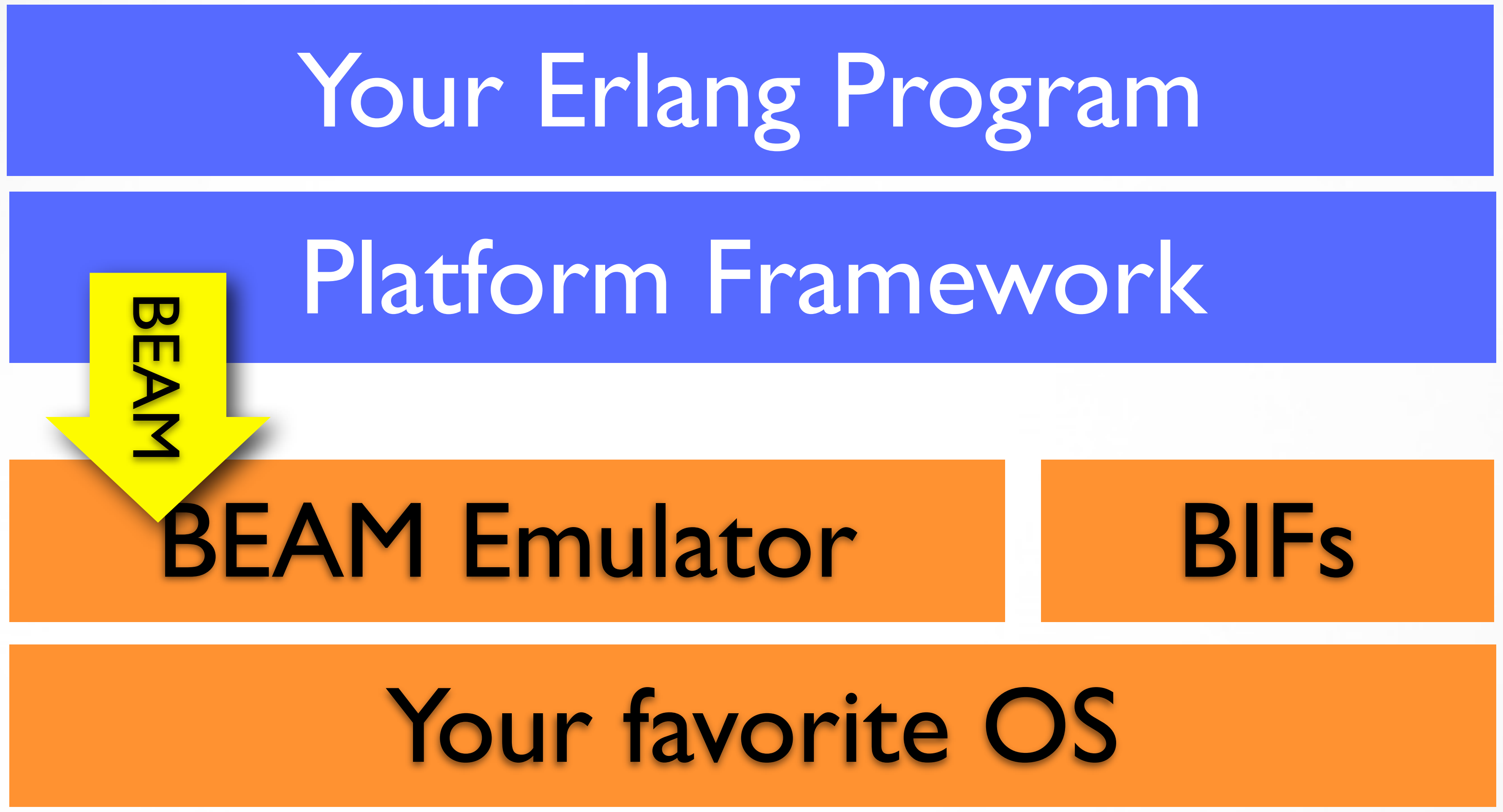
How to Learn Erlang

Dont dissect a frog,
Build One!

Nicolas Negroponte


Your Erlang Program
Platform Framework
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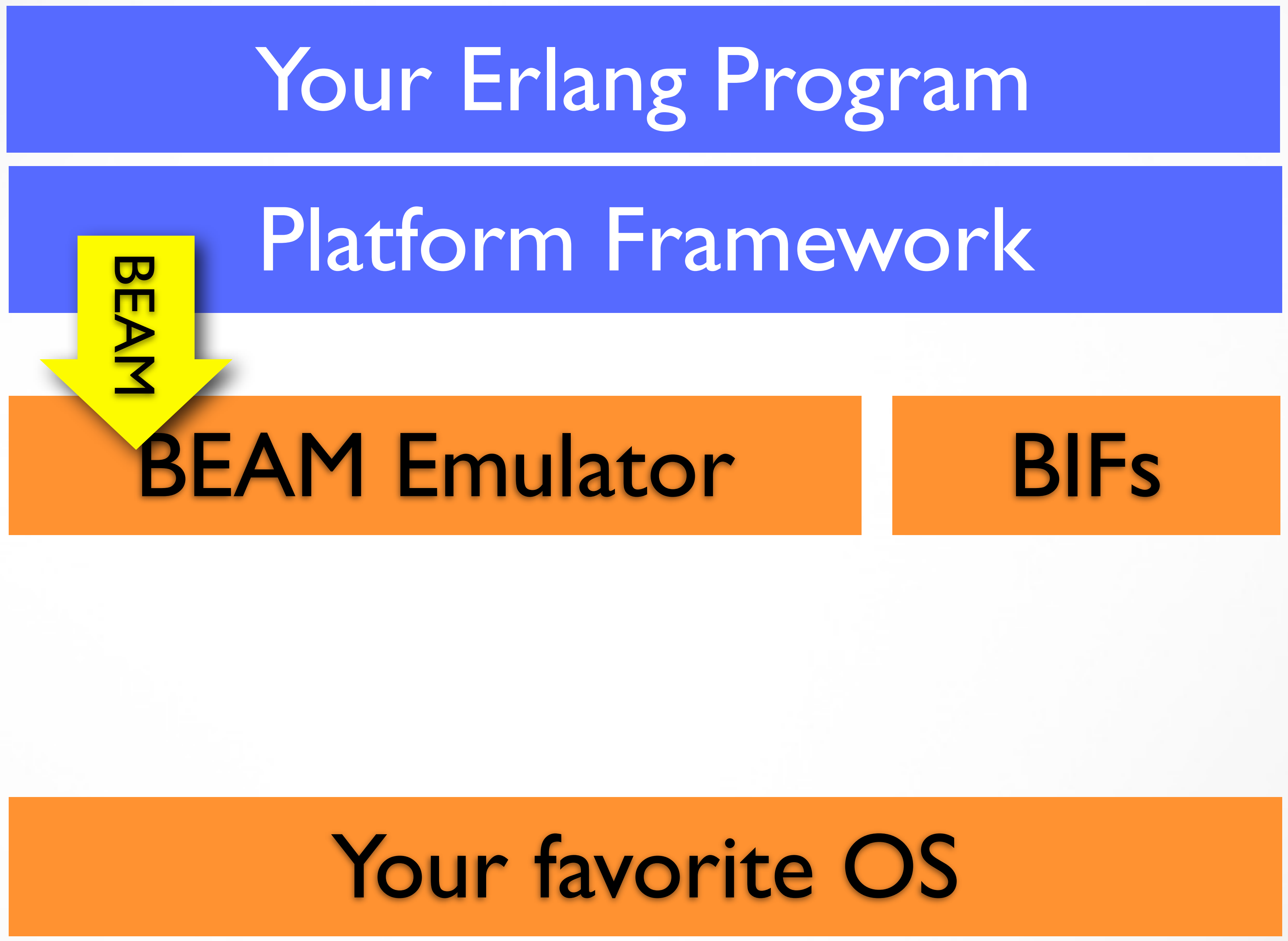
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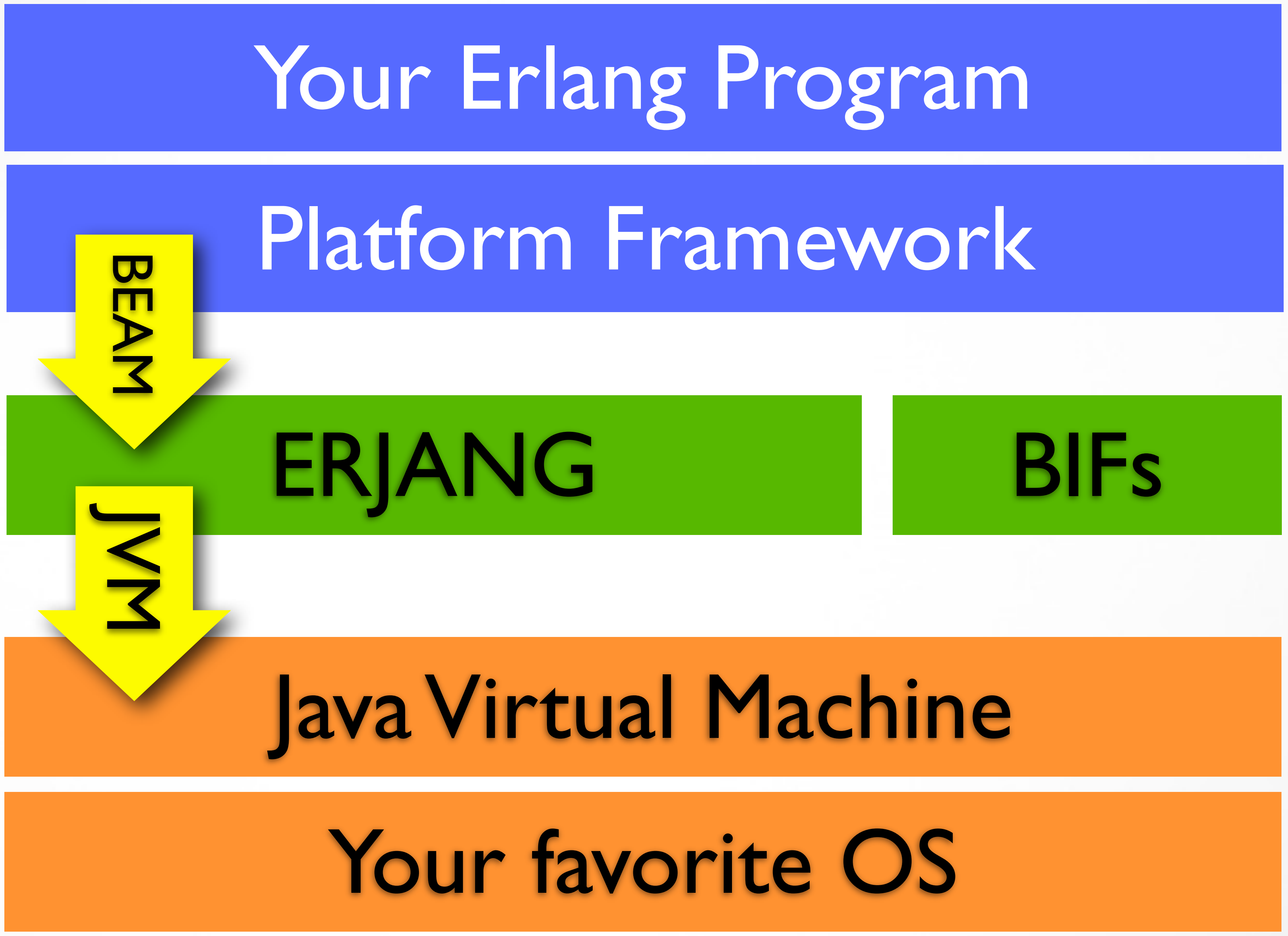
Your Erlang Program
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ERJANG
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Java Virtual Machine
Your favorite OS

Kresten Krab Thorup
Erlang Person of the Year, 2010

basho

OTP Actor Behaviors

- Servers
- Event Handlers
- Finite State Machine
- Supervisors
- Networking: TCP, HTTP

Tail Recursion

- Tail recursion is critical to programming Erlang processes
  - process enters a function
  - function acts on an incoming message
  - as last action in the function, it calls itself to handle the next message

Essence of OTP Behaviors

```
loop(State) ->
```

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```
loop(State) ->
    receive
        % handle messages here,
```

Essence of OTP Behaviors

```
loop(State) ->
    receive
        % handle messages here,
        % messages may affect State
    end,
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```
loop(State) ->
    NState = receive
                 % handle messages here,
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             end,
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loop(State) ->
    NState = receive
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                end,
    loop(NState).
```

Essence of OTP Behaviors

```
loop(Callbacks, State) ->
    NState = receive
                   Msg ->
                       Callbacks:handle(Msg, State)
               end,
    loop(Callbacks, NState).
```

Essence of OTP Behaviors

```
loop(Callbacks, State) ->
    NState = receive
                    M1 ->
                        Callbacks:handle1(M1,State);
                    M2 ->
                        Callbacks:handle2(M2,State);
                    M3 ->
                        Callbacks:handle3(M3,State)
                end,
    loop(Callbacks, NState).
```

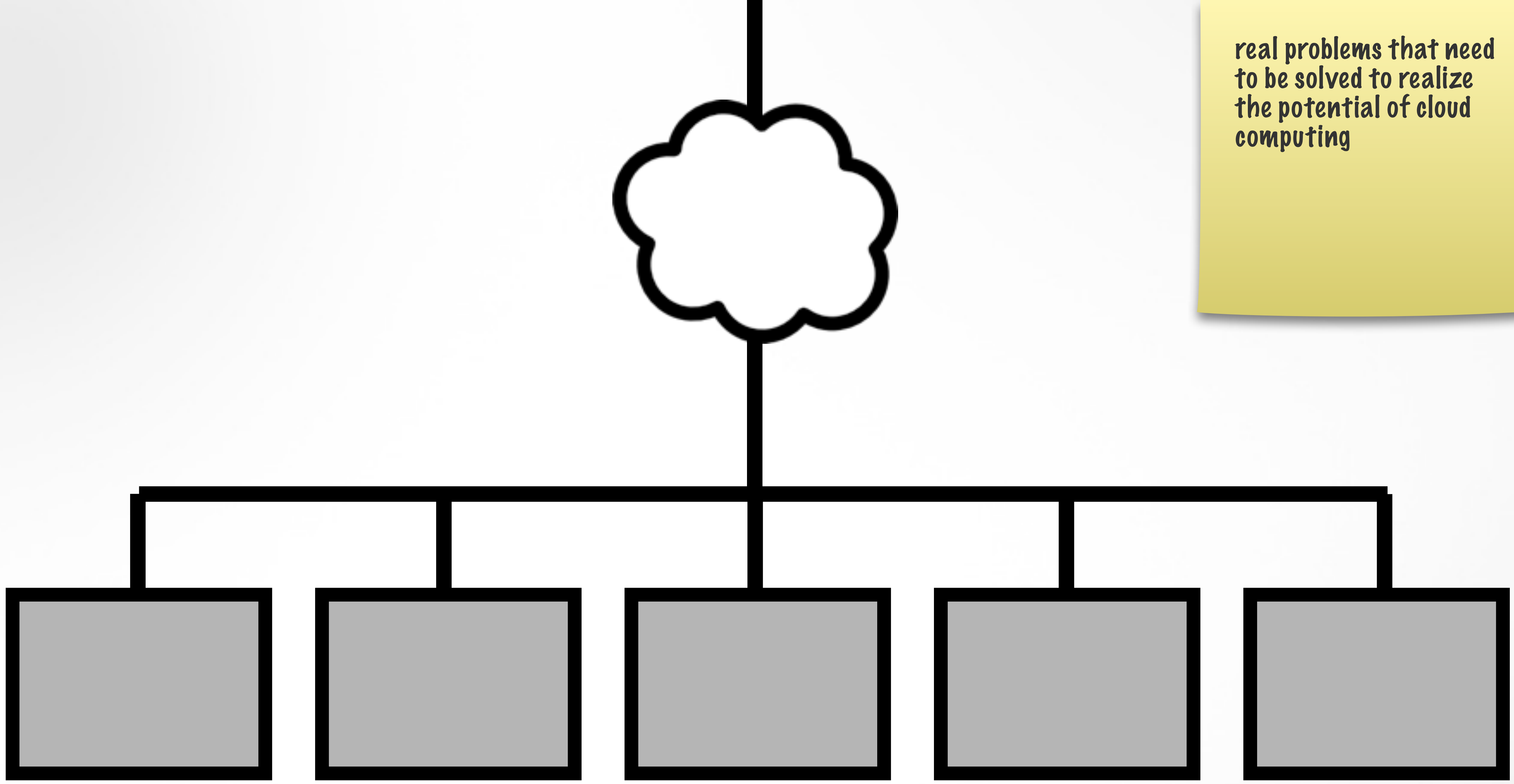
Essence of OTP Behaviors

```
loop(Callbacks, State) ->
    {Next, NState} =
                receive
                    M1 ->
                        Callbacks:handle_m1(M1,State);
                    M2 ->
                        Callbacks:handle_m2(M2,State);
                    M3 ->
                        Callbacks:handle_m3(M3,State)
                end,
    case Next of
        stop -> ok;
        _ -> loop(Callbacks, NState) end.
```

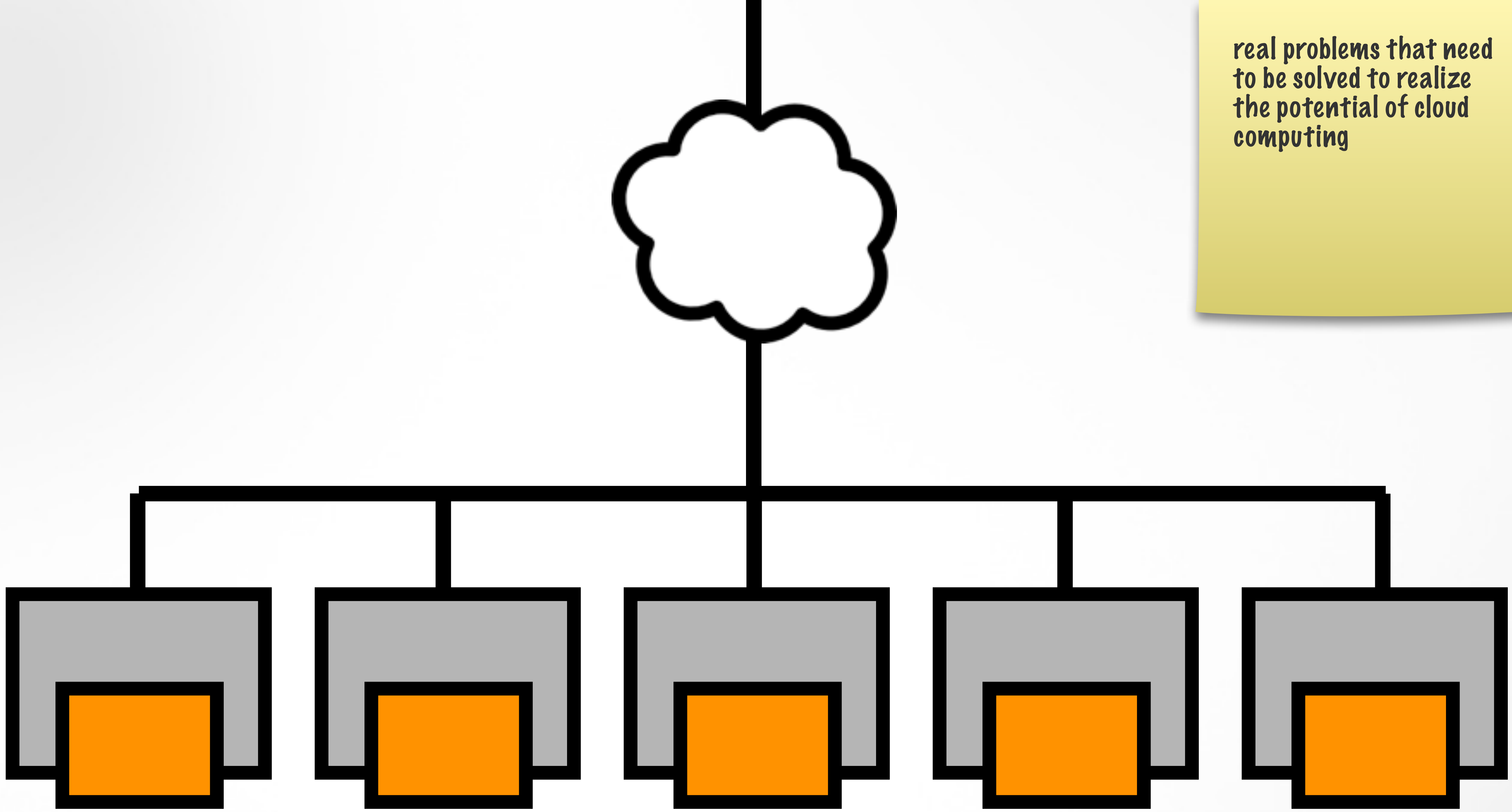
Behavior Loops

- These are the basics
- Actual OTP behavior loops are much more sophisticated
- gen_server, gen_fsm, supervisor, etc. all assume specific callback functions, checked by the compiler

Erlang Systems



real problems that need to be solved to realize the potential of cloud computing



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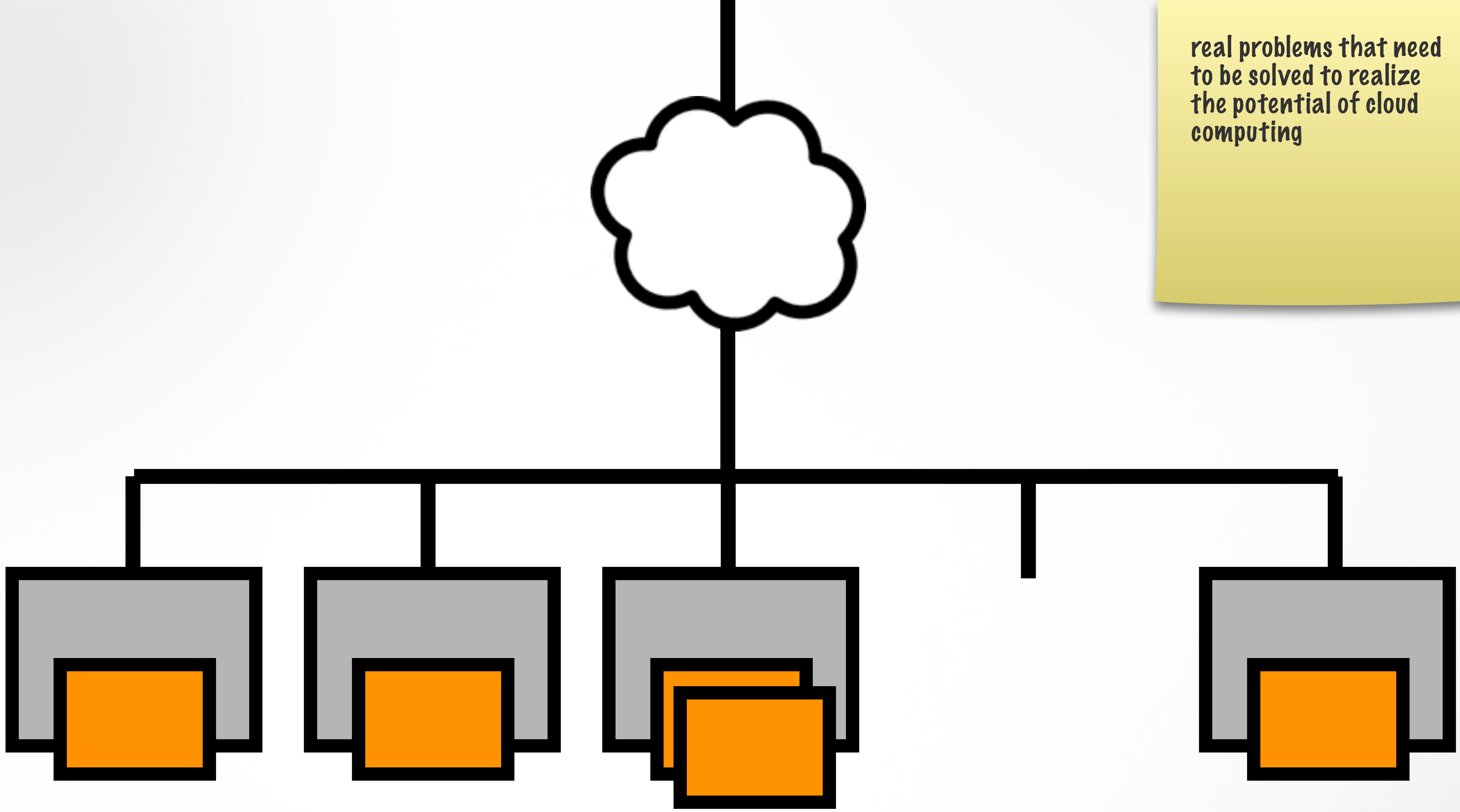

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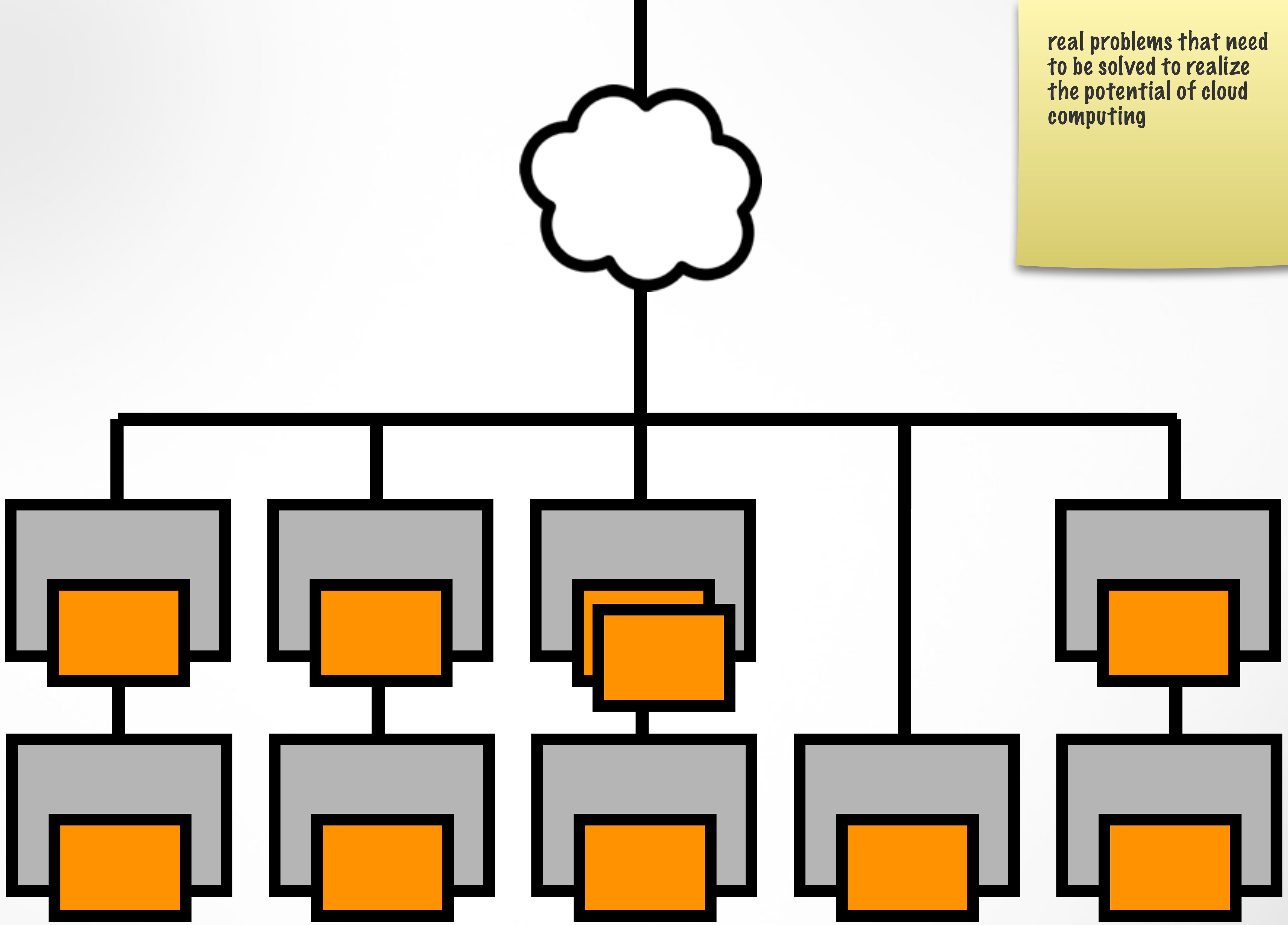

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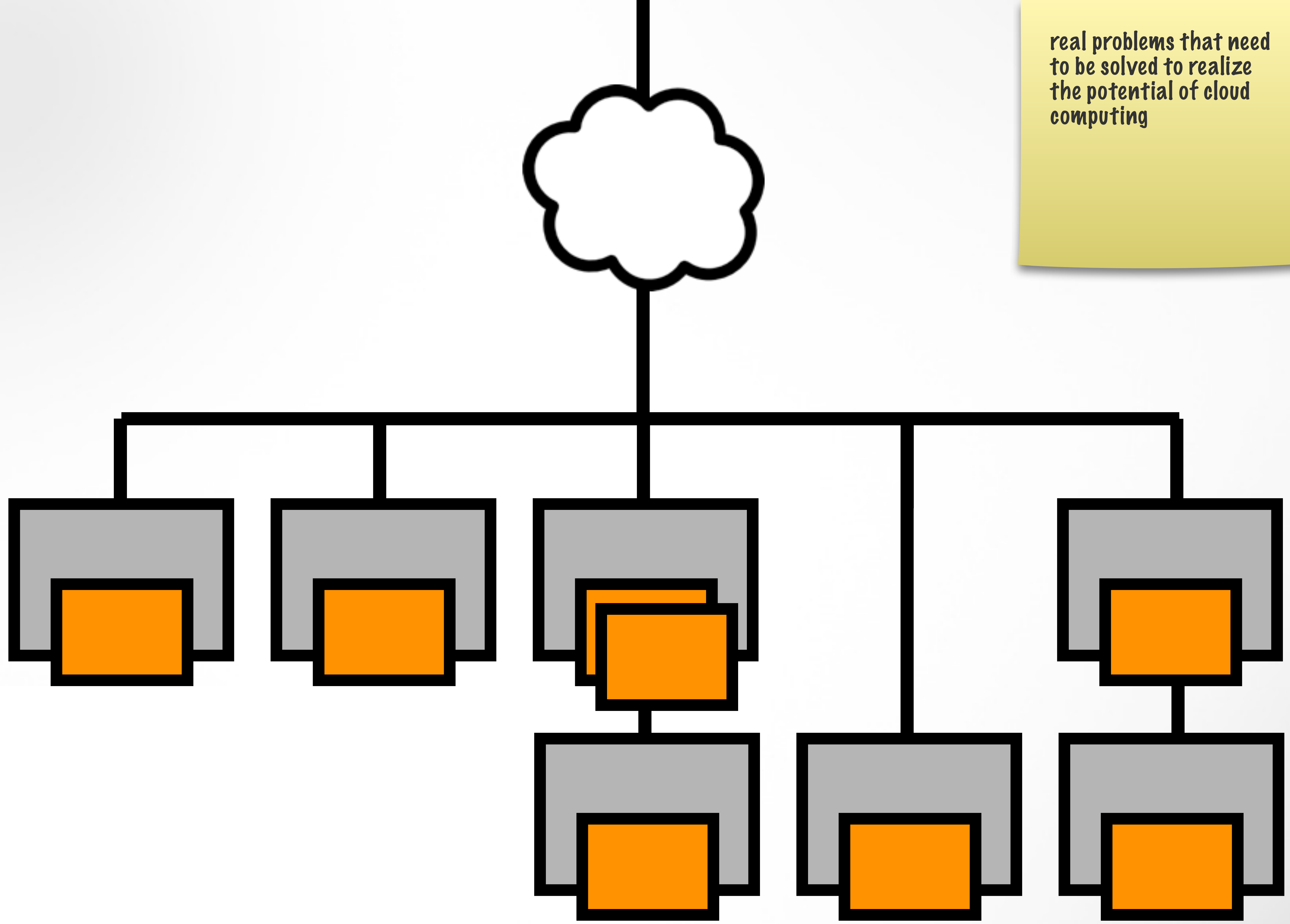

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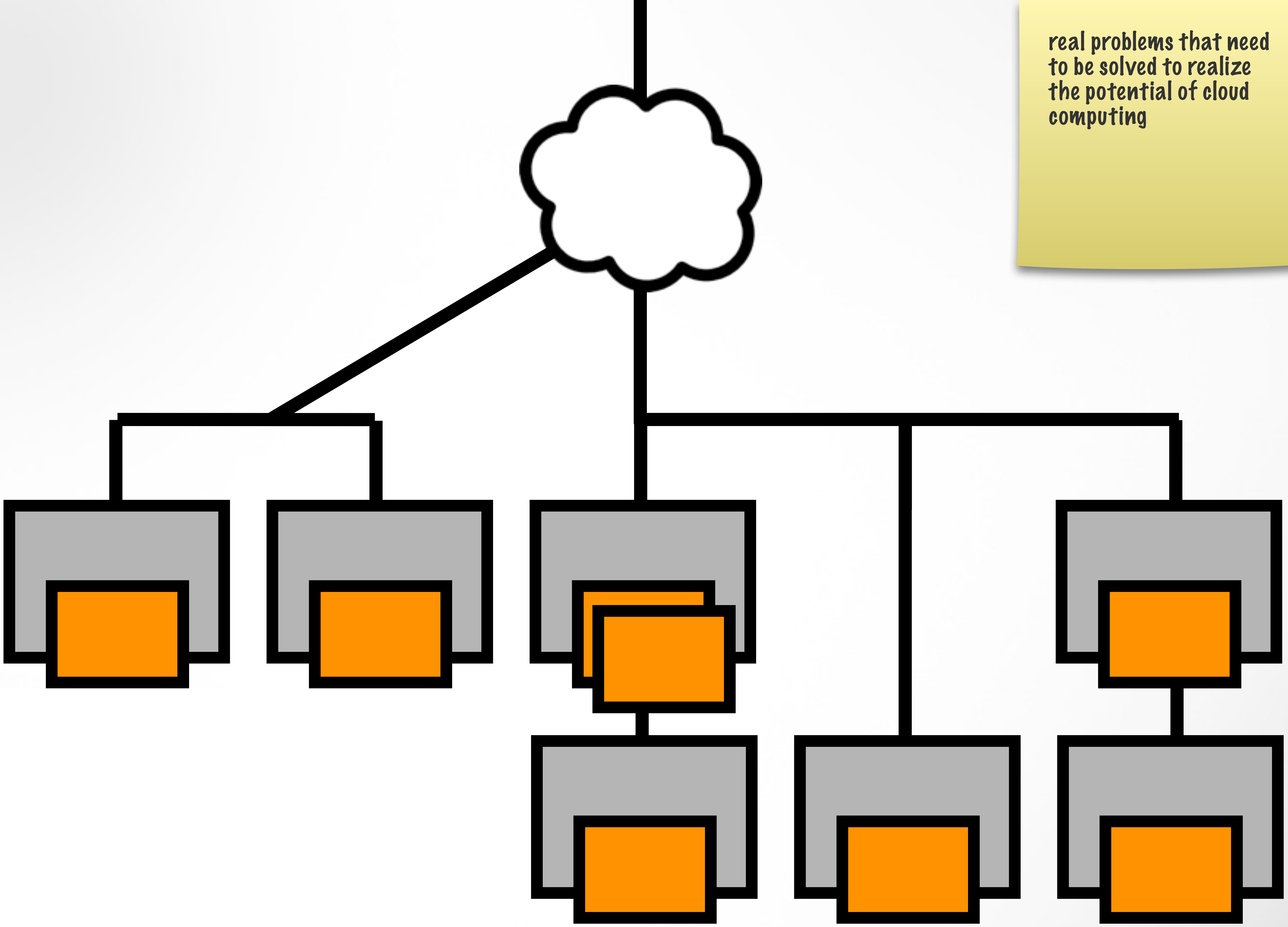

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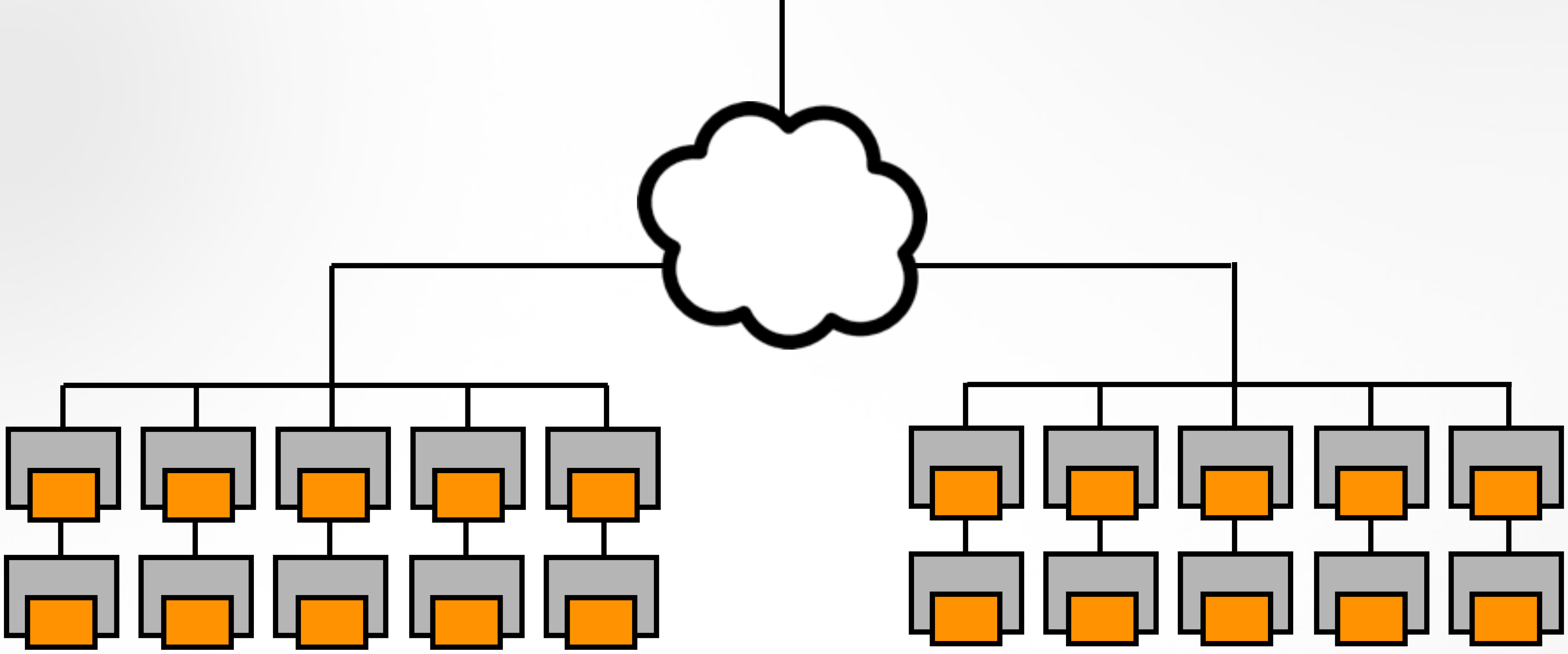

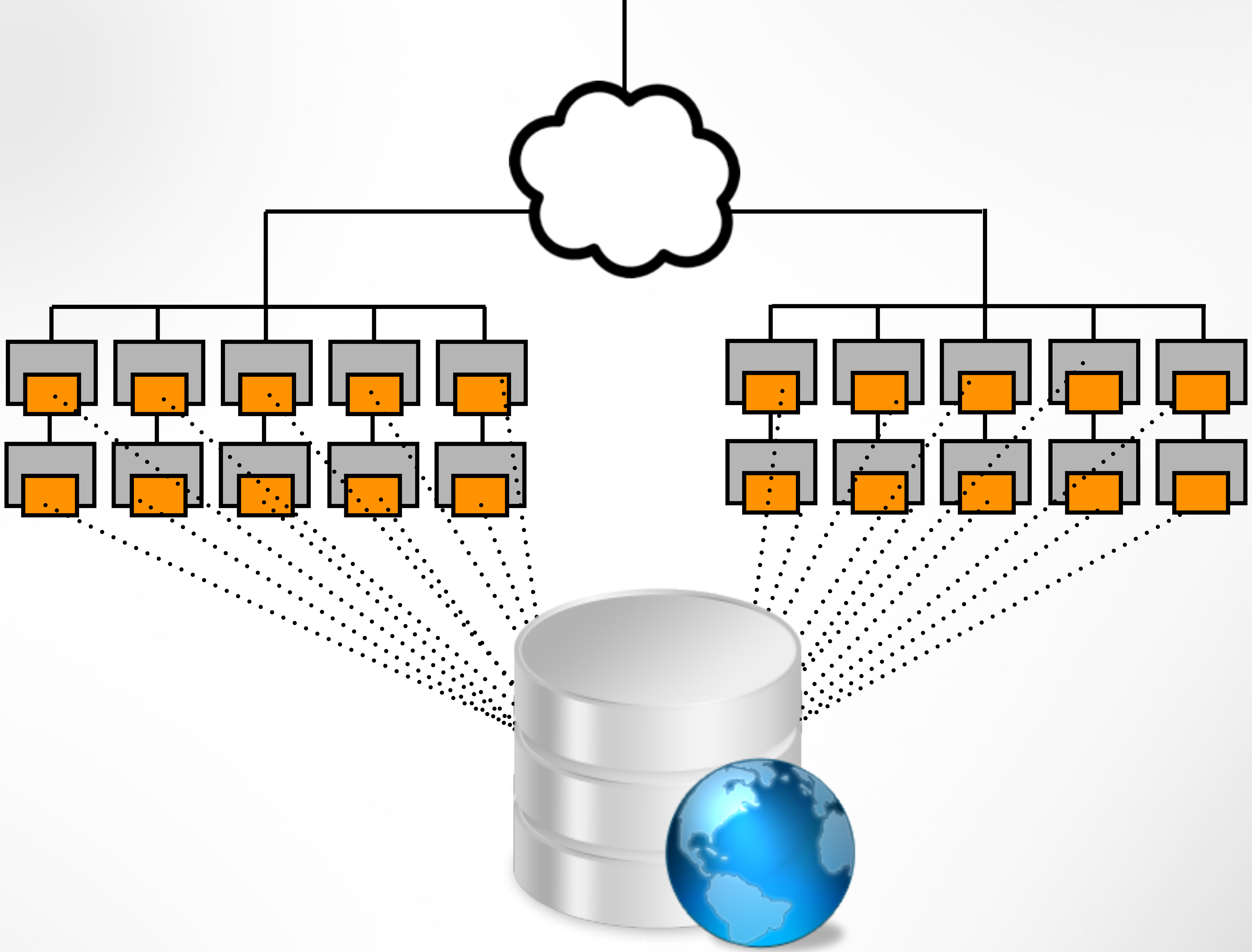

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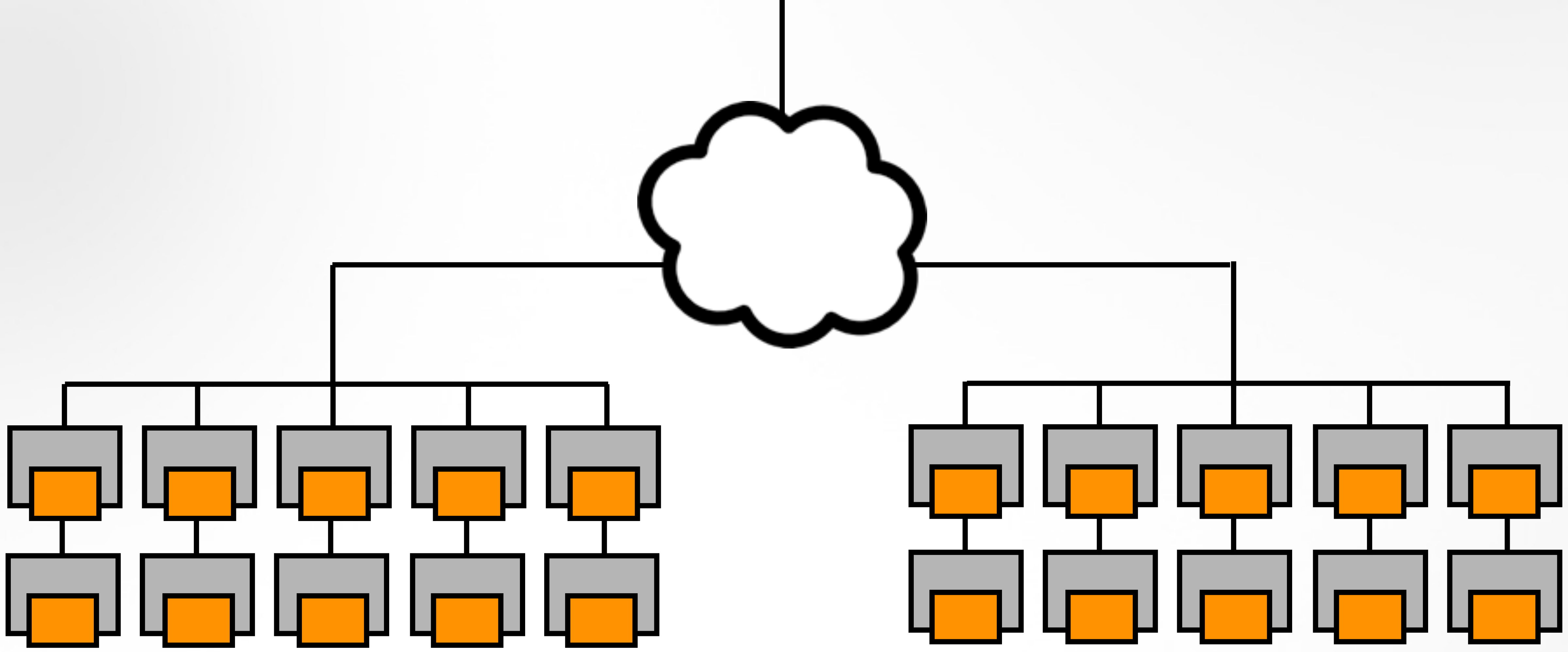
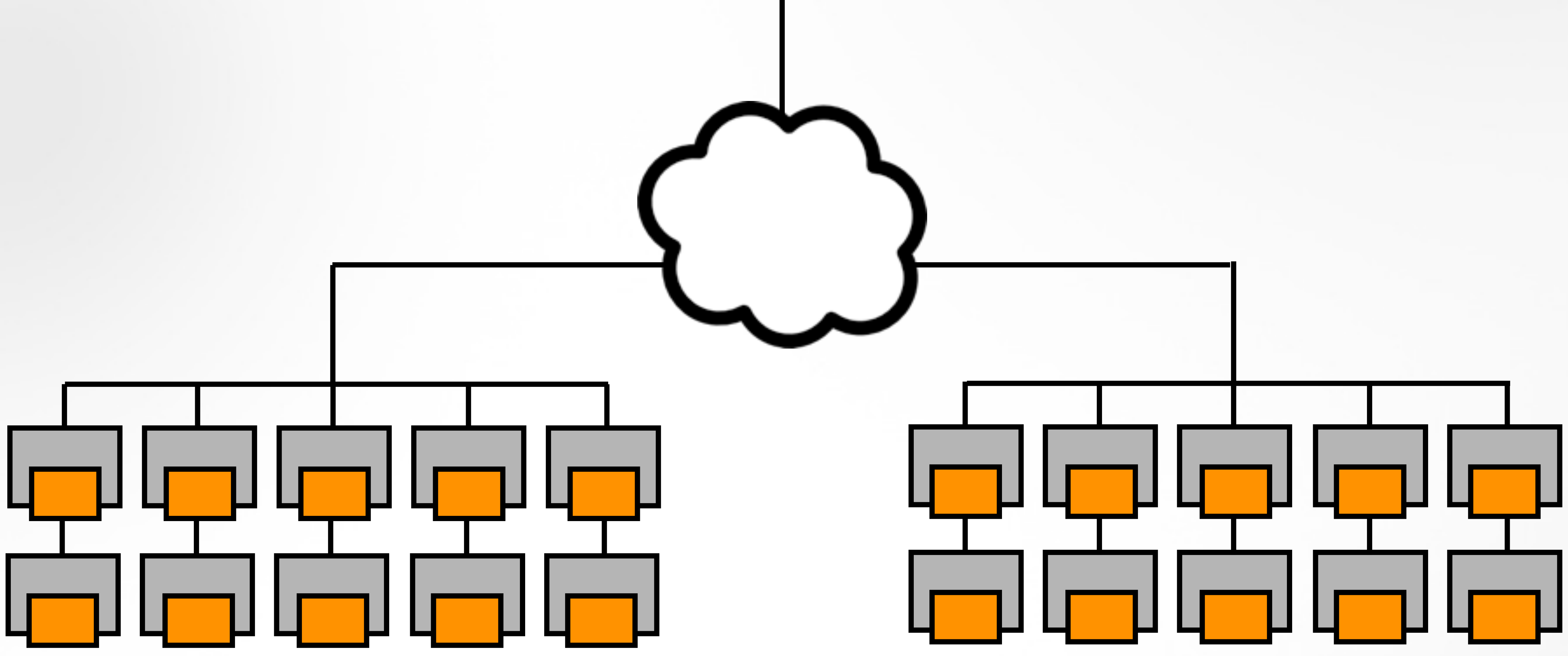
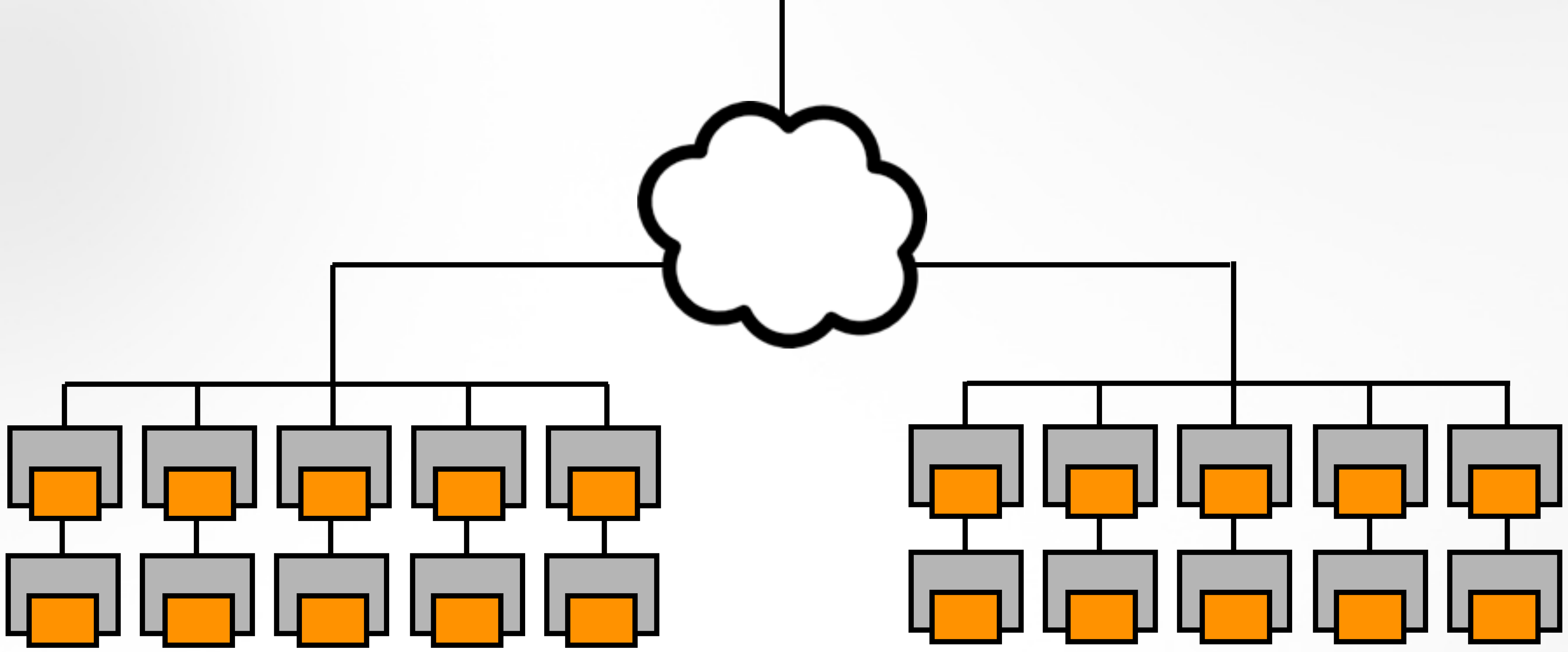




Async Messaging



Async Messaging

State [Fault] Containment

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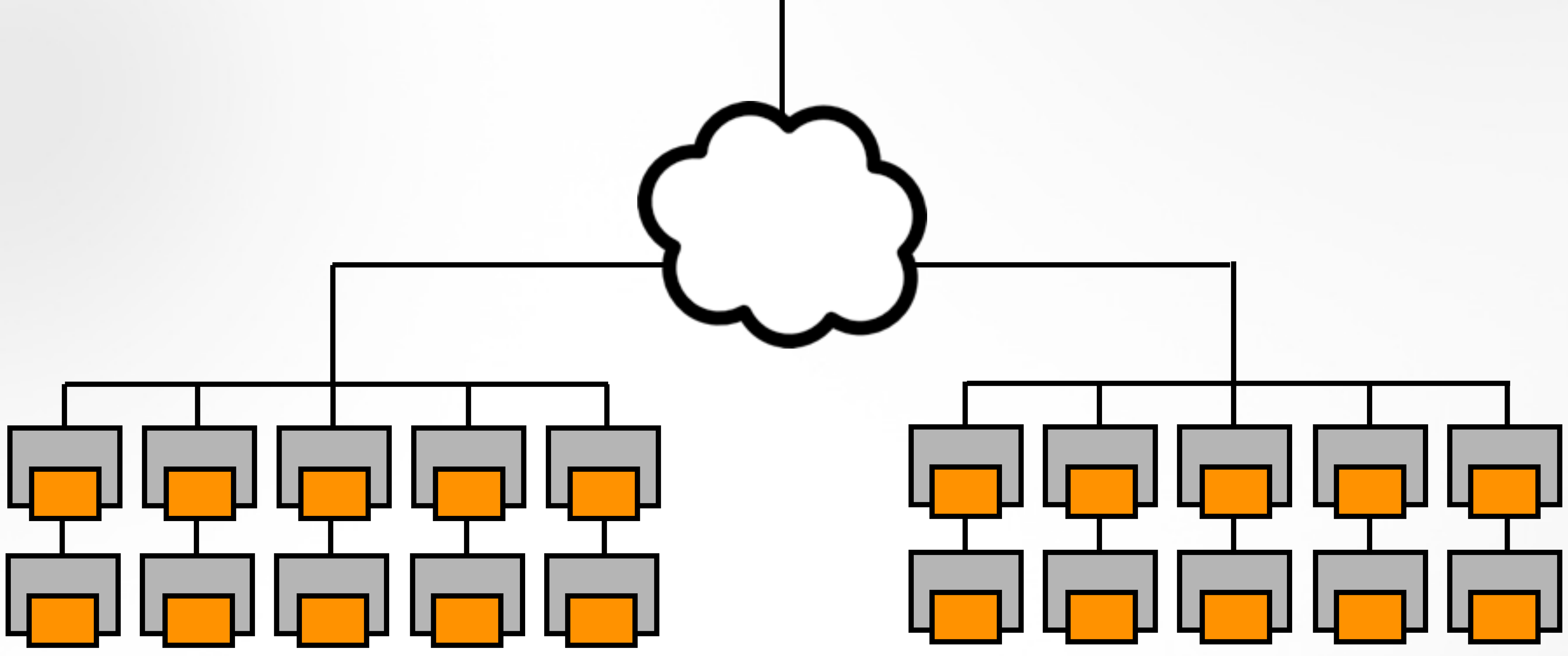

Async Messaging

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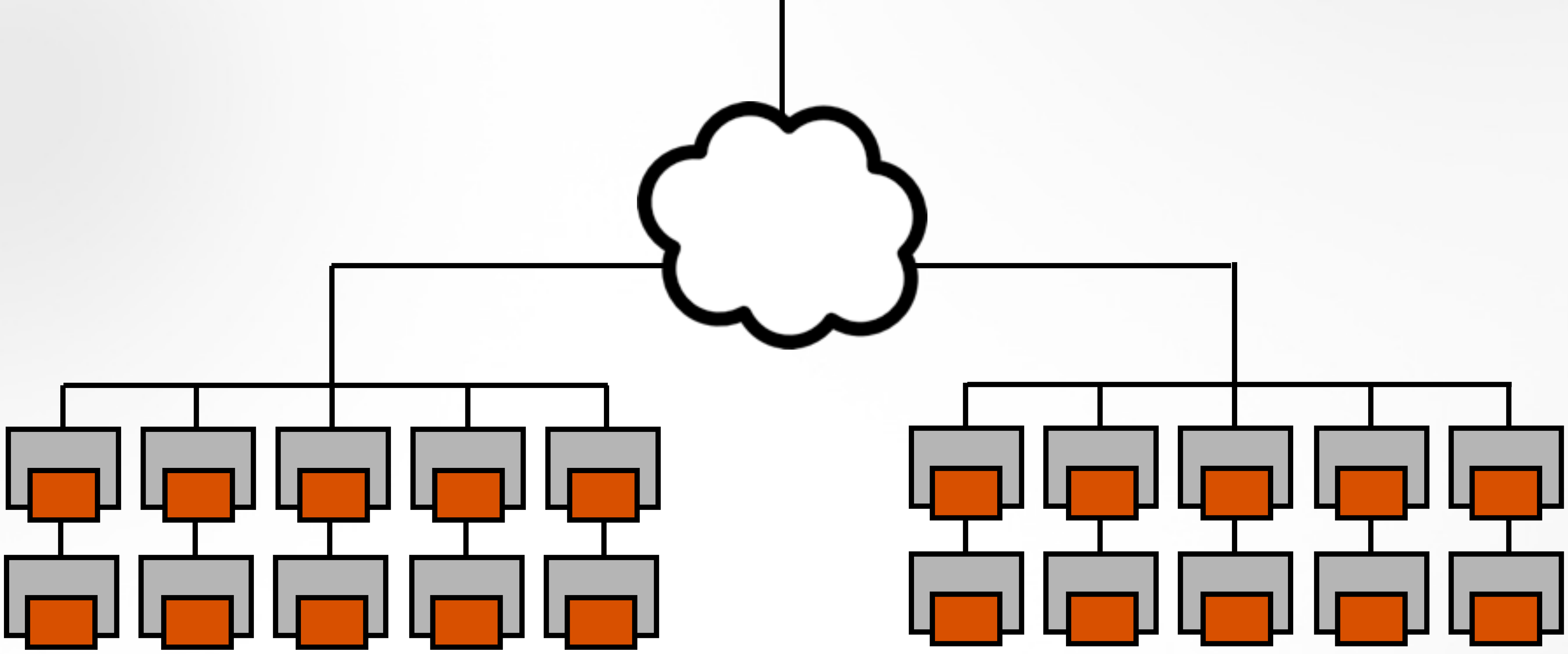
Fault Monitoring



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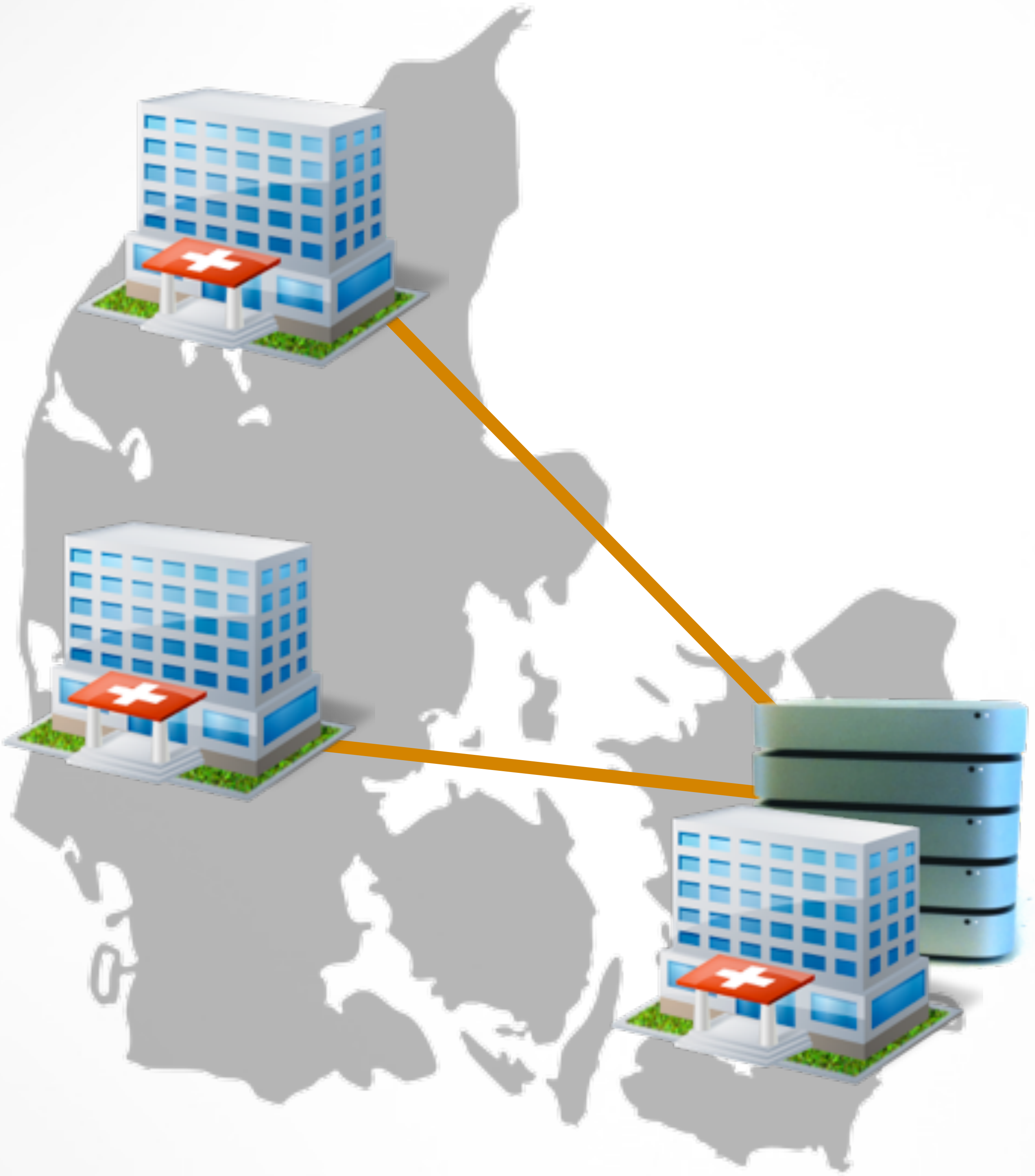
Common Medicine Card



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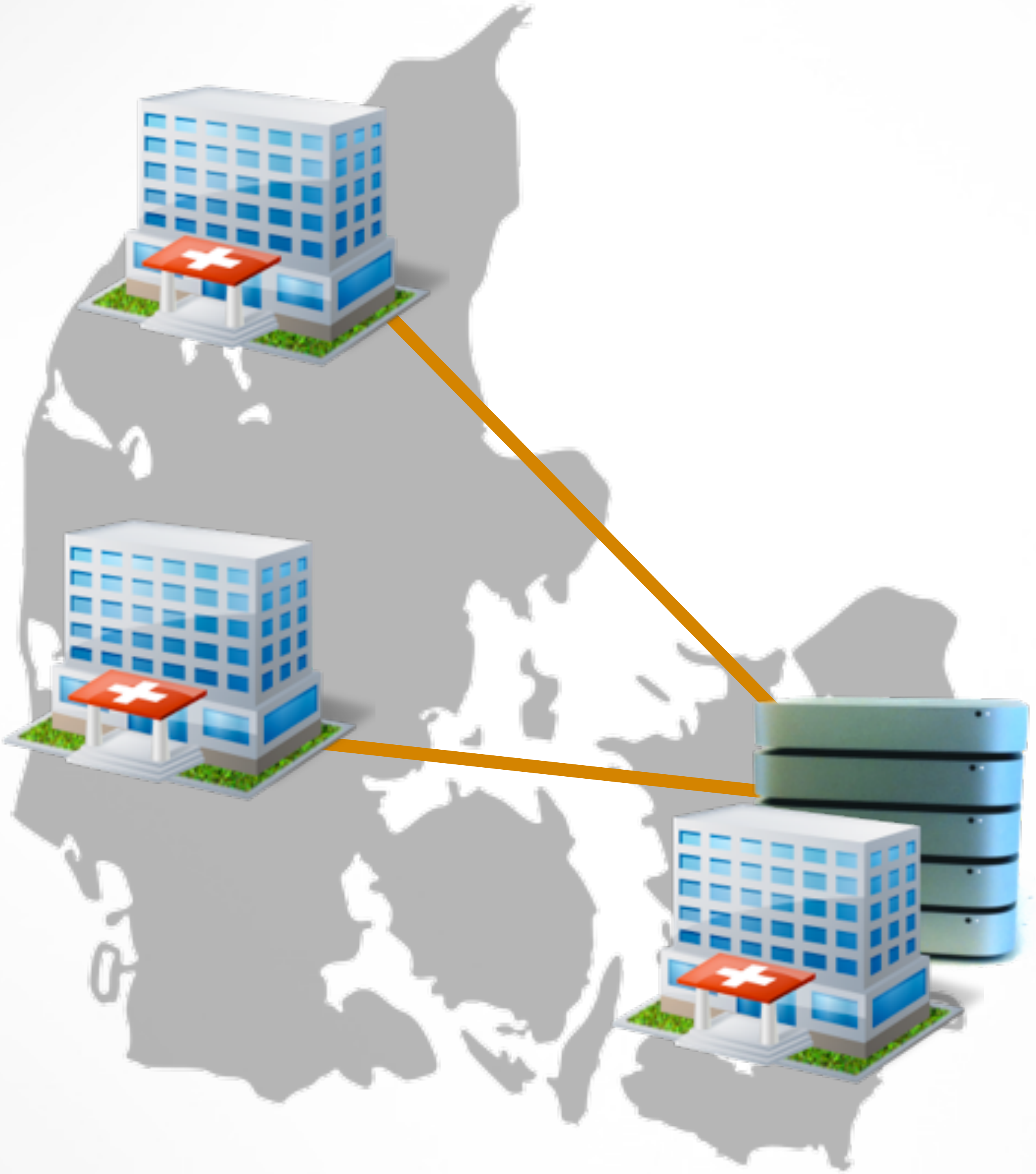

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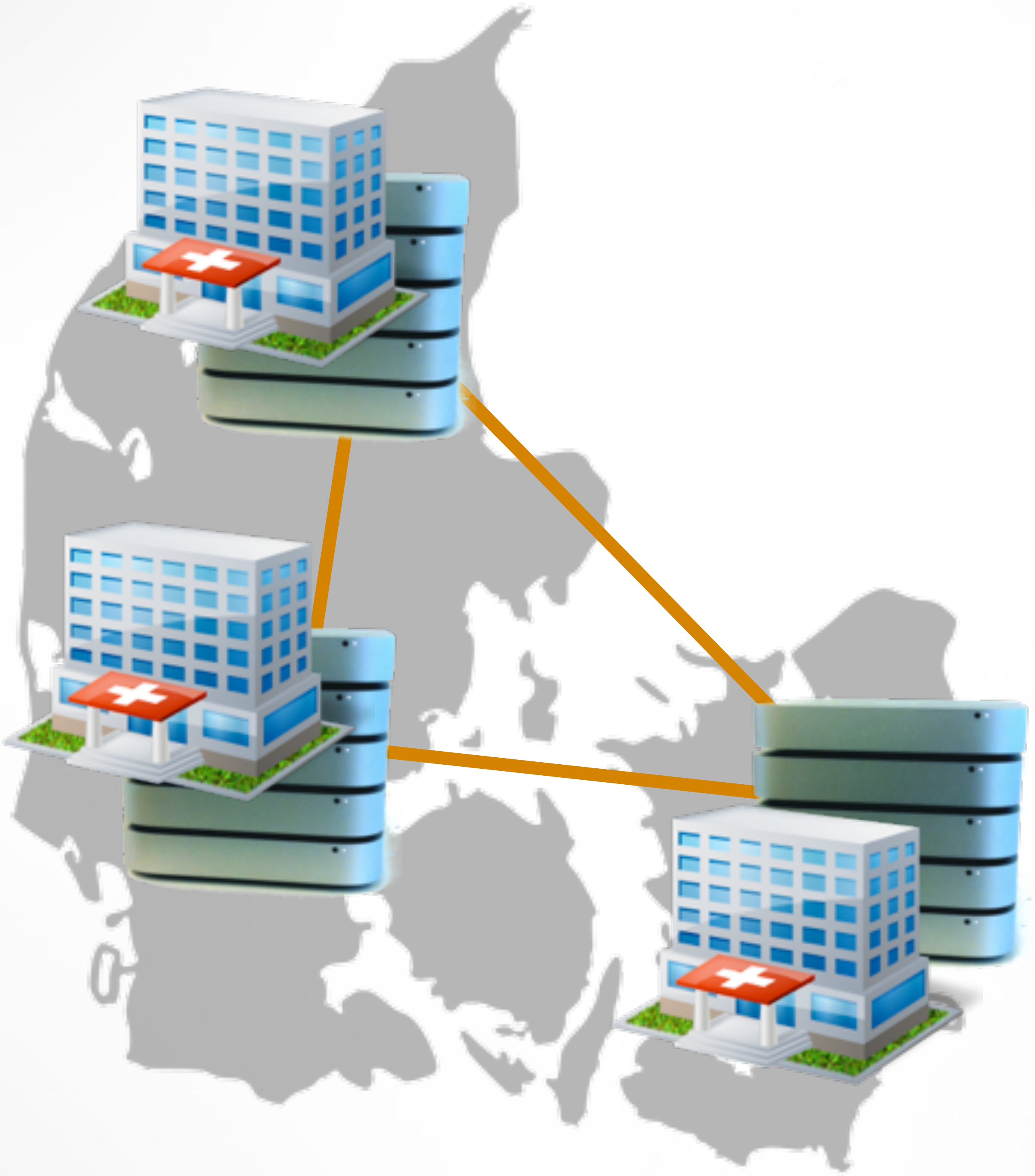

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Who Else Uses Erlang?

facebook

ejabberd

riak

T · · Mobile · · ·

klarna

CouchDB
relax

RabbitMQ
Open Source Enterprise Messaging

Advice for New Erlang Users

Integration Using Erlang

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- Trivial access to TCP, UDP
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- Application protocol handlers built using gen_server or gen_fsm

basho

Integration Using Erlang

- Often write little networked clients and servers directly in the erl shell
- Packet decoding and bit syntax sets Erlang apart from netcat, perl, etc. in this regard
- It’s like a middleware/coordination DSL

dbg and Tracing

- Erlang’s tracing is one of its most amazing features
- Learn the dbg module, you’ll use it every day
- I have needed the Erlang debugger only once, I always use dbg instead

Advice for New Users

- All that great stuff you've heard about Erlang? It's true
- Simple concurrency and coordination
- Hot code loading
- Always-available code tracing
- Sound, practical reliability
- Easy integration
- Enables "production prototypes"
- Open source at github.com
- Language and docs available at erlang.org

Warning: "Let It Crash"

- This philosophy can be hard for non-Erlangers to buy into
- QA sees a crash in the log, they treat it as something bad. Always.
  - explaining it was designed that way doesn't always fly
- Programmers new to Erlang (or sometimes not so new) always want to try to handle the errors instead

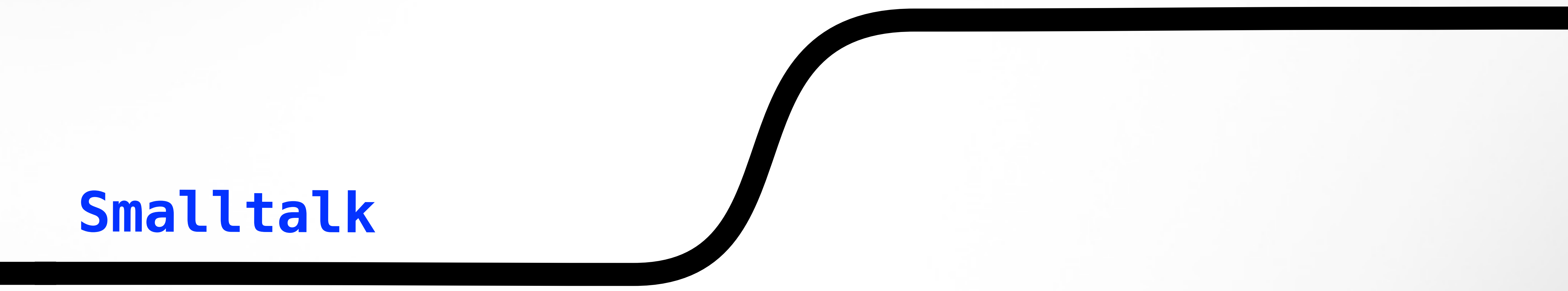
But “Let It Crash” Works

- Crash and recovery is invaluable for early adopter customers
- They keep using the system even if something goes wrong
- Most of the time, they’re unaware of the crash/recovery
- With dbg and hot code loading, you can debug and repair live systems

But Wait! There's More

- extensive library of useful modules
- details of OTP applications, supervision, code upgrade, hot code loading
- ets and dets: Erlang Term Storage (in memory) and Disk ets (persistent)
- mnesia: distributed transactional database
- rebar: open source build and dependency management system

Revolution?



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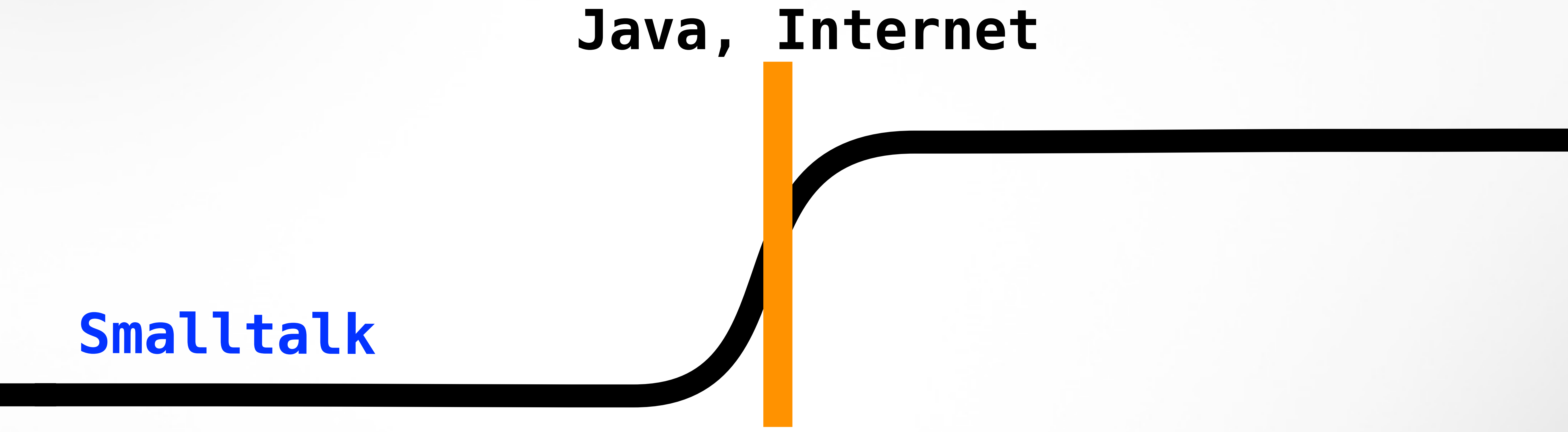
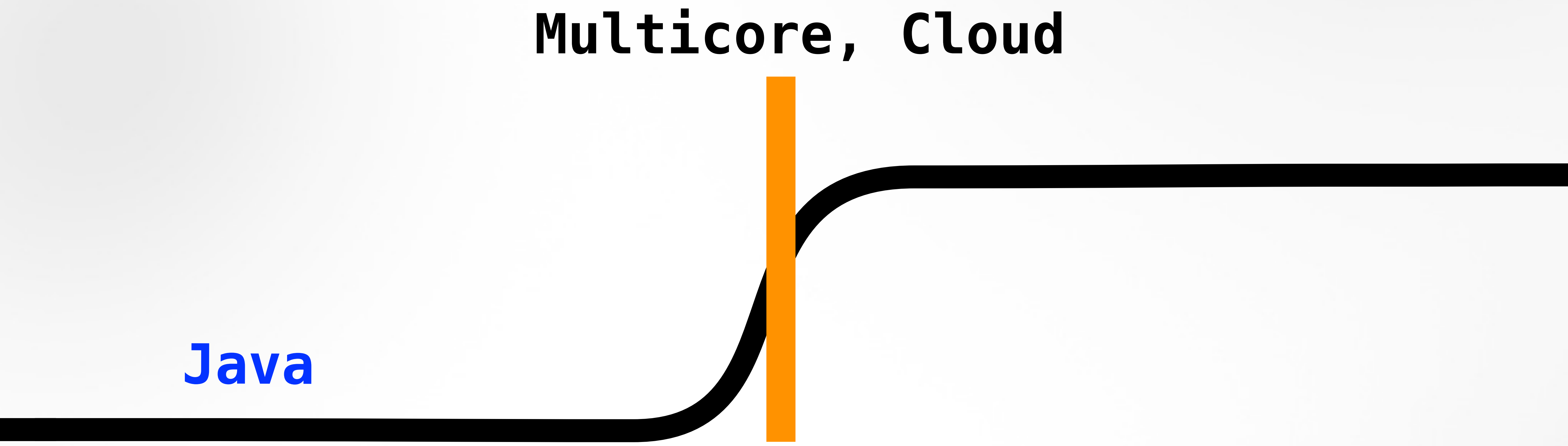


Java

Multicore, Cloud



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- RPC/RMI
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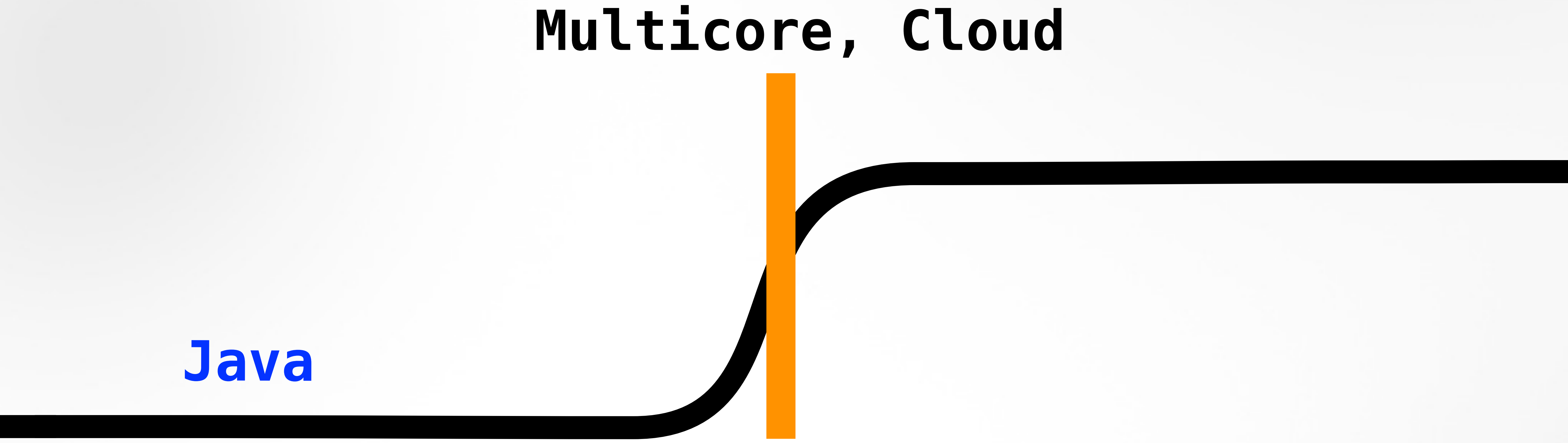

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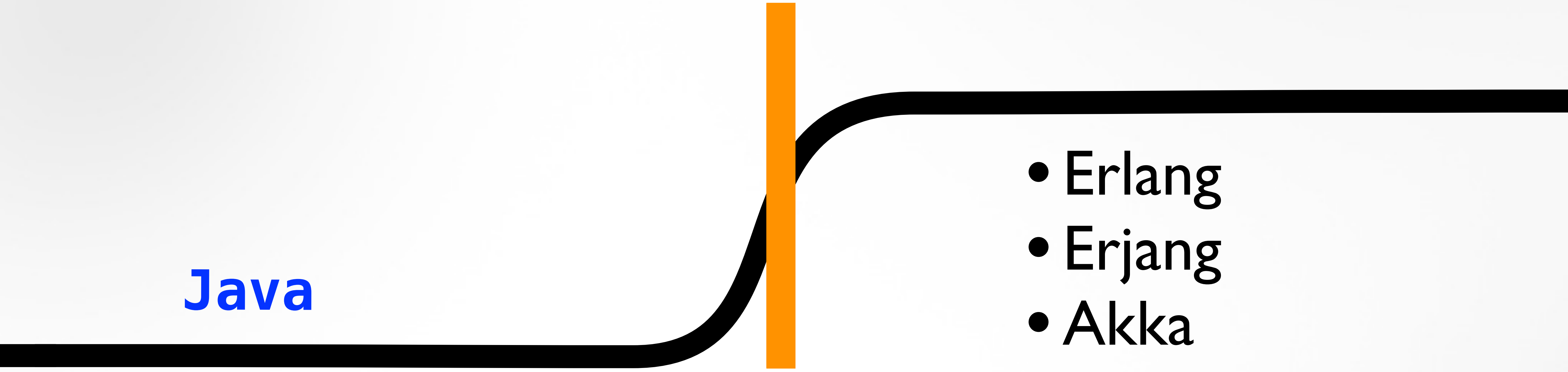
Anomalies

Multicore, Cloud, Actors



- Erlang
- Erjang
- Akka

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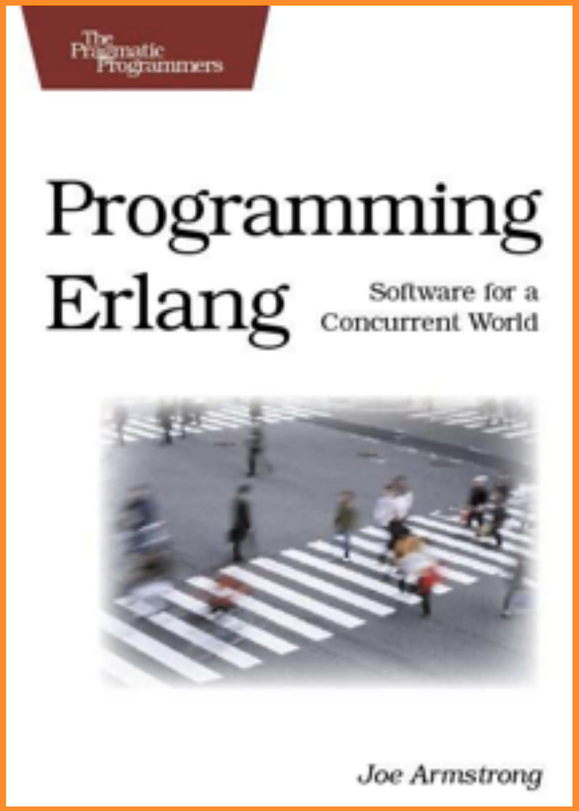
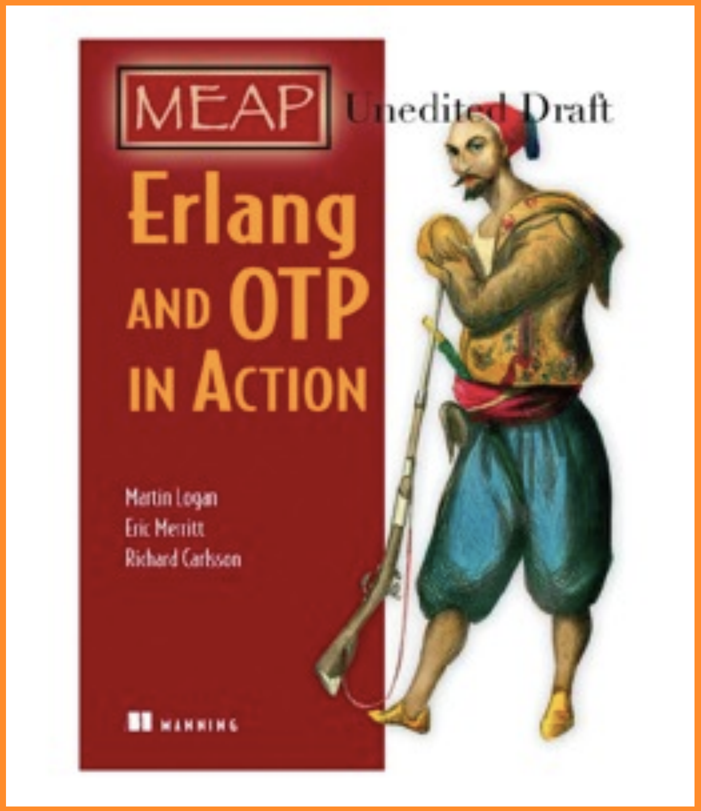
Read These



A Concurrent Approach to Software Development
Erlang Programming
O'REILLY
Francesco Cesarini & Simon Thompson



Also: http://learnyousomeerlang.com/

Thanks