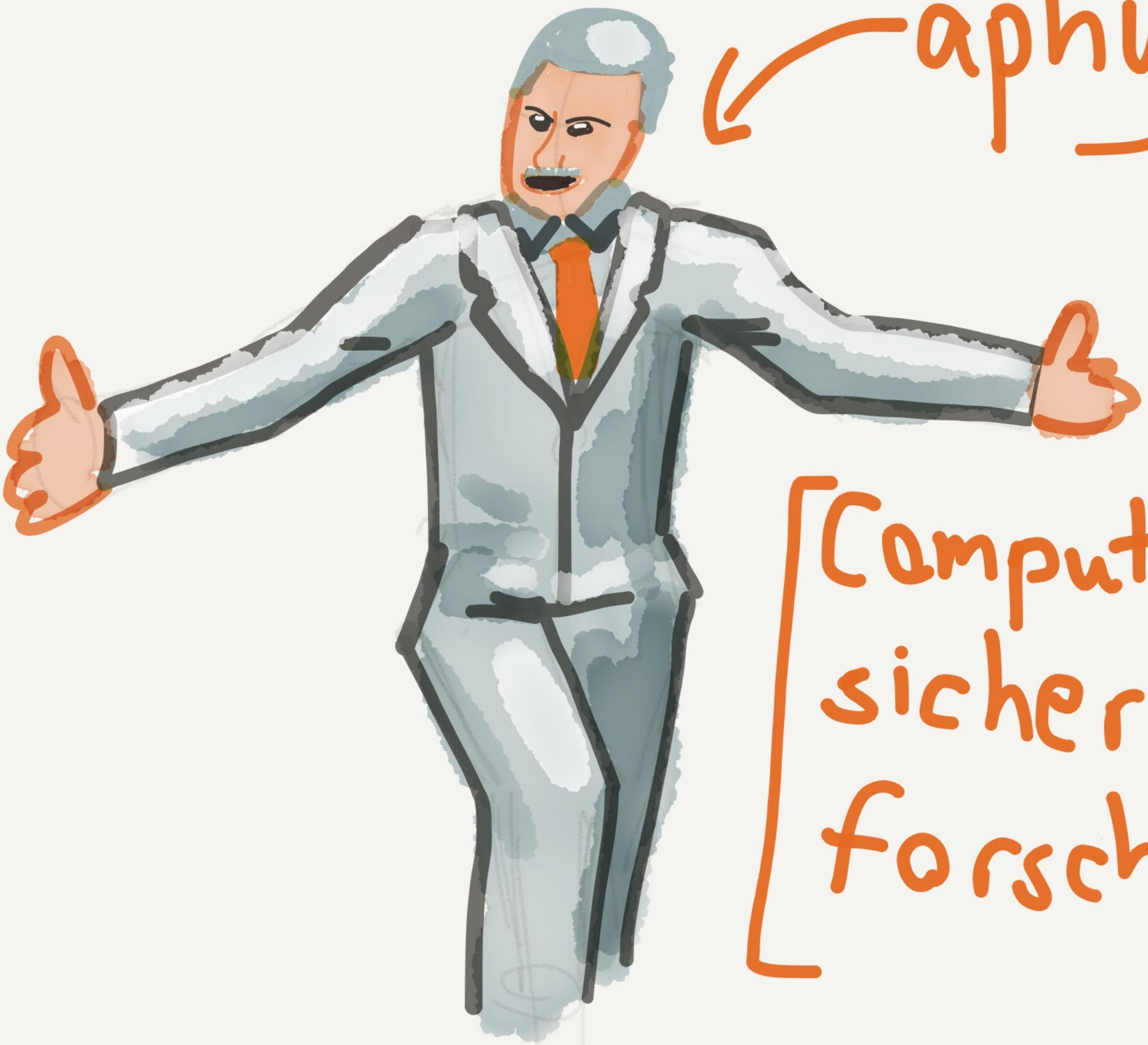
Jepsen

5

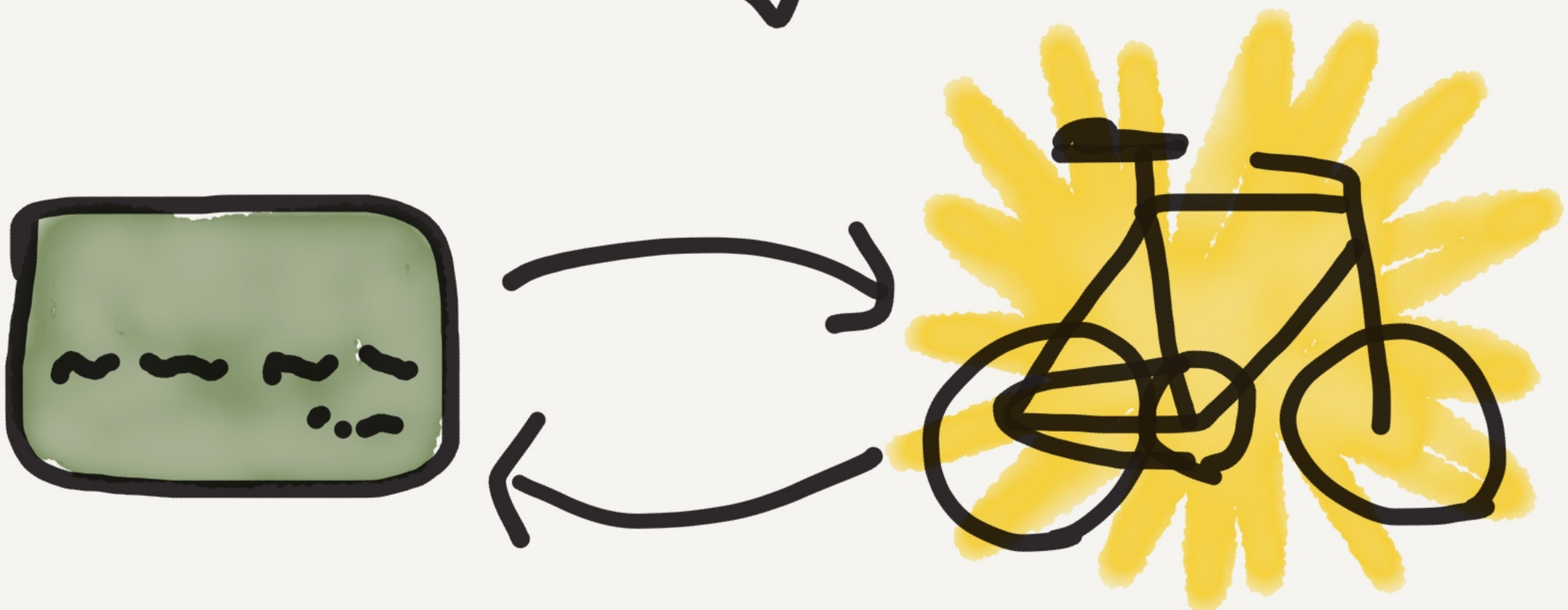
WHAT EVEN ARE COMPUTERS



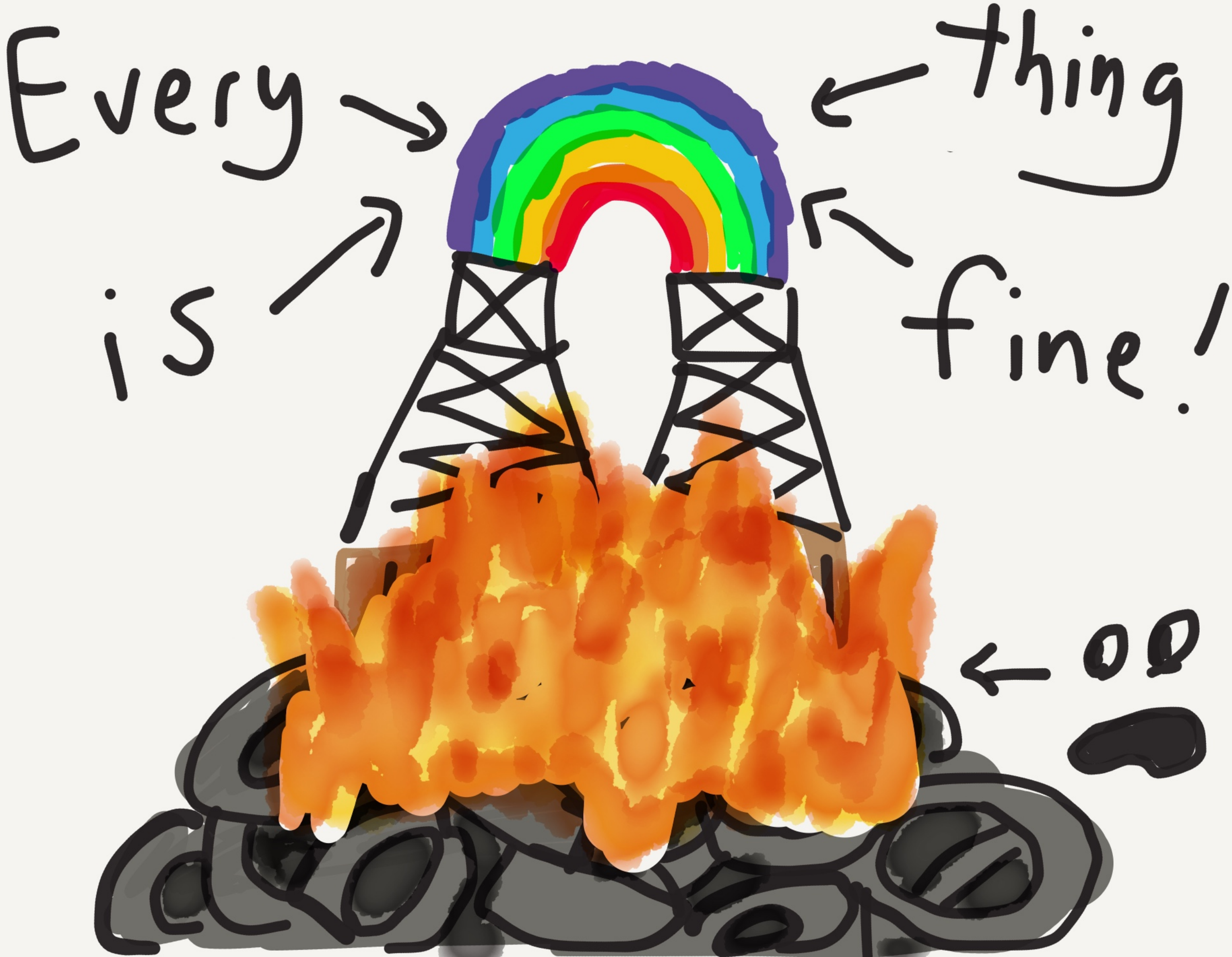
aphyr

[Computer-
sicherheits-
forscher]

stripe

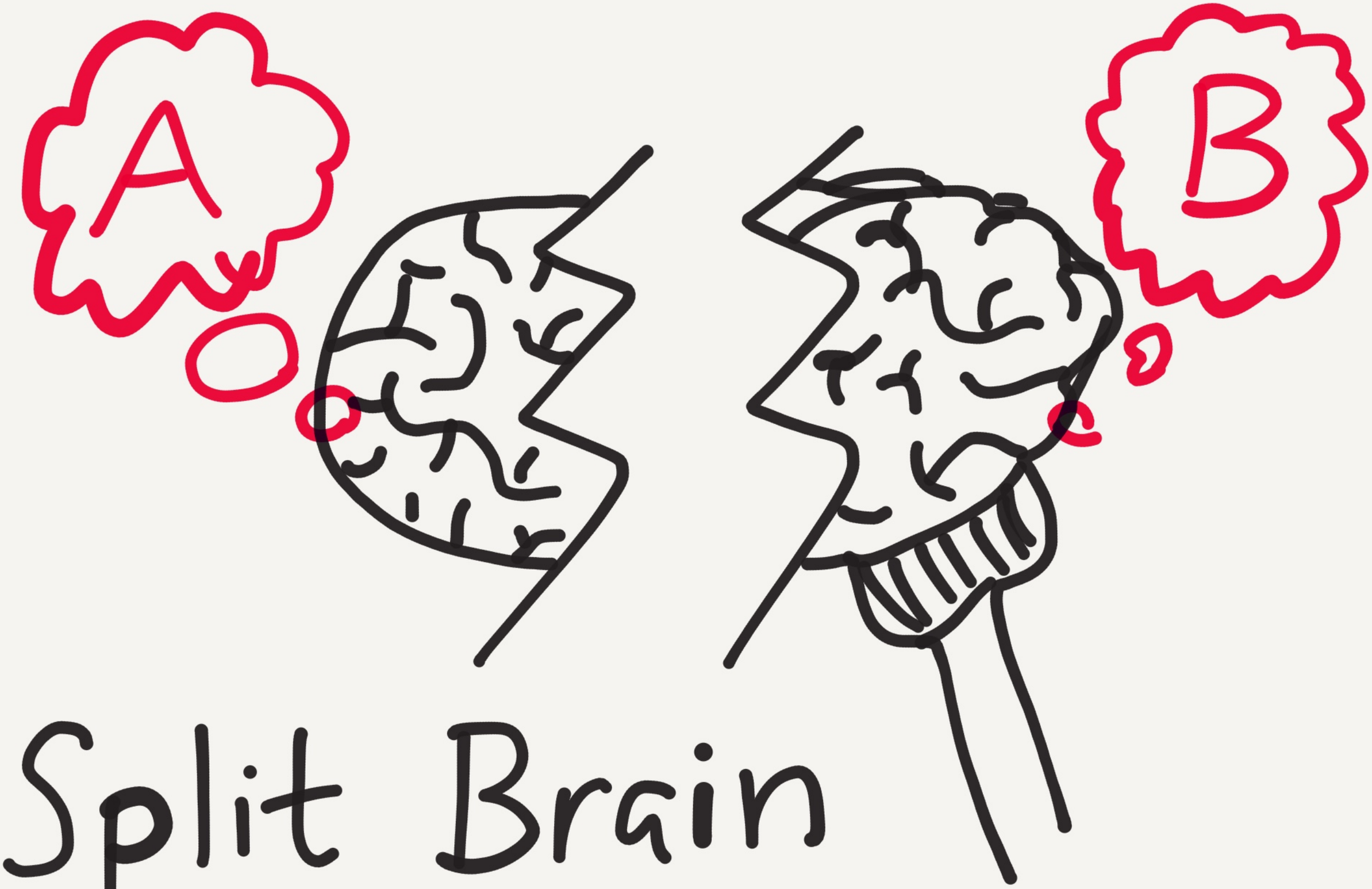


Public API
API code
Ruby
DBs


Every
thing
is
fine!

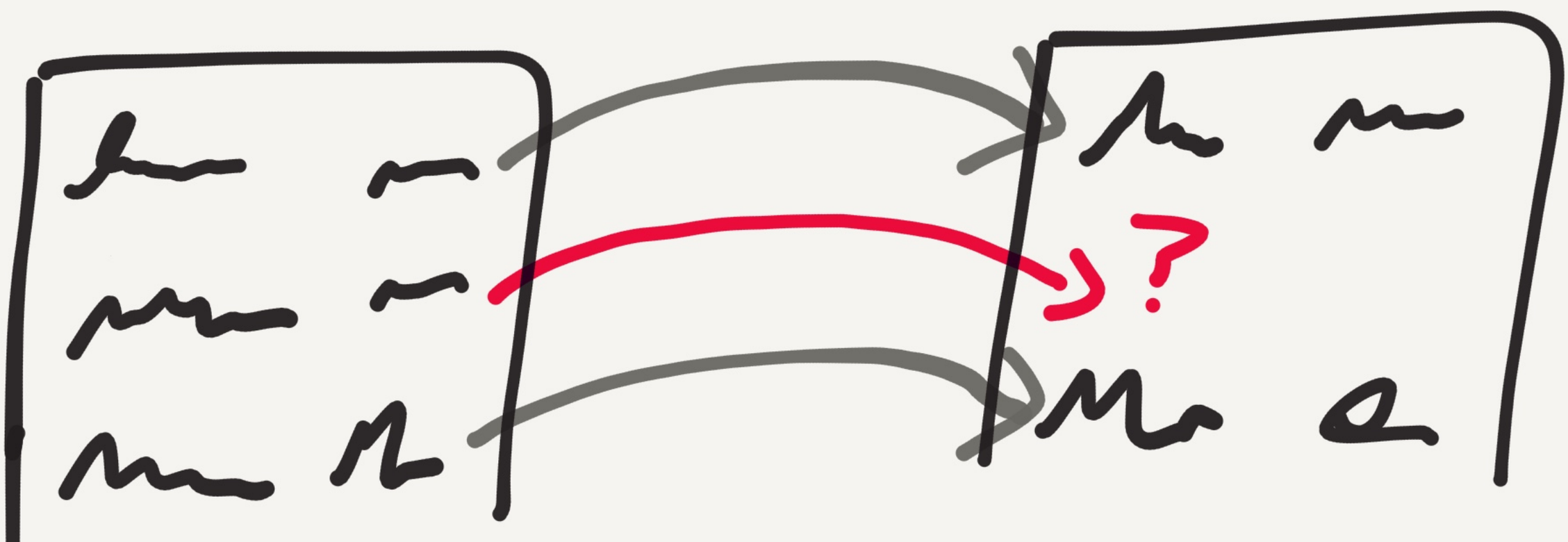
Databases!
Queues!
Discovery!

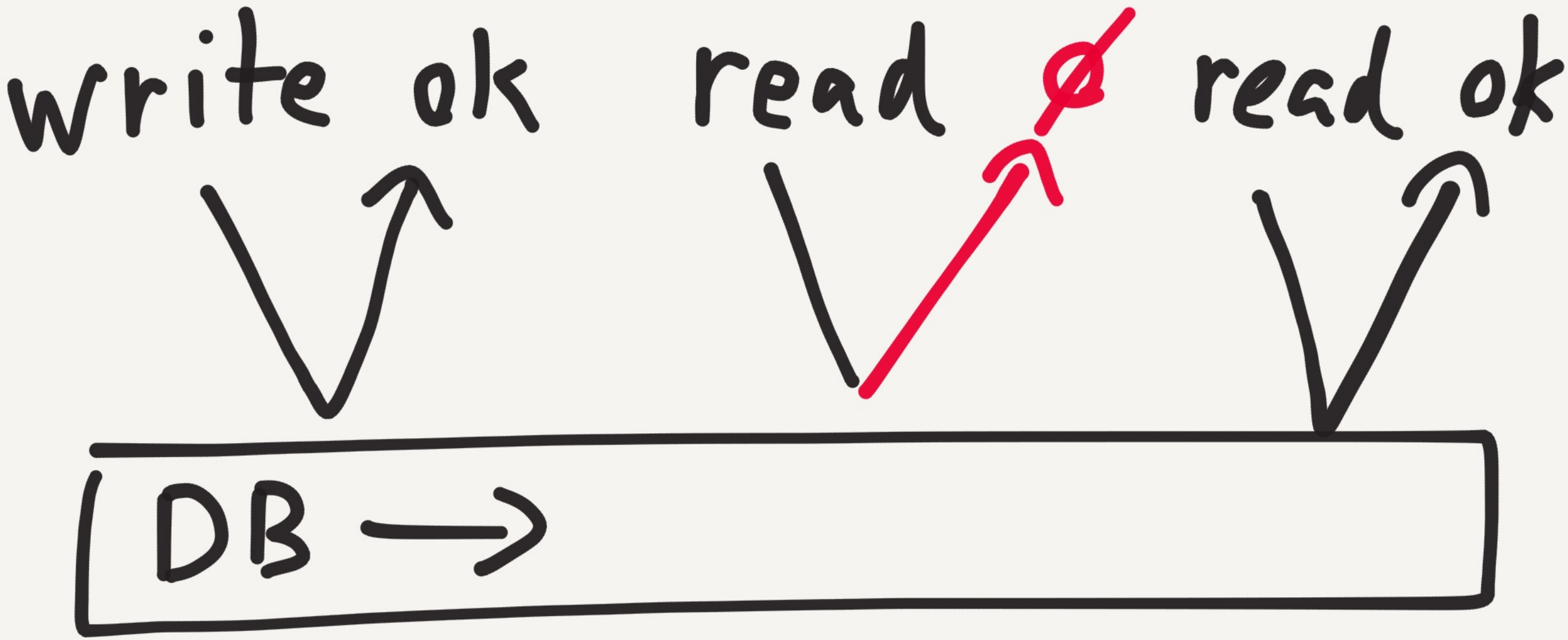
THE HORROR



Split Brain

Broken Foreign Keys

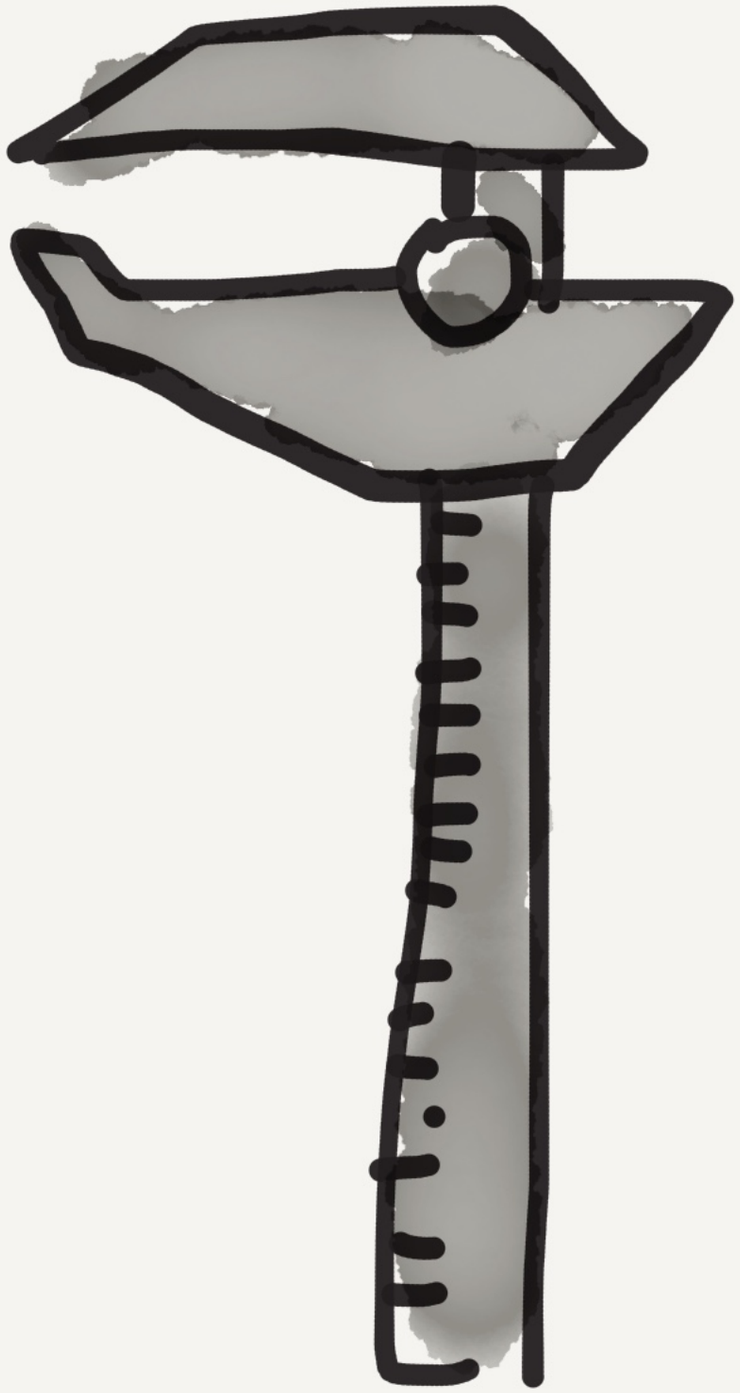




Anomalies

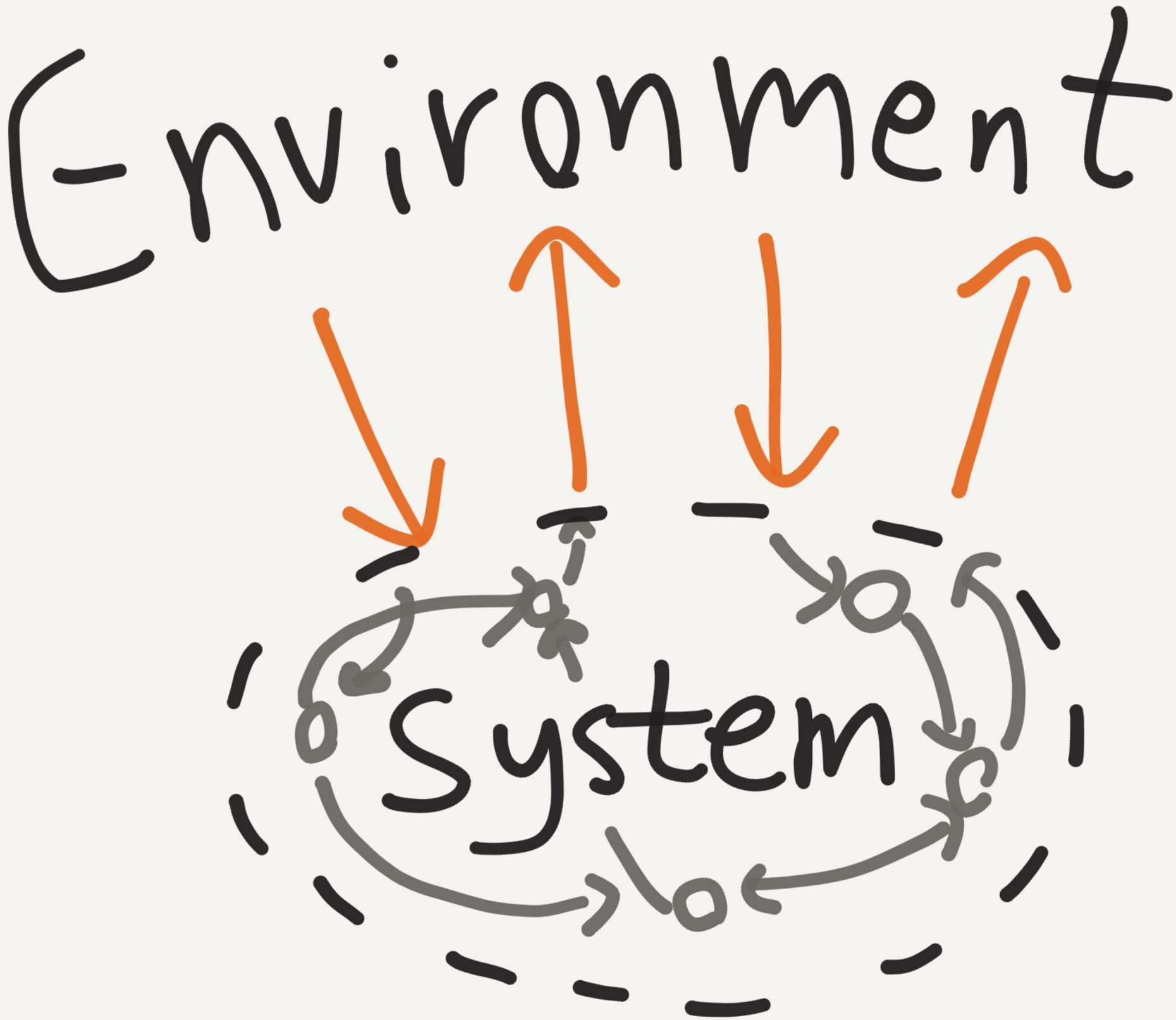
How do you know if a system is safe?

Measure your Systems

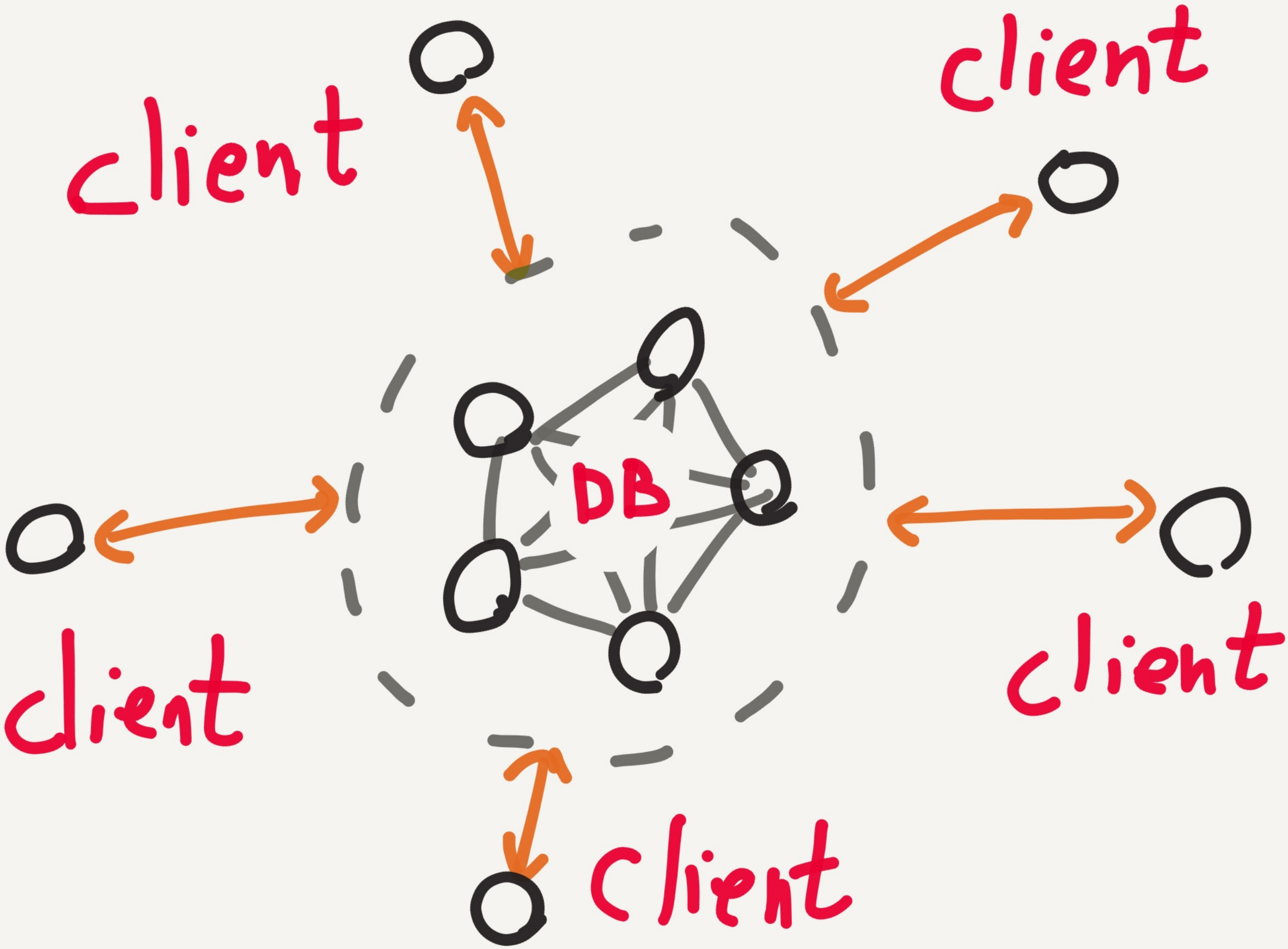


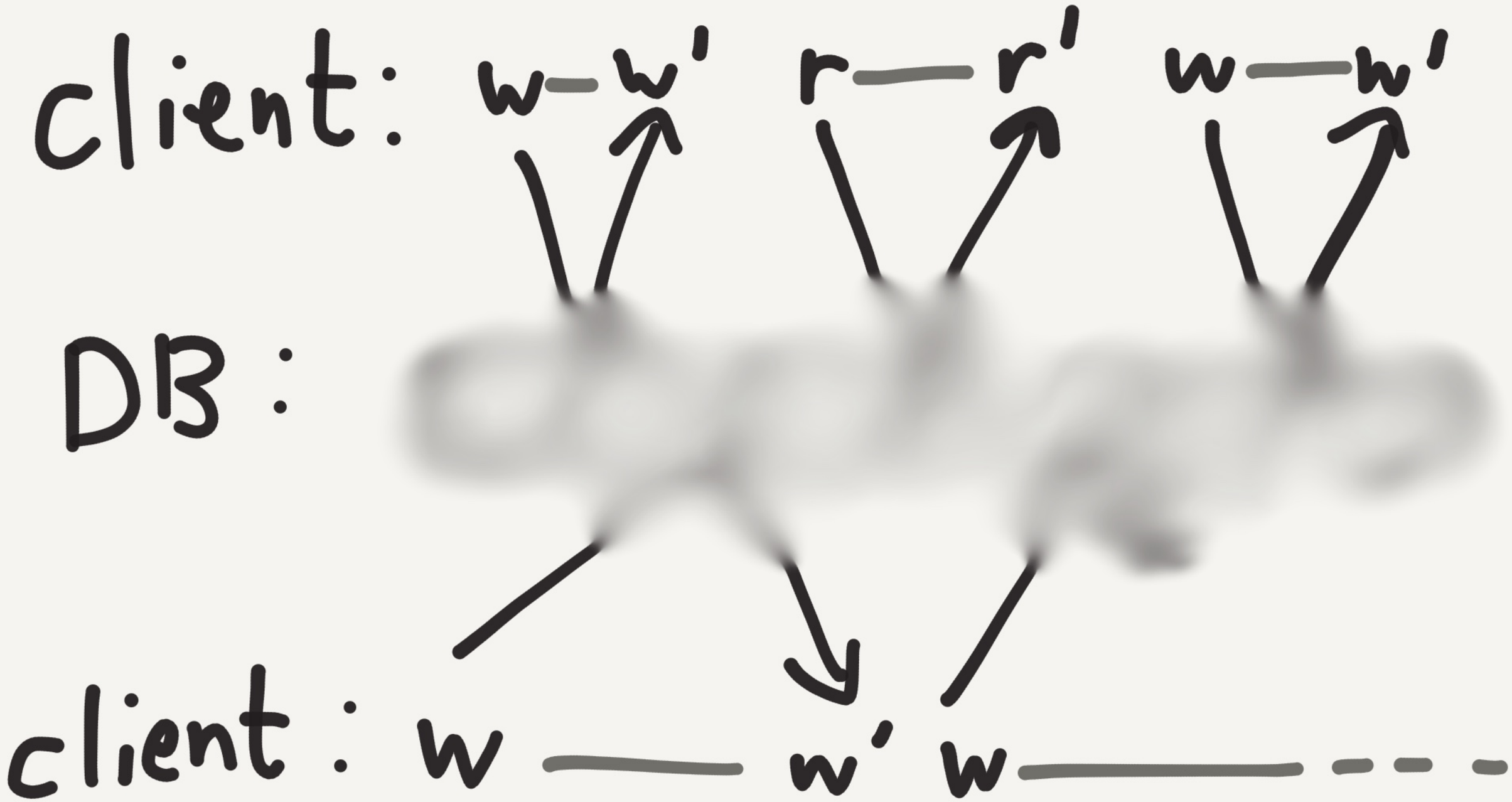
Jepsen

github.com/aphyr/jepsen

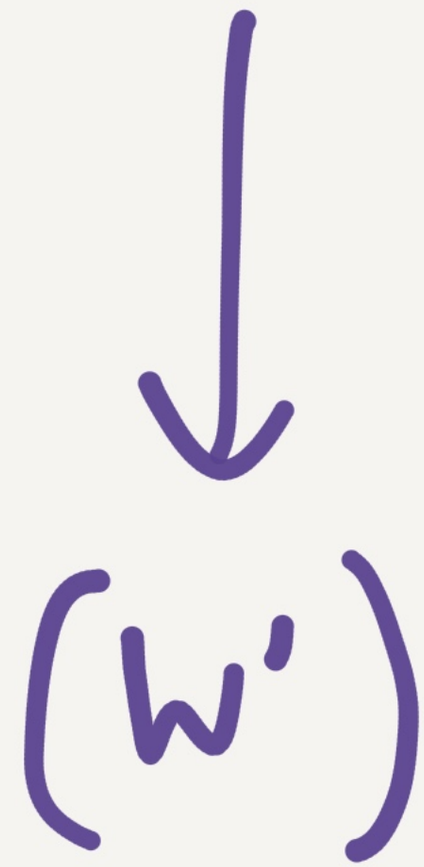

Environment
System

-INVARIANTS-


client
client
client
client
client
DB


client: w w' r r' w w'
DB:
client: w w' w

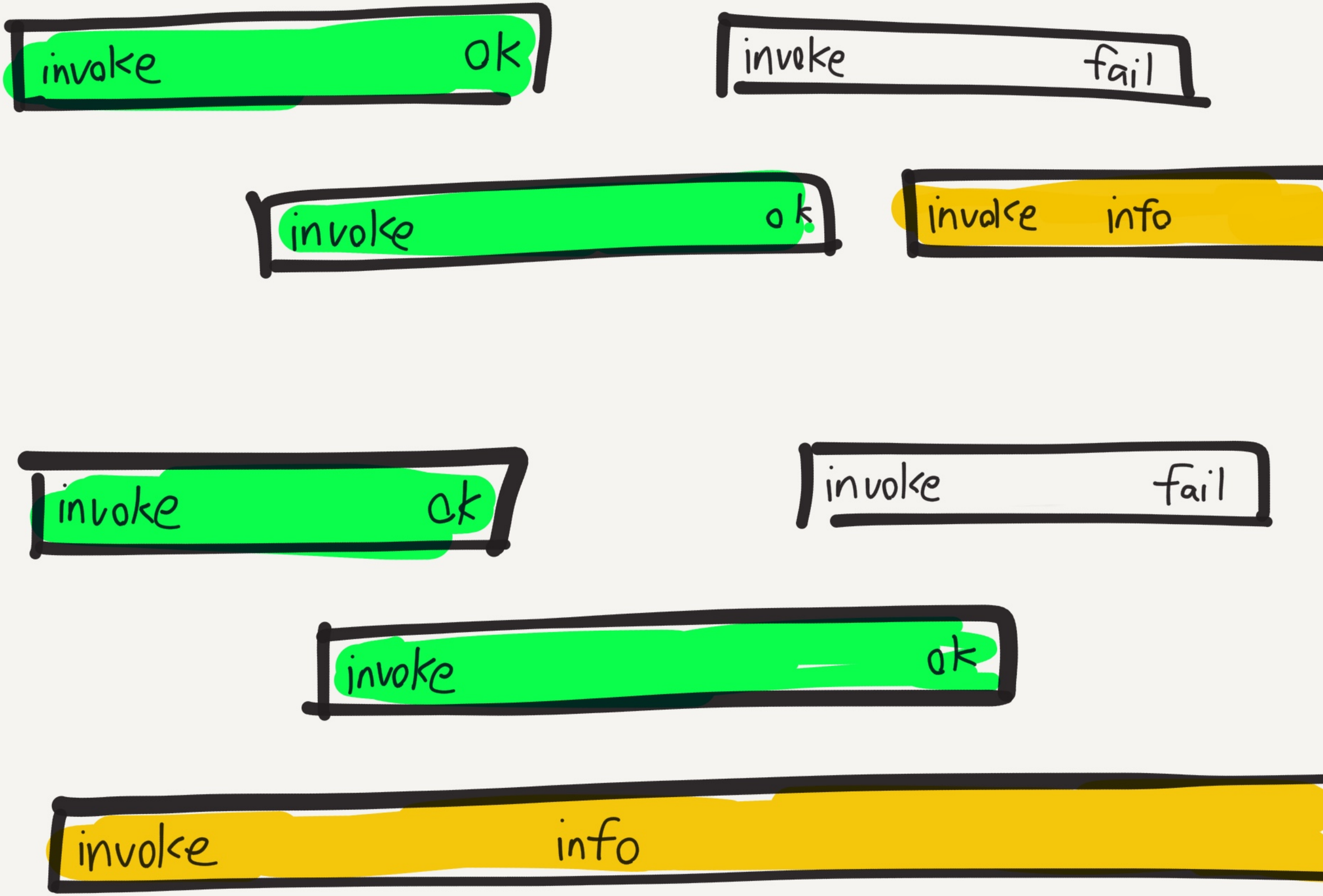
Clients Generate random operations (w) and apply them to the system

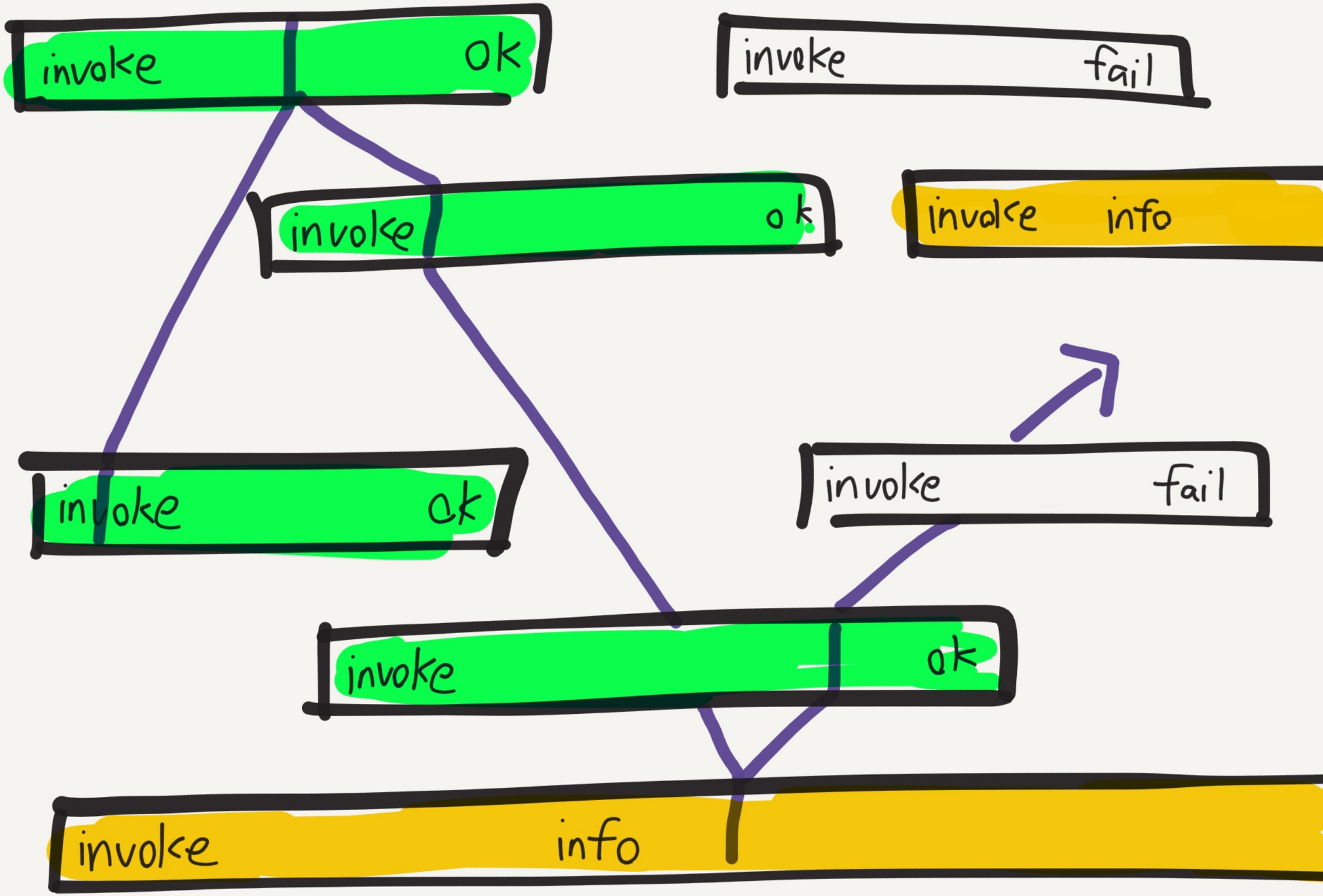


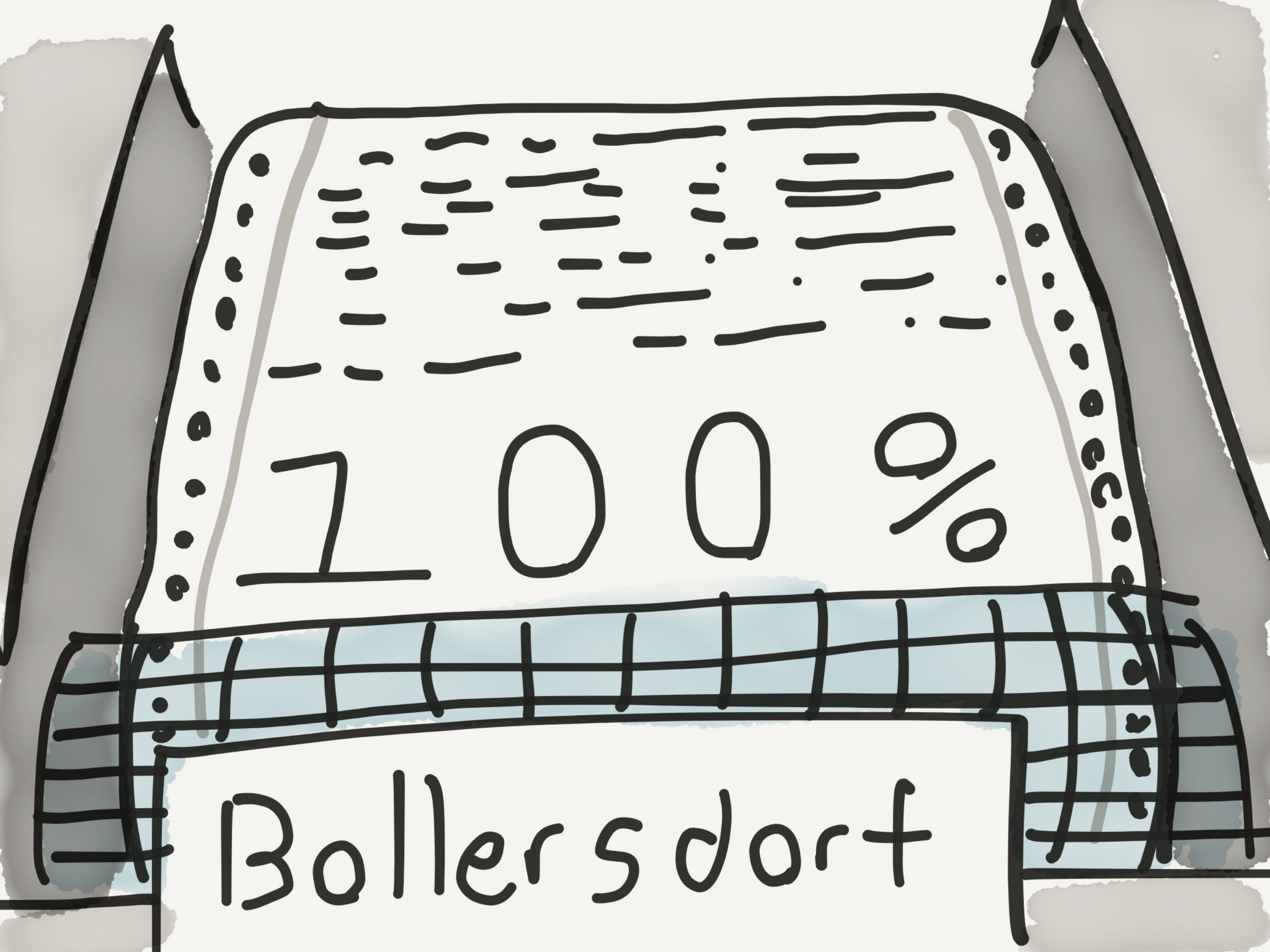
invoke ok

invoke fail

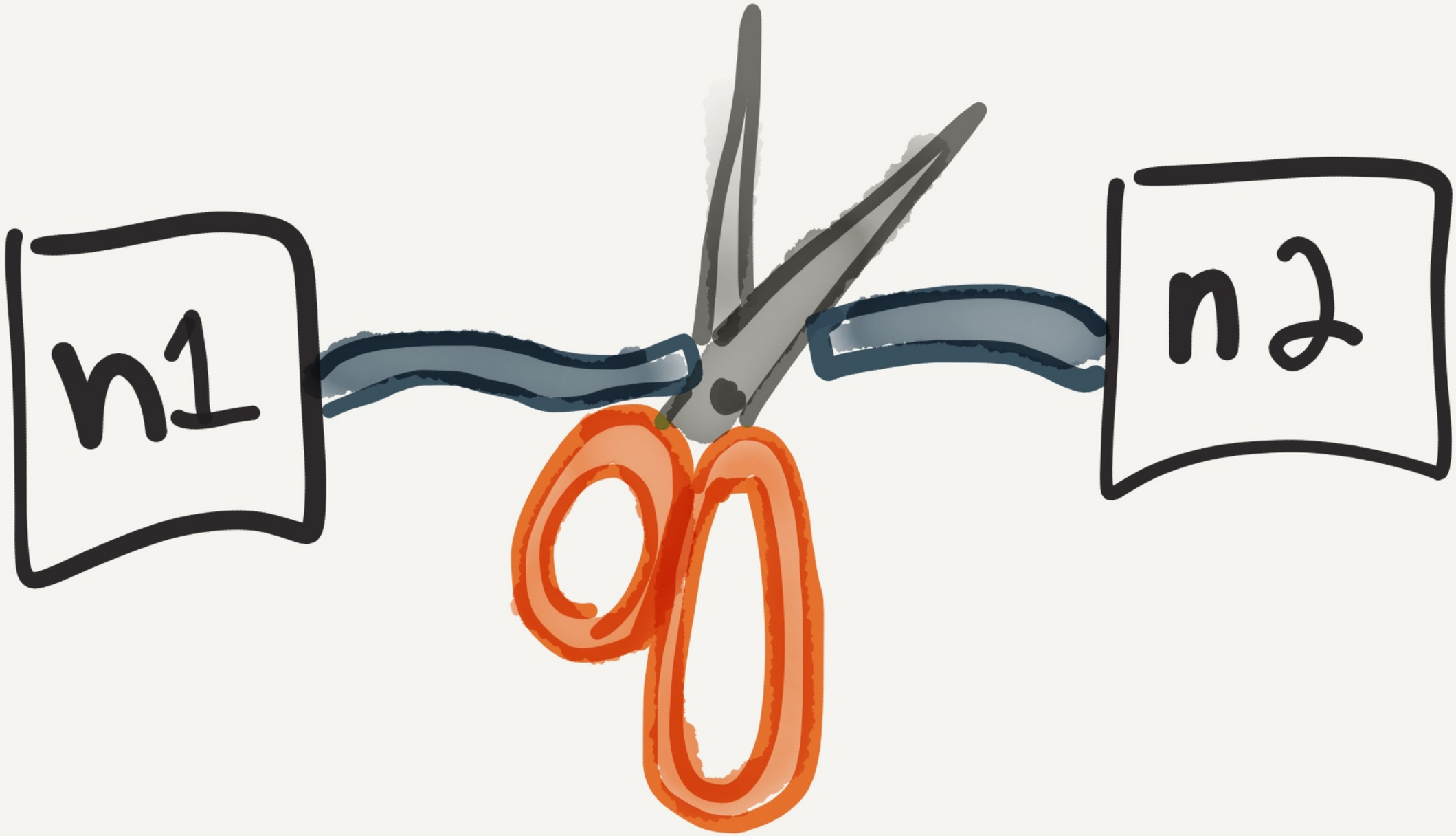
invoke ? ? info ? ? ?


invoke ok
invoke fail
invoke ok
invoke info
invoke ok
invoke fail
invoke ok
invoke info


invoke
ok
invoke
fail
invoke
ok
invoke
info
invoke
ok
invoke
fail
invoke
ok
invoke
info


100%
Bollersdorf

1. Generate ops
2. Record history
3. Verify history is consistent w/ model



Partitions!

"So, what have you found?"

Riak

5/13

LWW → lost writes

CRDTs → safe

5/13

Mongo

Data loss at all

Write concerns

Redis Sentinel

Split brain,

massive write loss

Cassandra

9/13

- LWW write loss
- Row isolation broken
- Transaction deadlock, data loss

NuoDB

9/13

Beat CAP by buffer-
-ing all requests in
RAM during partition

Kafka

In-sync Replica Set could shrink to 0 nodes, causing msg loss.

Zookeeper

9/13

Works.

etcd / Consul

stale reads

Elasticsearch

Loses documents in every class of partition tested.

RabbitMQ

Split brain, massive

message loss

Aerospike

Claims "ACID", was really LWW.

Elasticsearch 1.5.0

5/15

Still loses data

in every test case

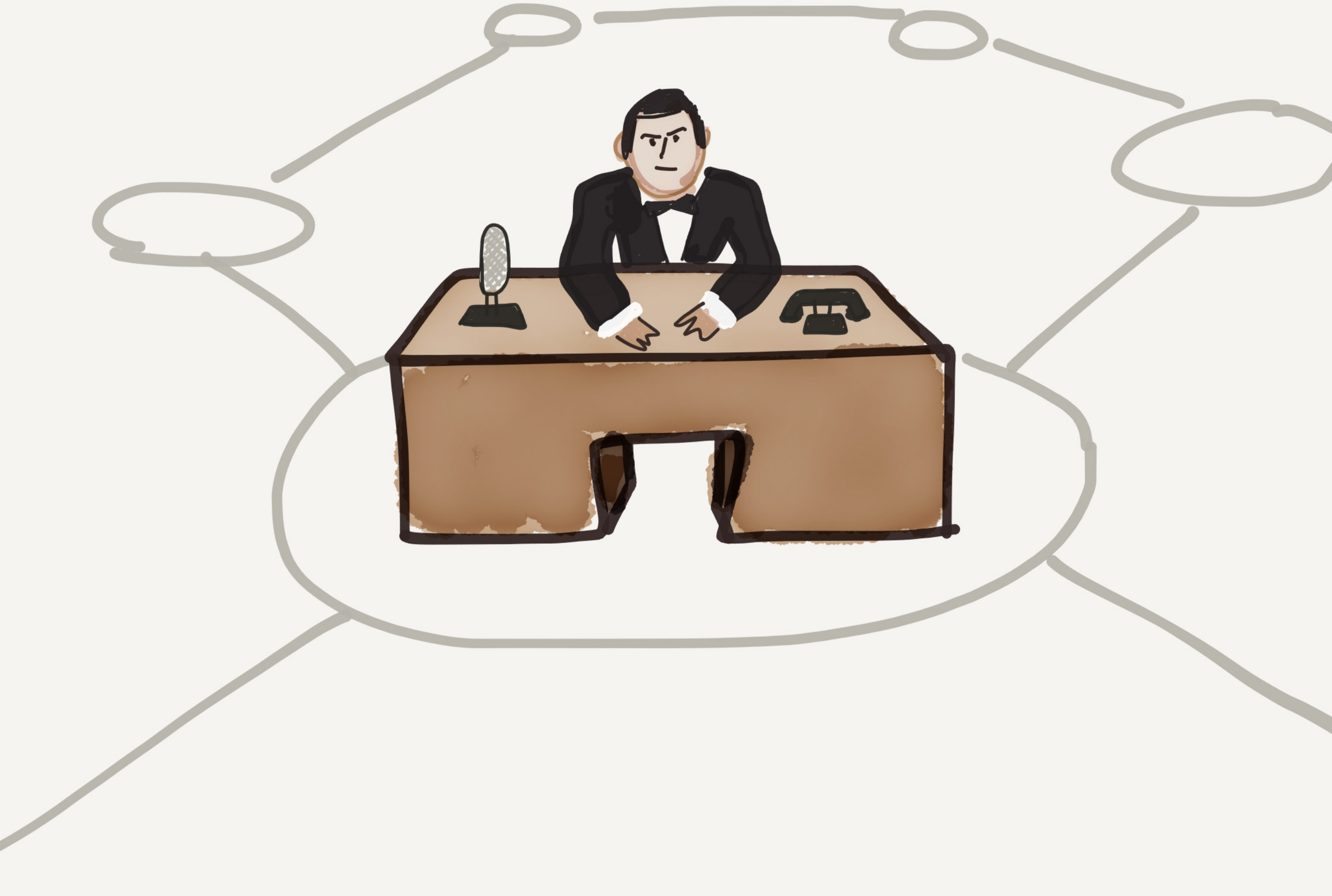
MongoDB 2.6.7

5/15

stale reads

dirty reads

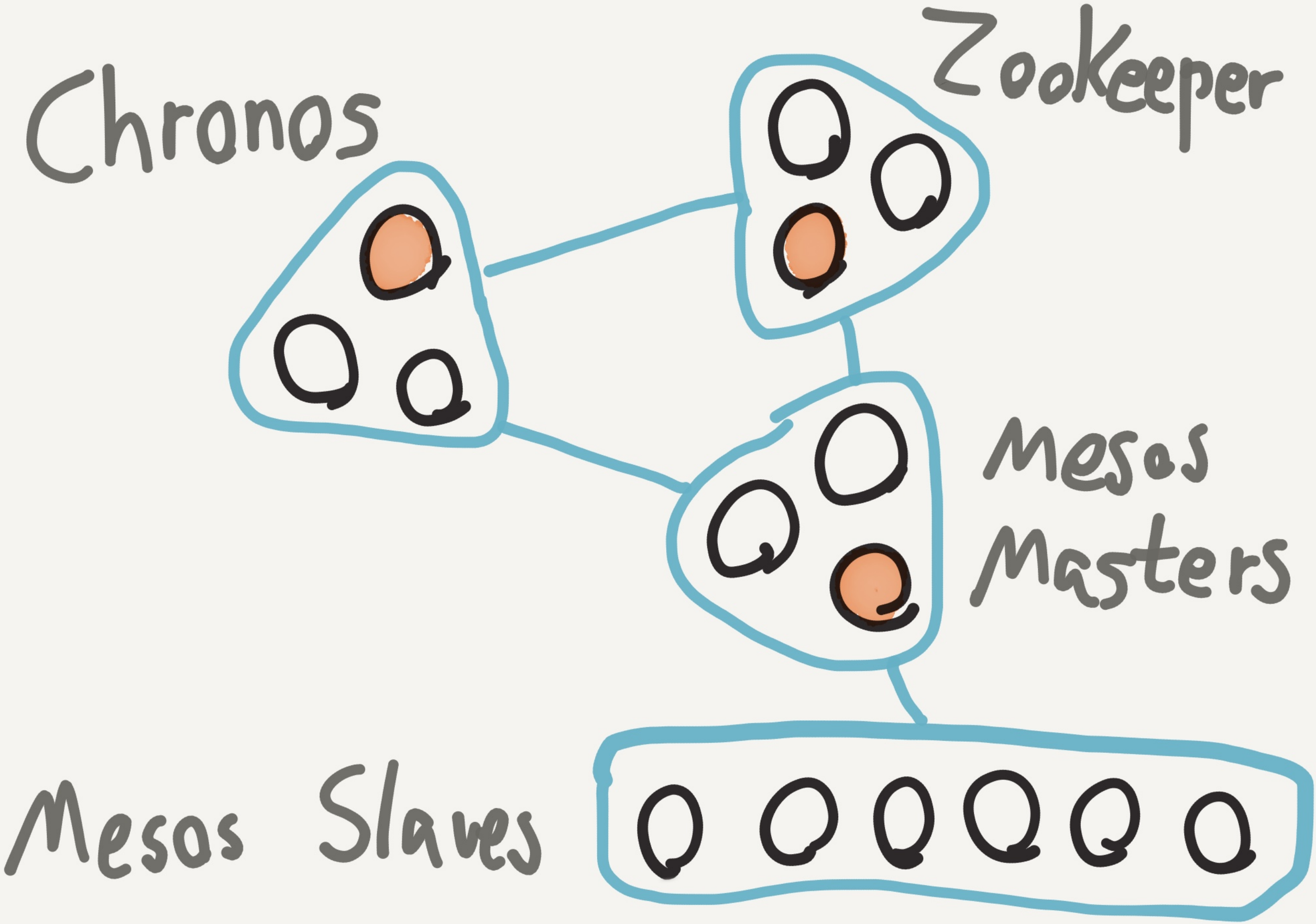
As an industry, we are woefully underprepared to handle distributed systems failure modes



Chronos

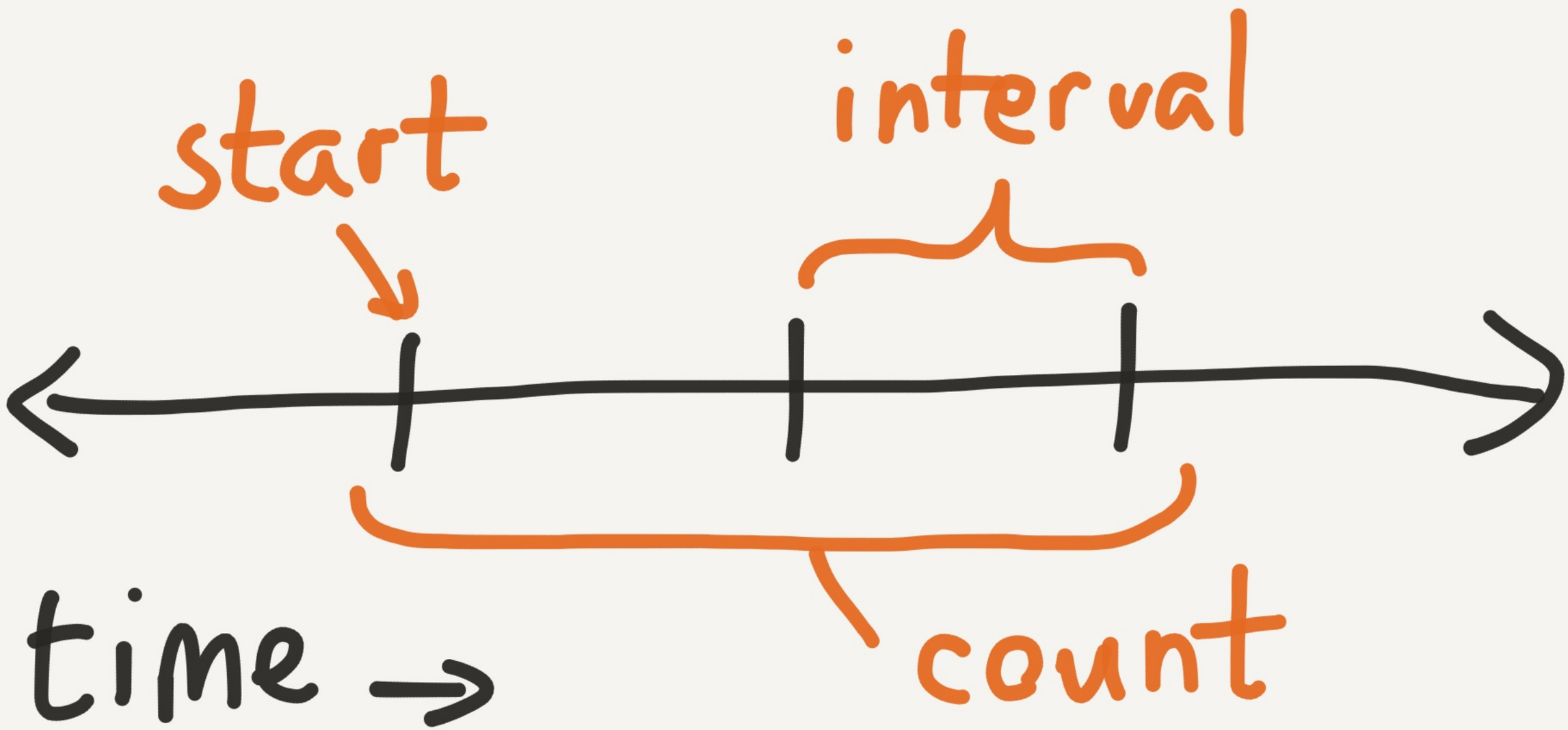
Like Cran, but

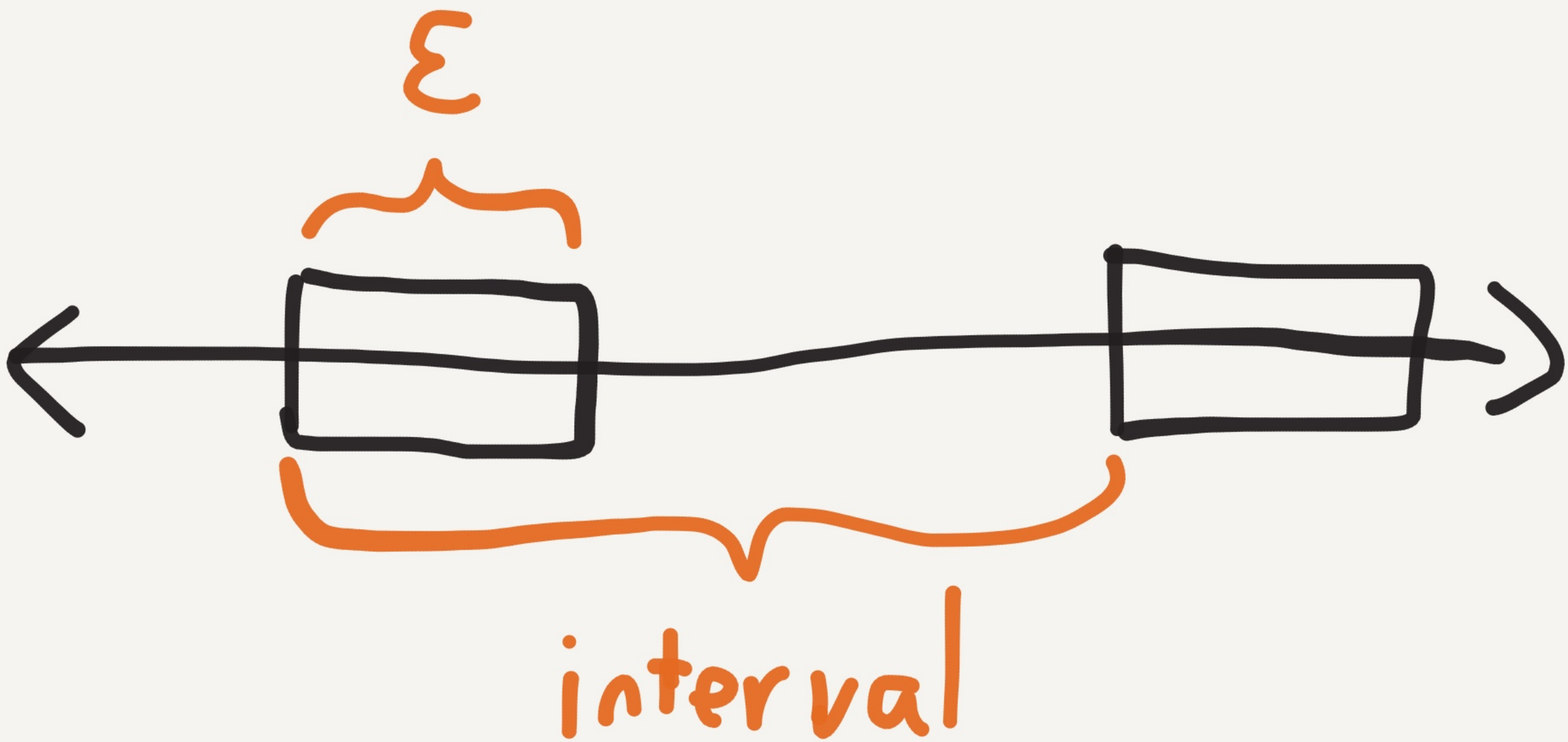
DISTRIBUTED

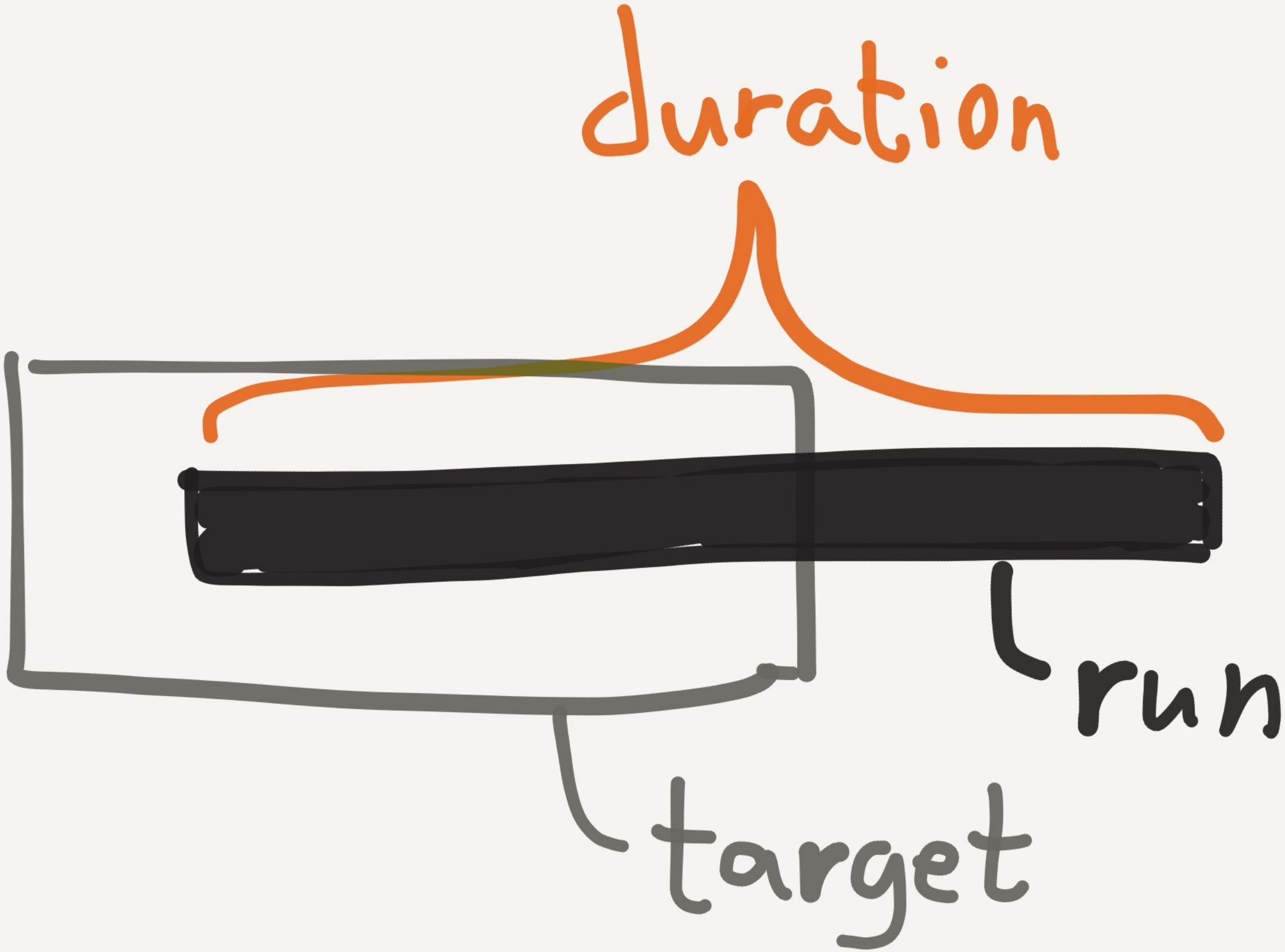

Chronos
Zookeeper
Mesos Masters
Mesos Slaves

n1	ZK	Chr	MM	
n2	ZK	Chr	MM	
n3	ZK	Chr	MM	
n4	ZK	Chr		MS
n5	ZK	Chr		MS

Job Spec

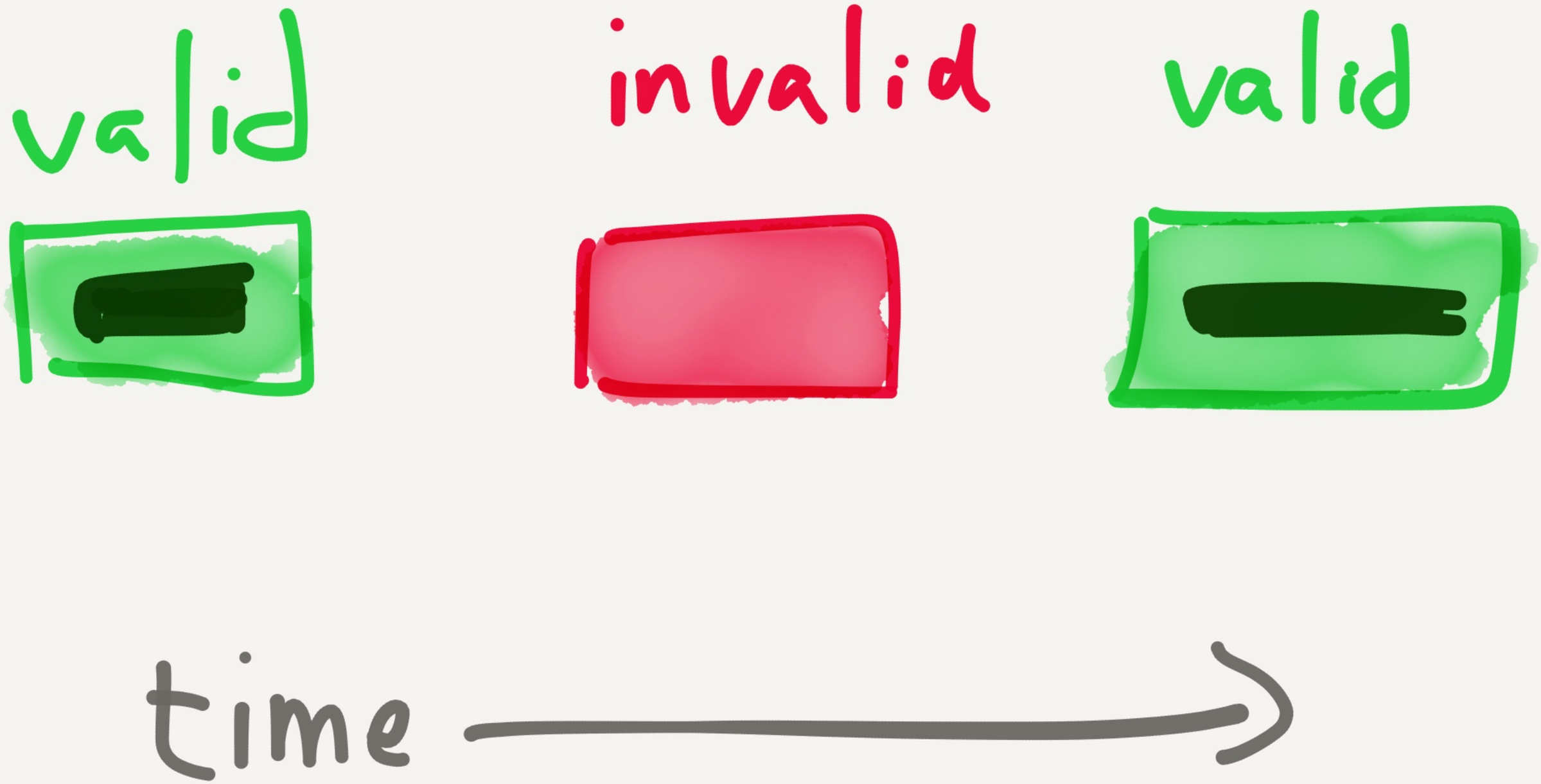


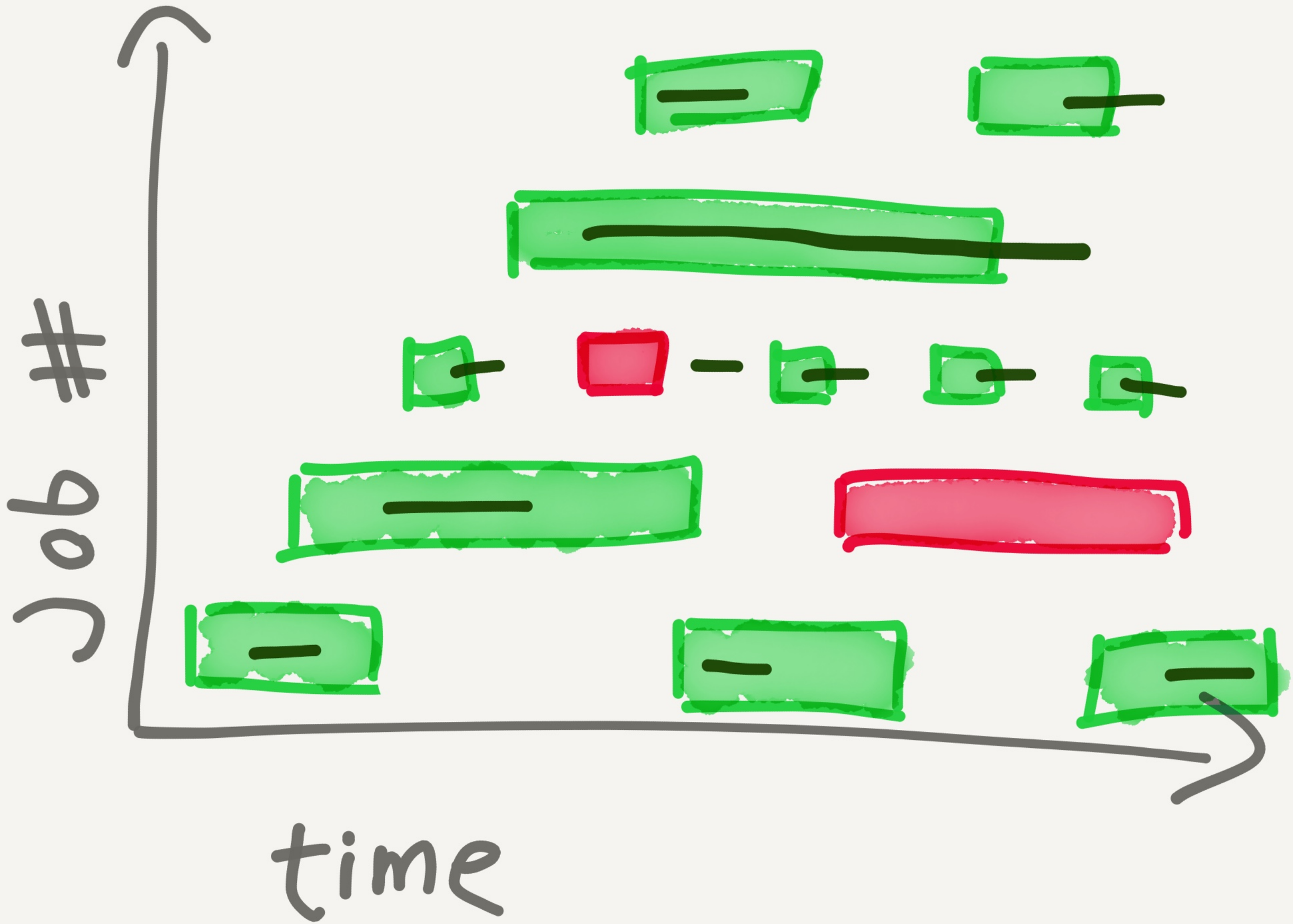

ε
interval


duration
run
target

Valid

invalid


valid
invalid
valid
time


job #
time

Fun Things

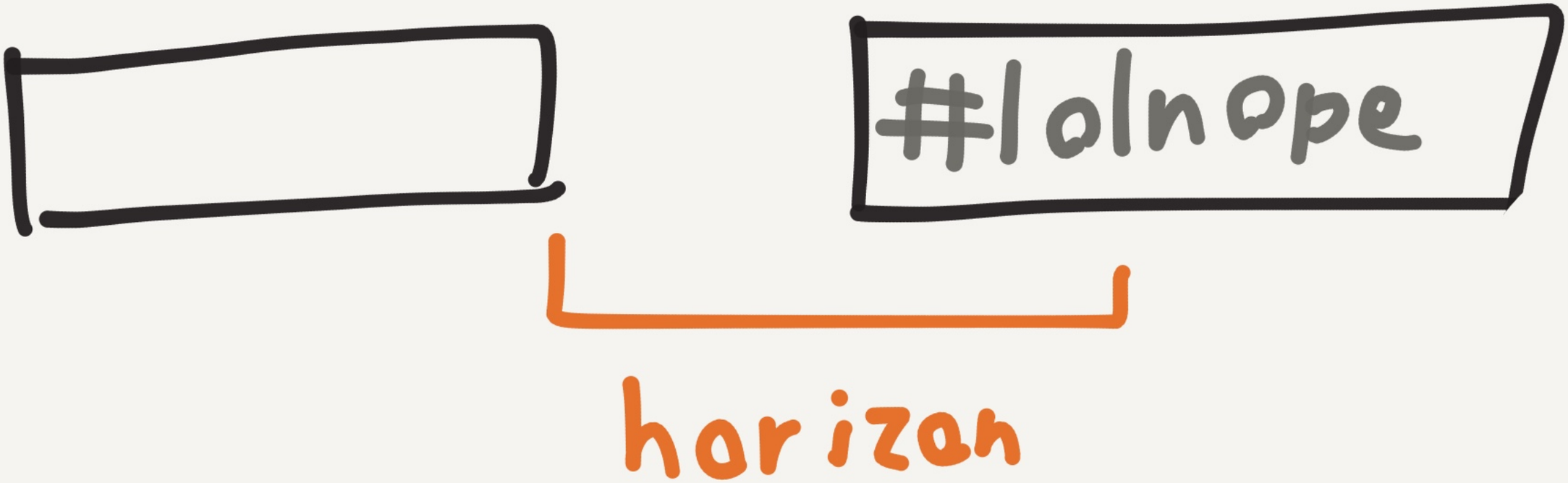
- Empty/invalid HTTP responses
- Connections refused
- Blank 400 responses

Chronos & Mesos processes will crash on losing ZK conn.

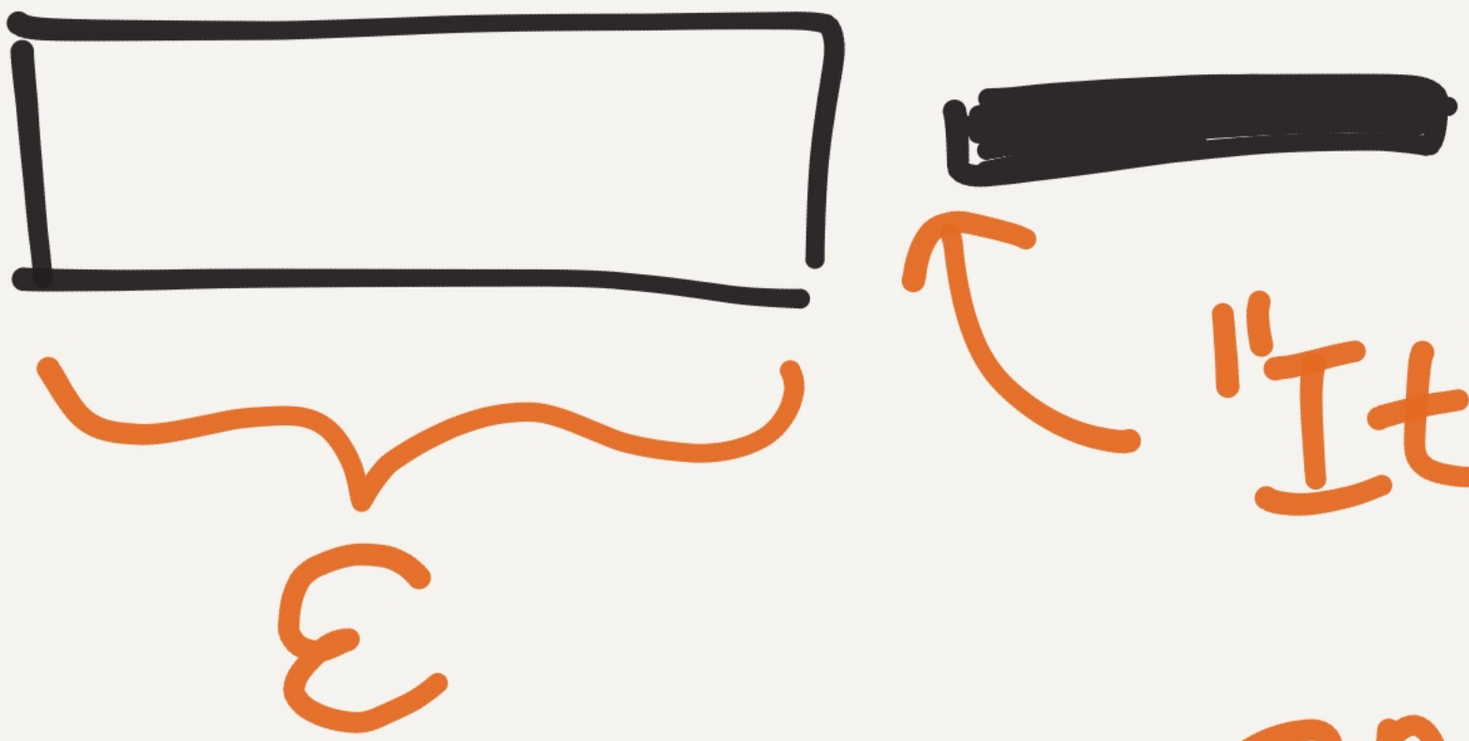
(By design)

(Except when they don't)

--schedule_horizon=60s

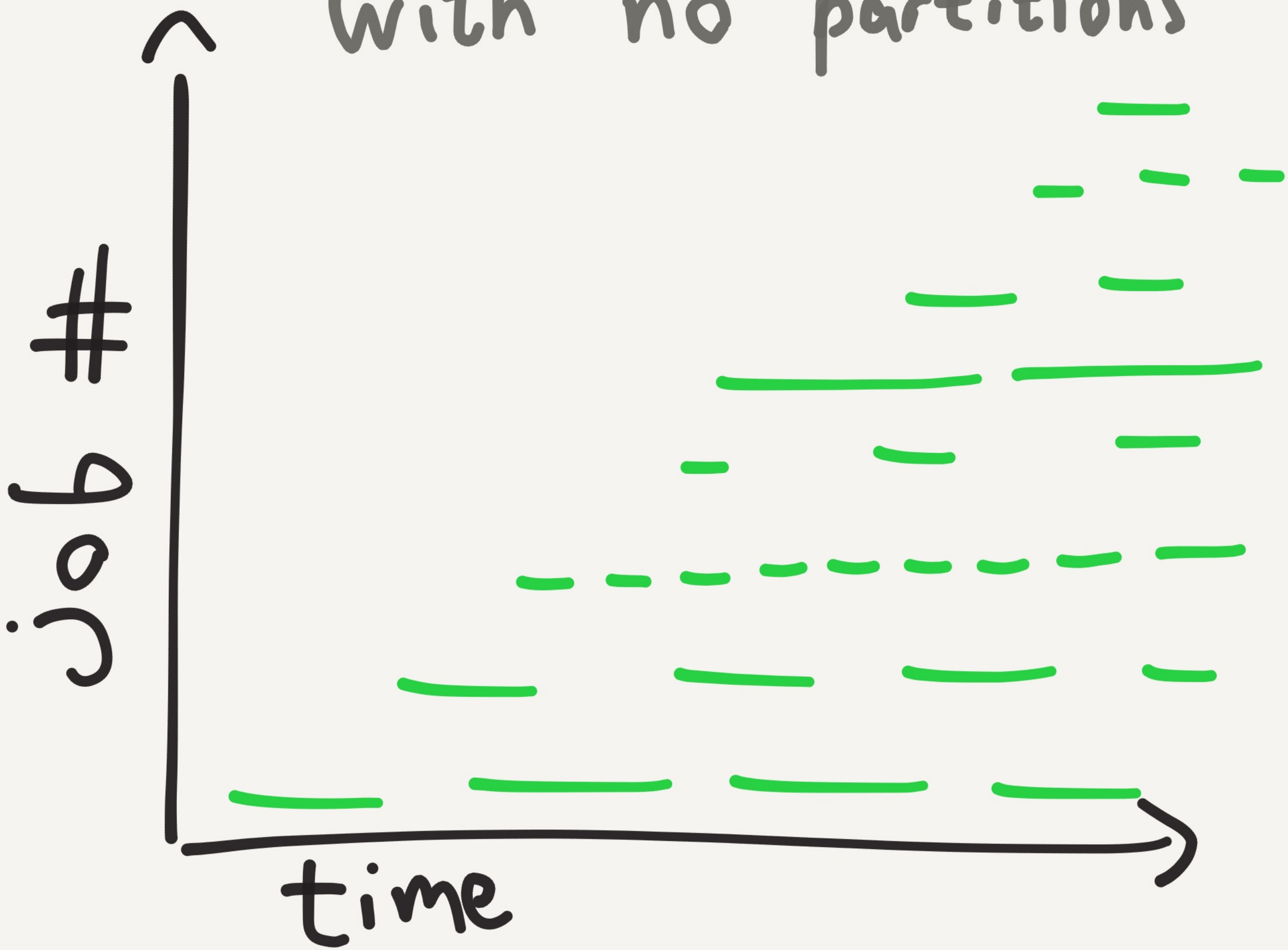


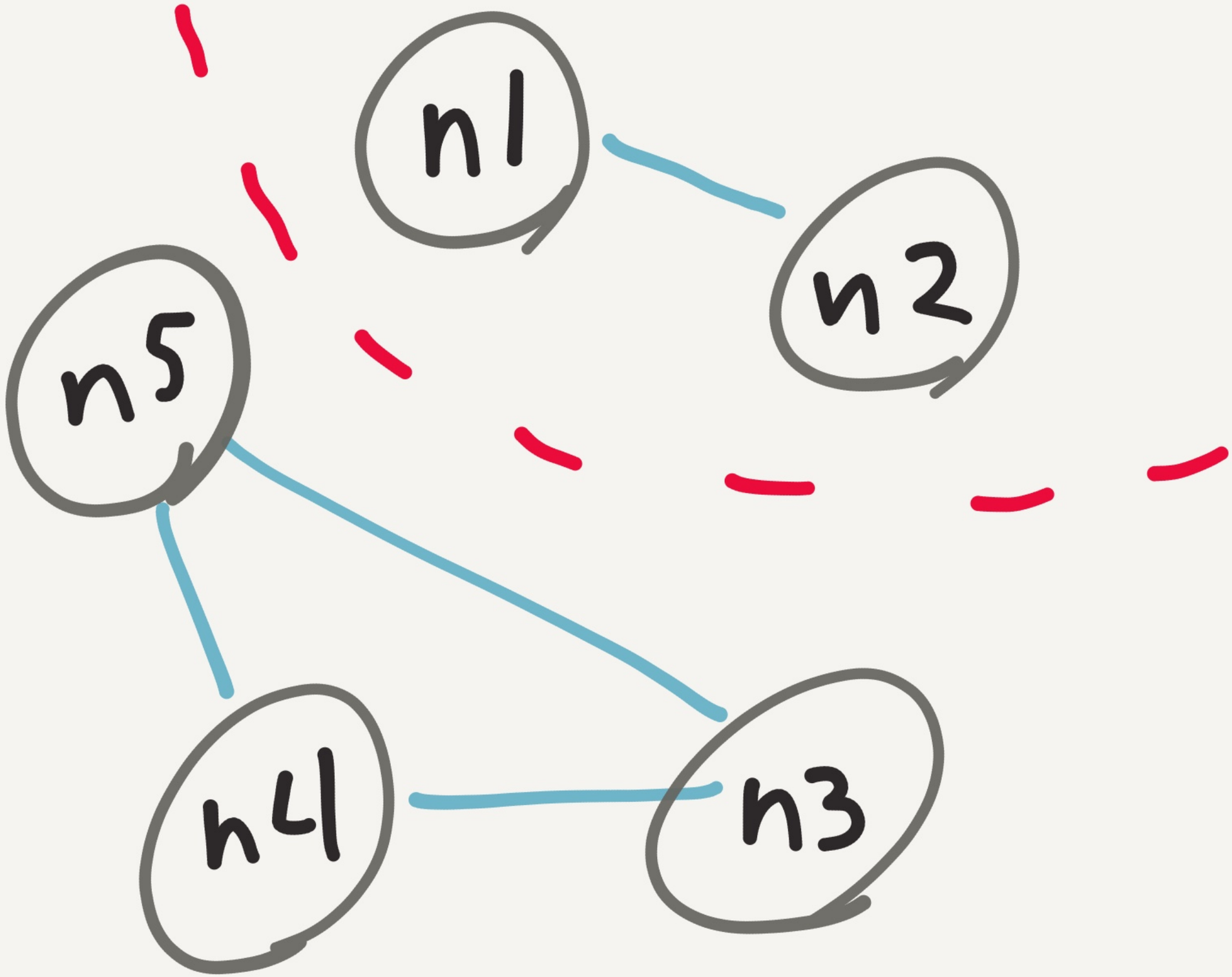
Epsilon is a fuzzy thing

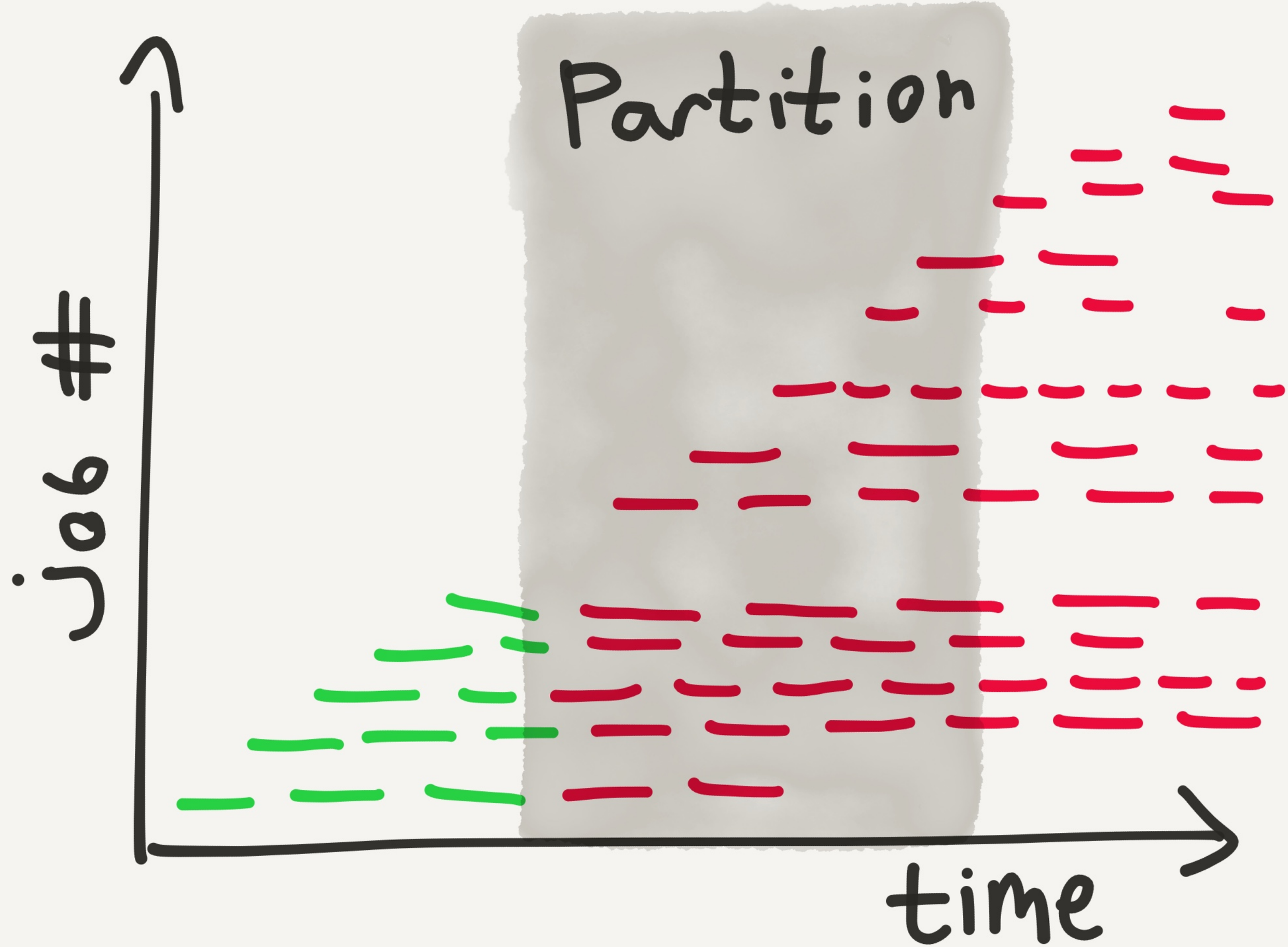


"It's <u>mostly</u> on time..."

with no partitions




n1
n2
n5
n4
n3


Partition
job
time

1: Partition occurs

2: Chronos loses 2K

3: Chronos pauses

4: Partition ends

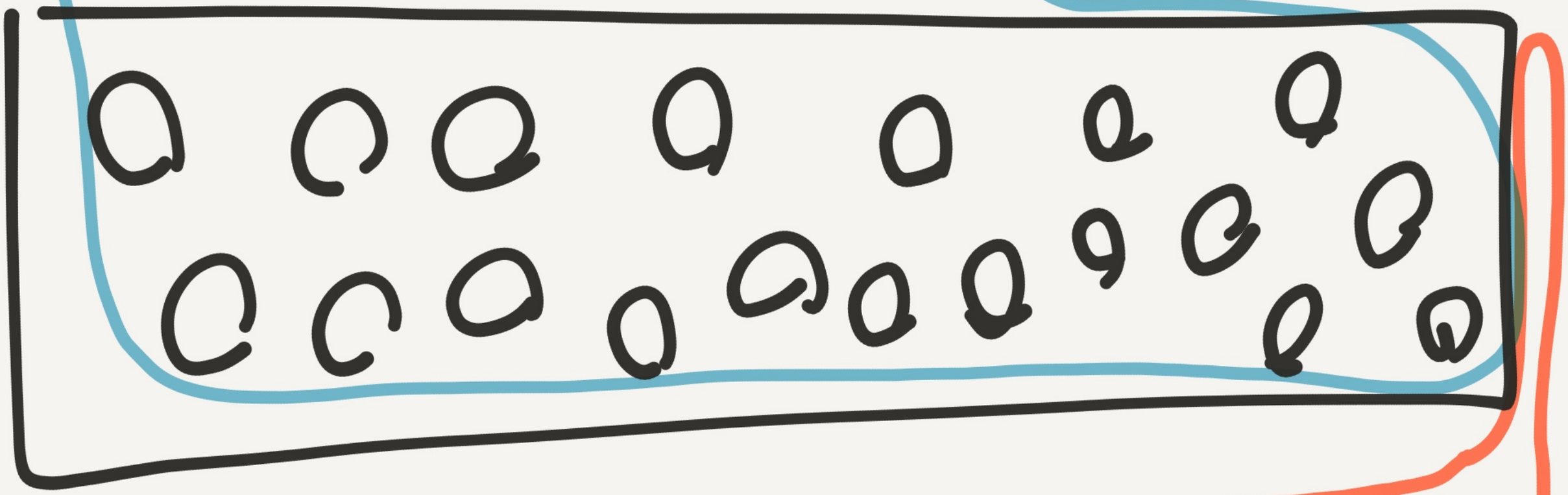
5: Re-election

Why can't the new Chronos leader run any tasks?

Bug #520

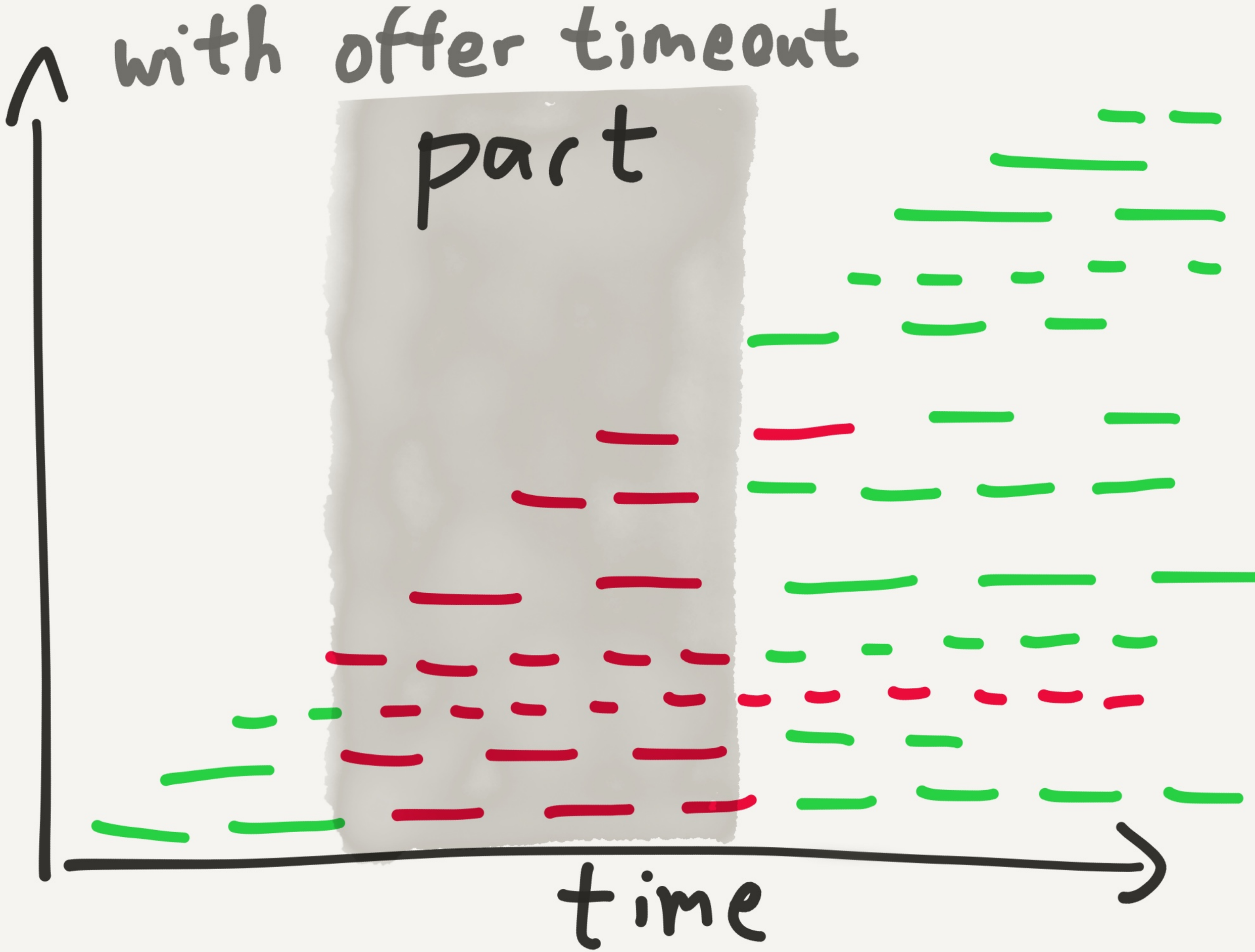
Chronos registers with a <u>new</u> framework ID

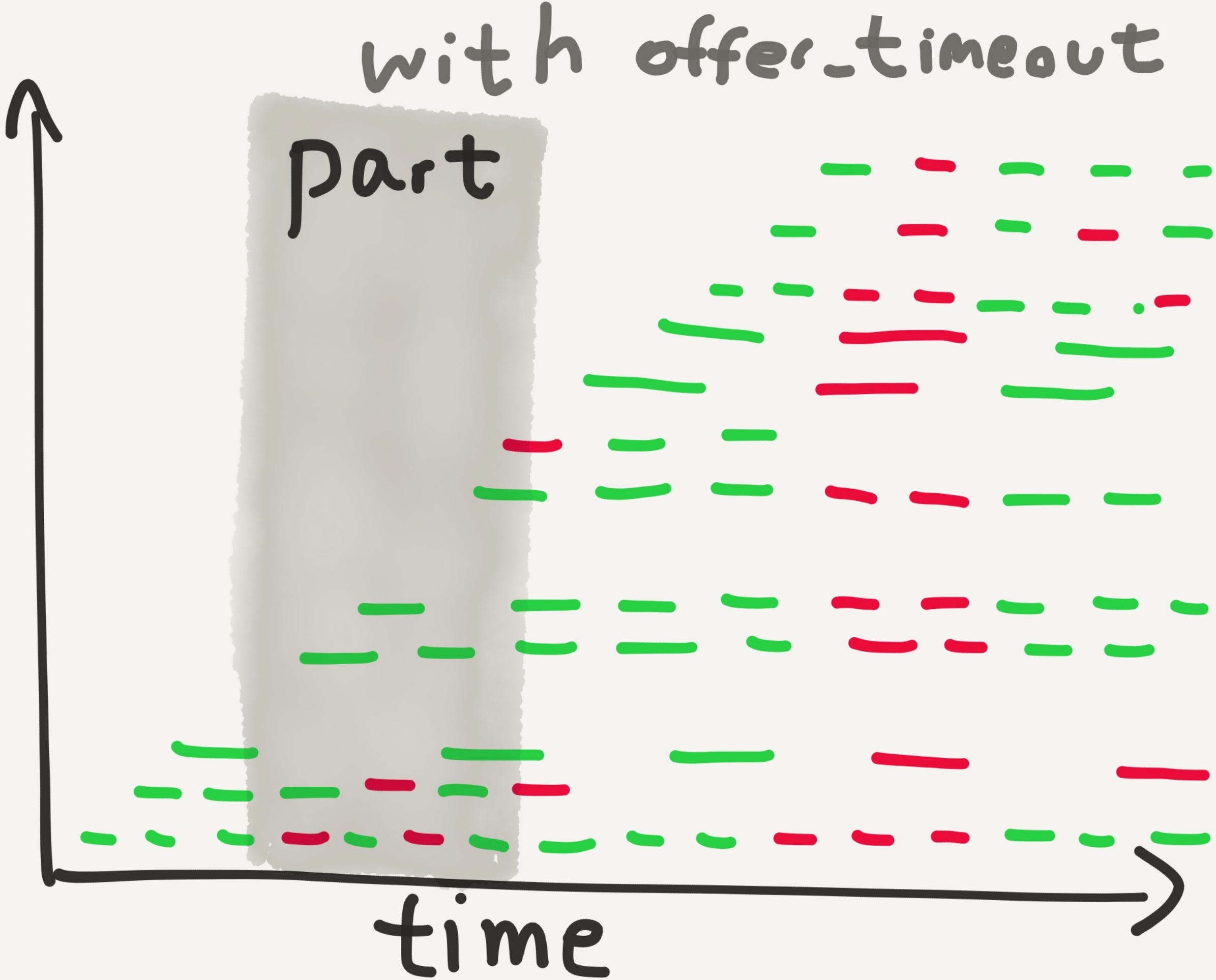
Old Chronos



New Chronos

--offer_timeout=30s

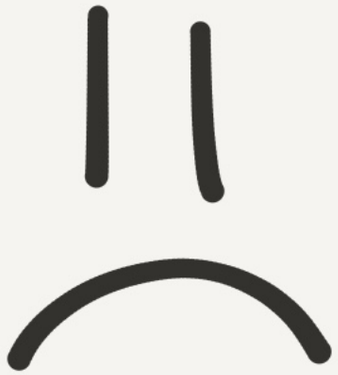

with offer timeout
part
time


with offer_timeout
part
time

Chronos

Recommendations

It's not gonna run your jogs on time.



Colocate quora!

ZK
MM
Chronos

ZK
MM
Chronos

ZK
MM
Chronos

- Wrappers for Chronos & Mesos daemons
- schedule_horizon
- offer_timeout
- Monitor your jobs
- Monitor daemon restarts

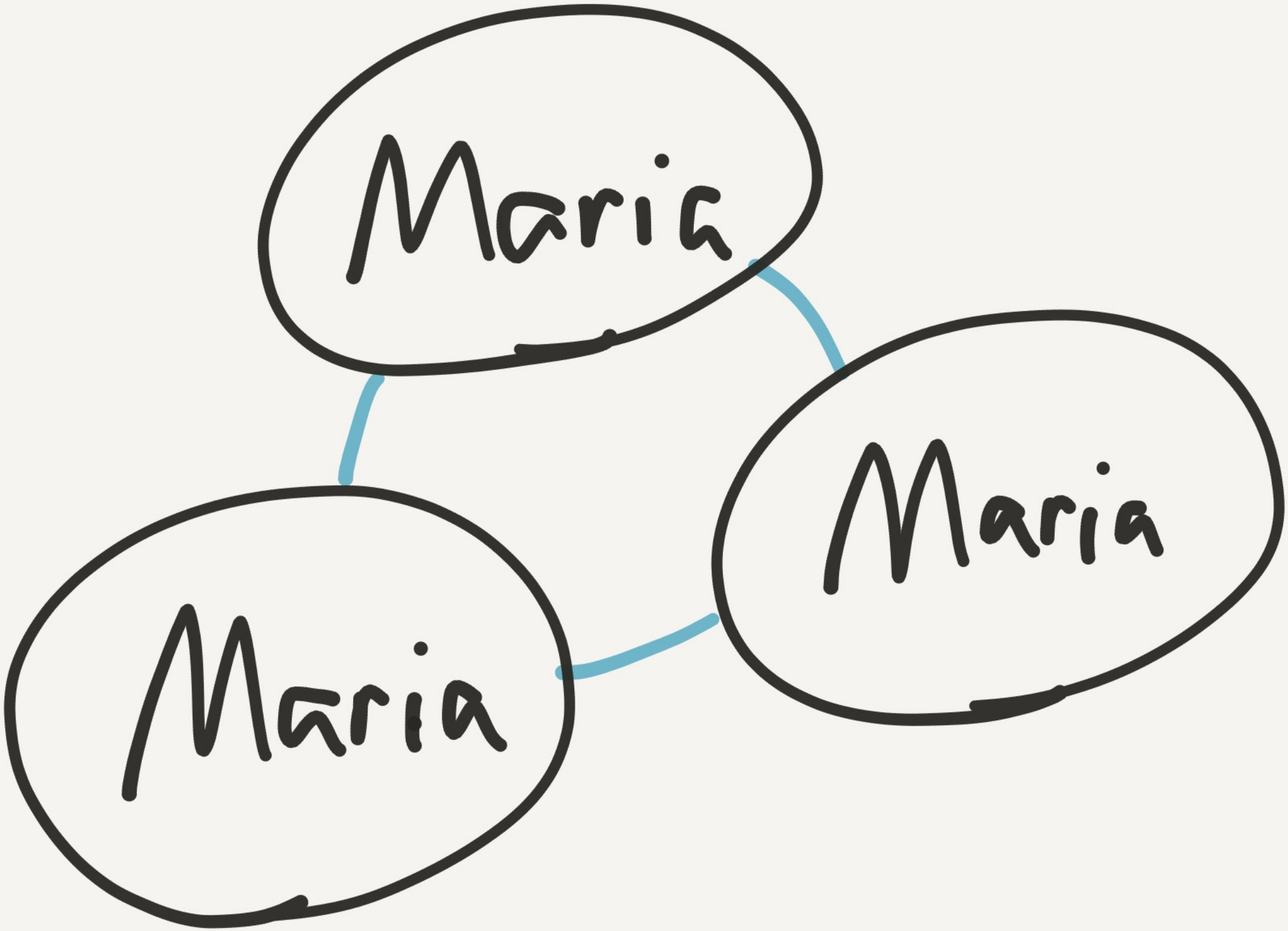
GALERA CLUSTER

Symmetric replication

for MySQL,

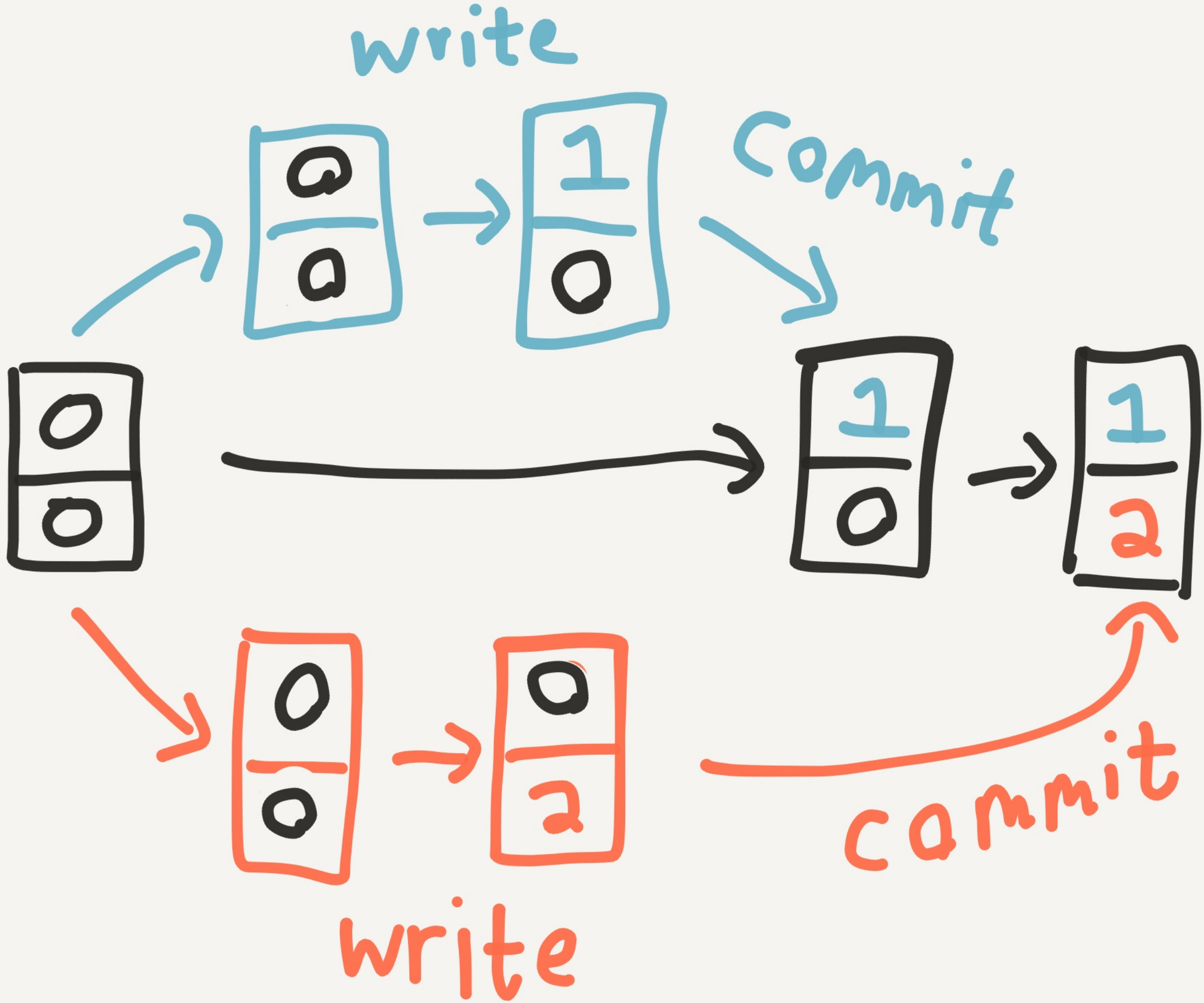
MariaDB,

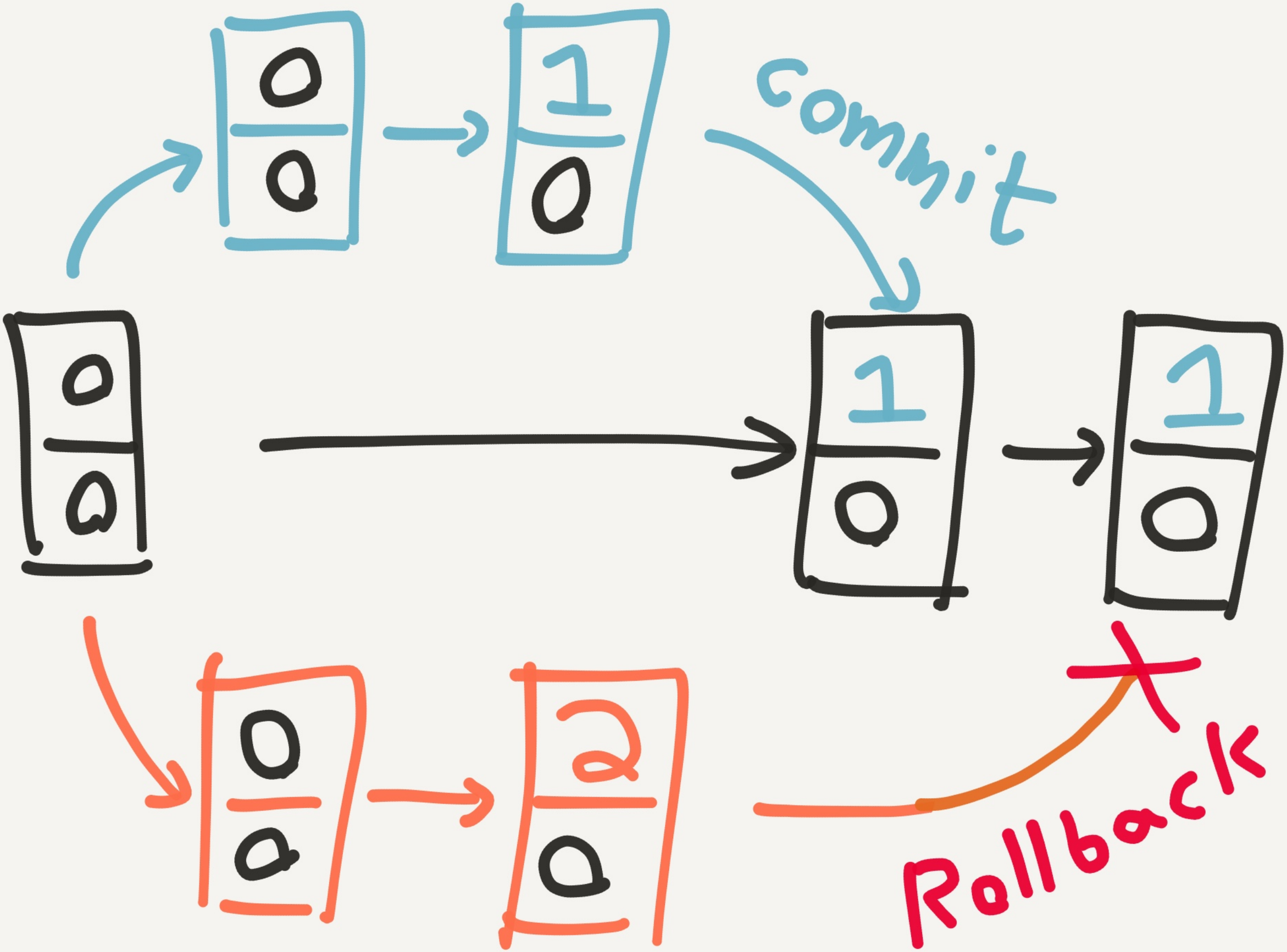
Percona XtraDB, ...


Maria
Maria
Maria

Between nodes, claims to provide

Snapshot Isolation


write
0
0
1
0
commit
0
0
1
0
1
2
0
0
0
2
commit
write


0
0
1
0
commit
0
0
1
0
1
0
0
0
2
0
Rollback

"SI level occurs between Repeatable Read and Serializable"

(so, use 1SR, get SI)

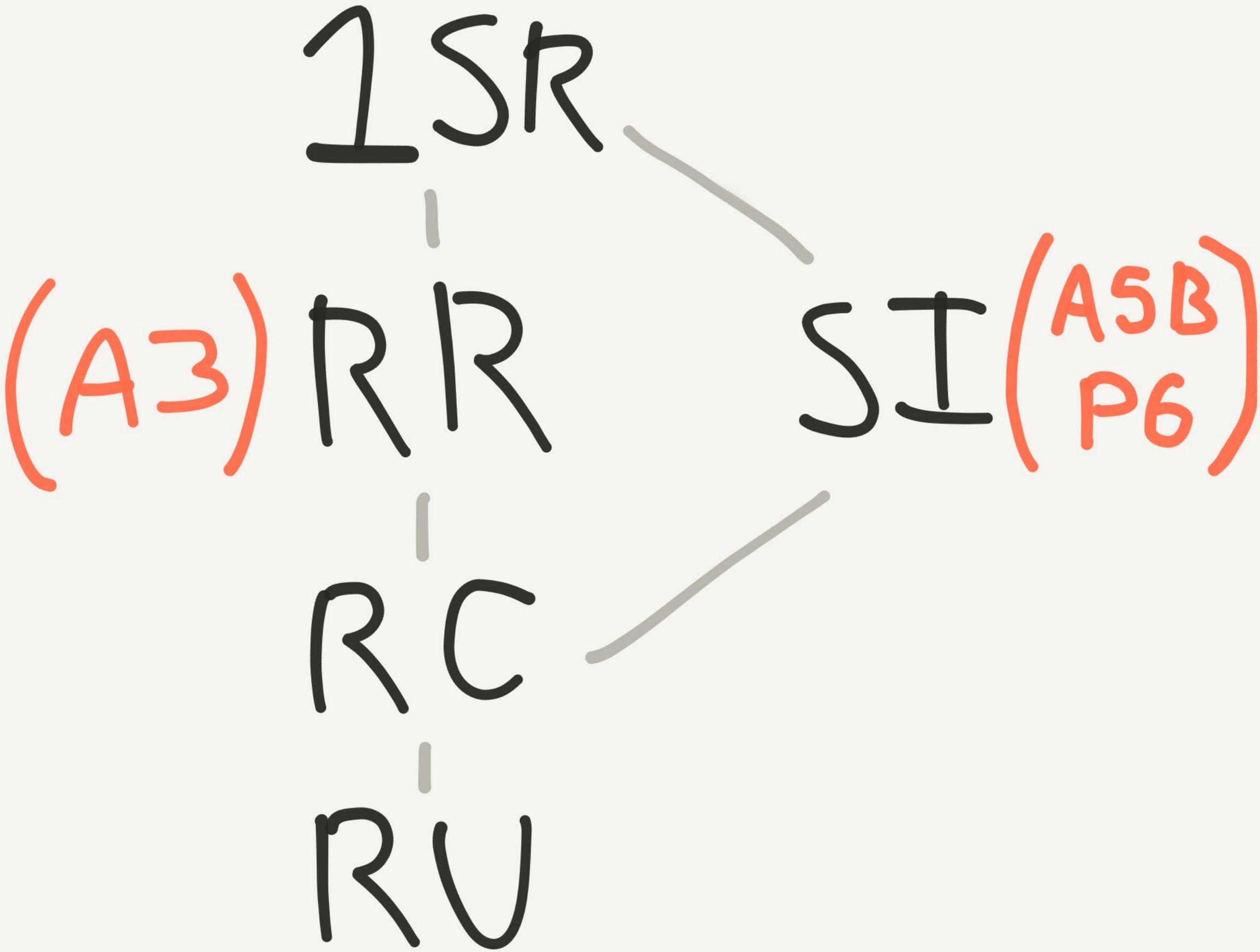
serializability 1SR

snapshot isolation SI (wrong!)

repeatable read RR

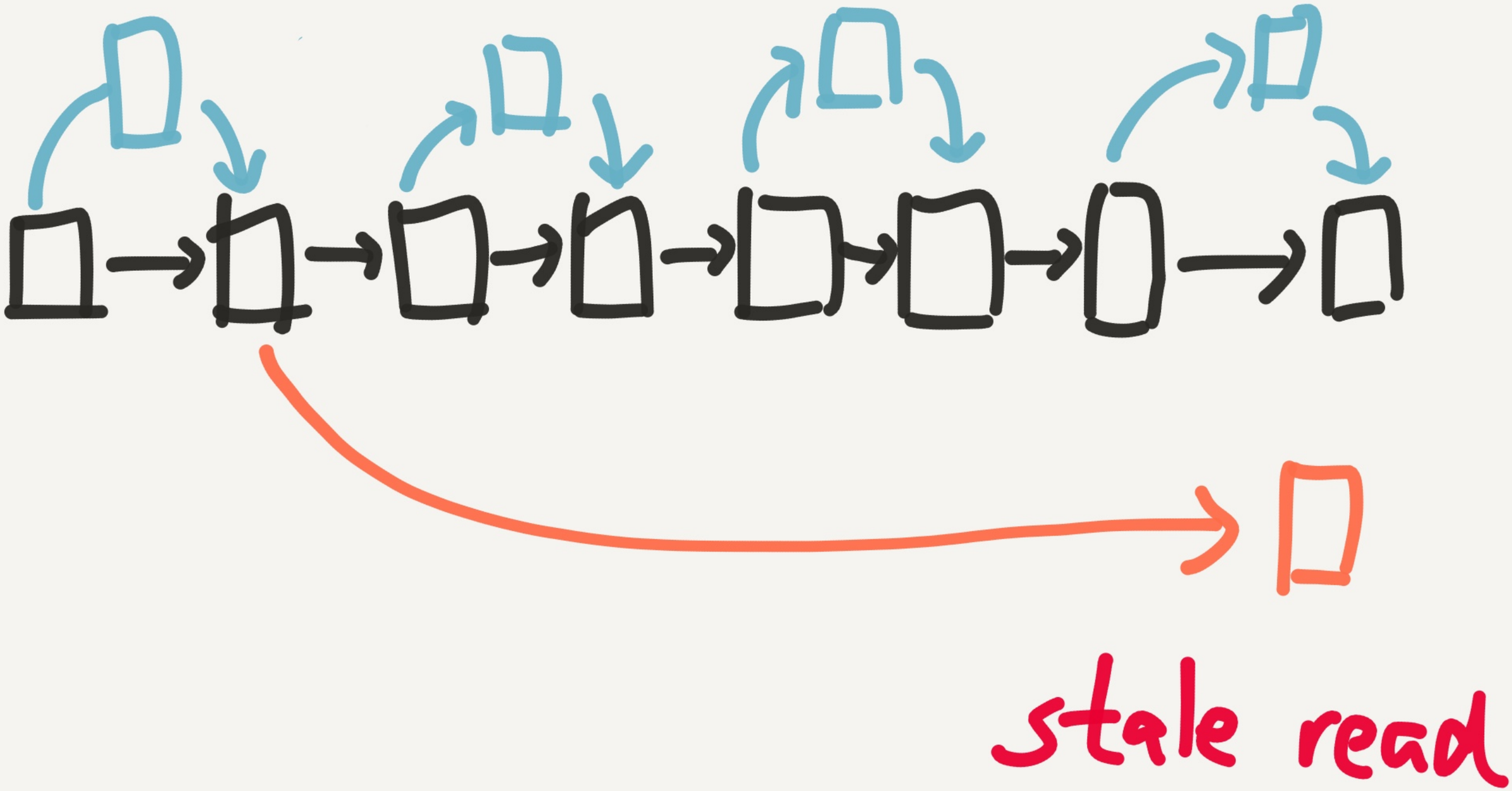
read committed RC

read uncommitted RU

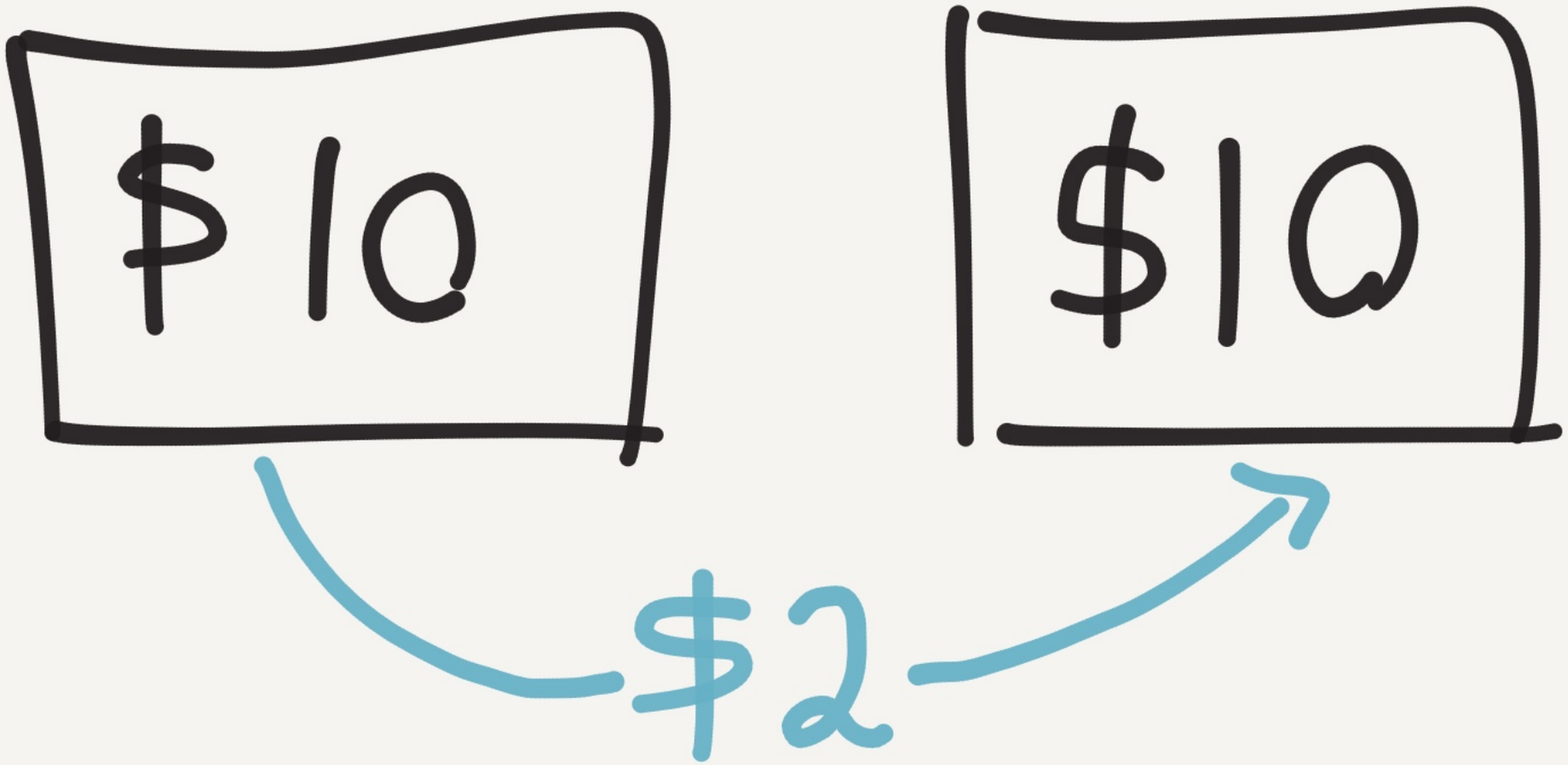

1SR
(A3) RR
SI (ASB P6)
RC
RU

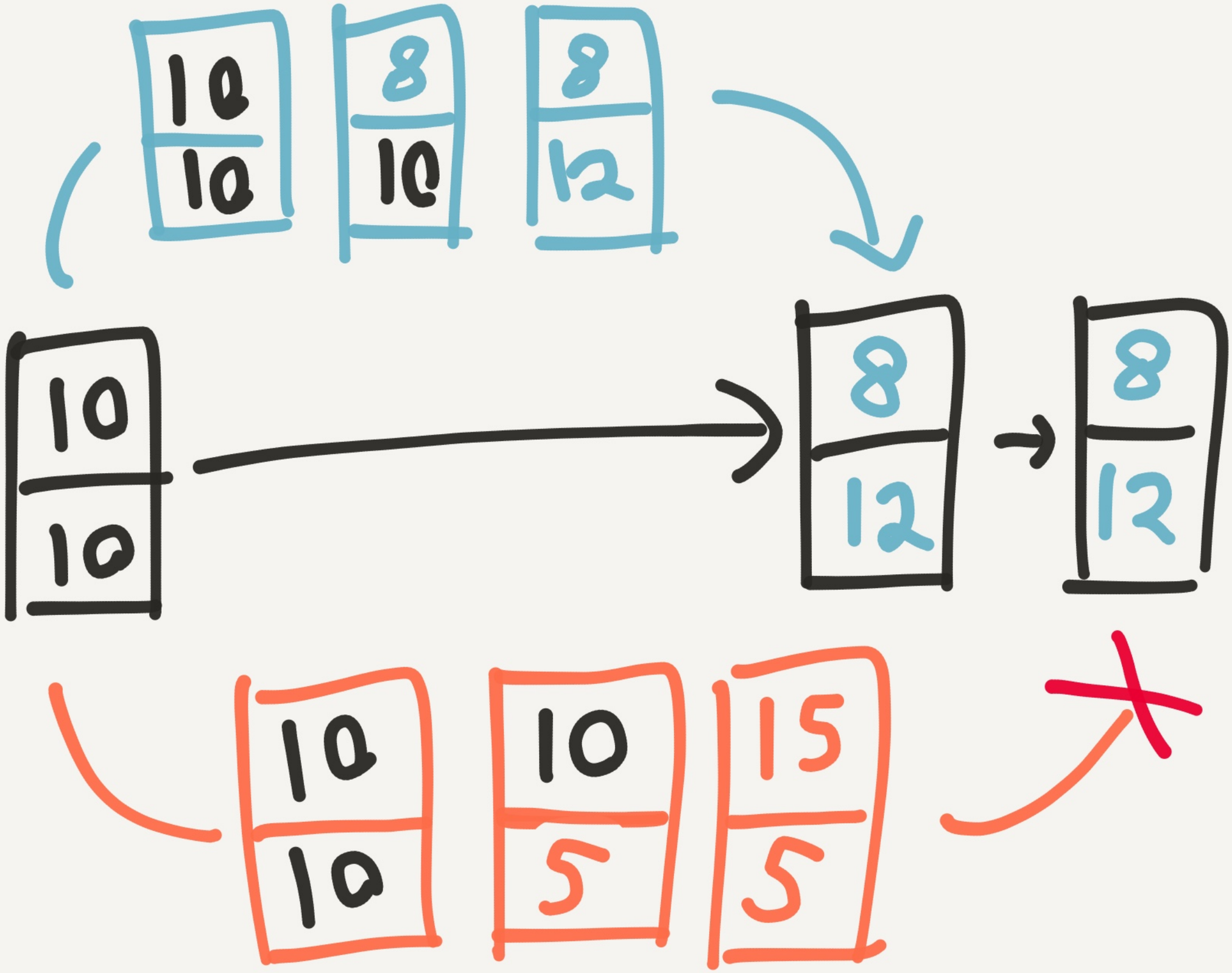
OK...so how do we test it?

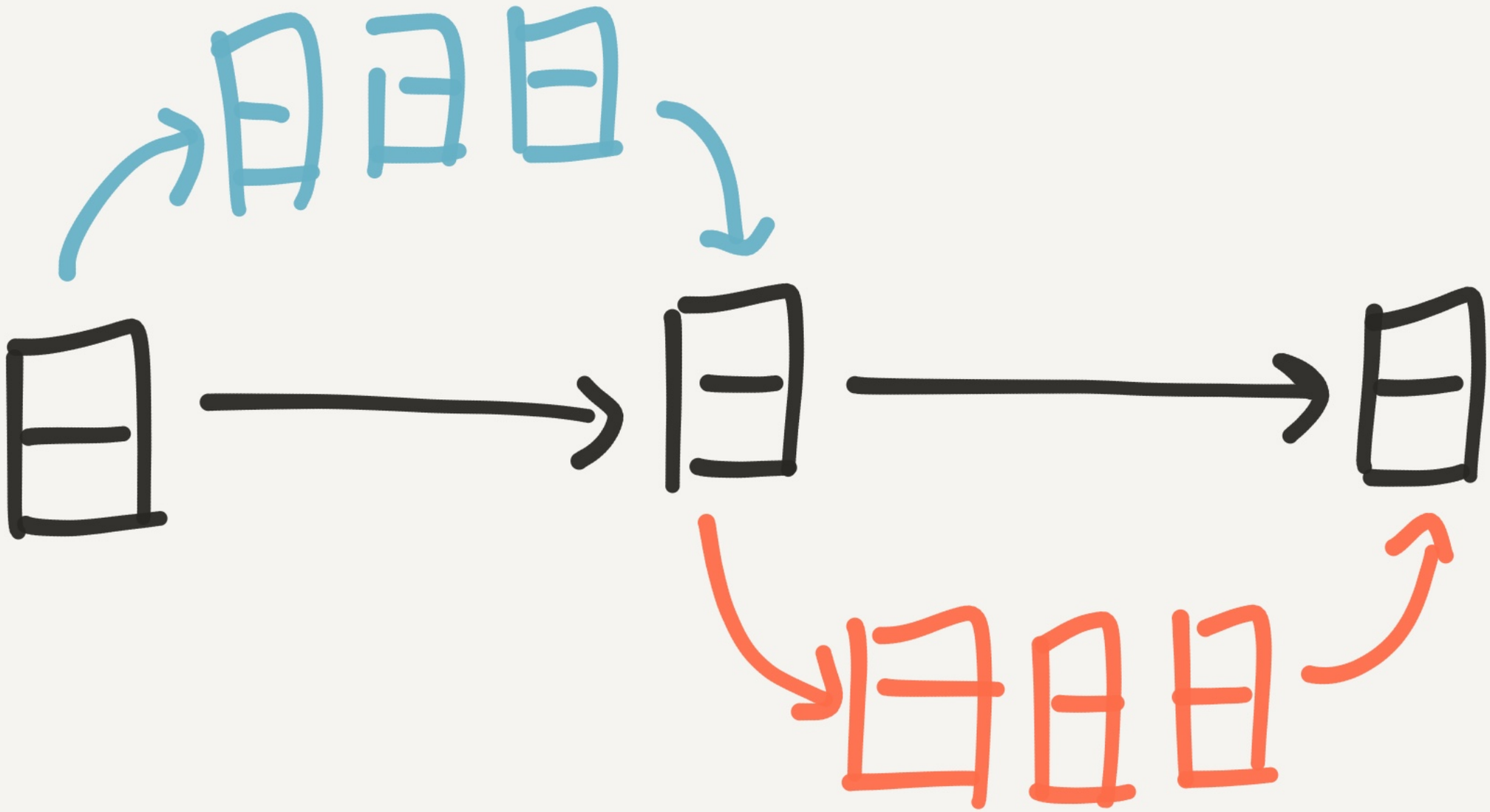
Can't use our linearizability checker...


stale read

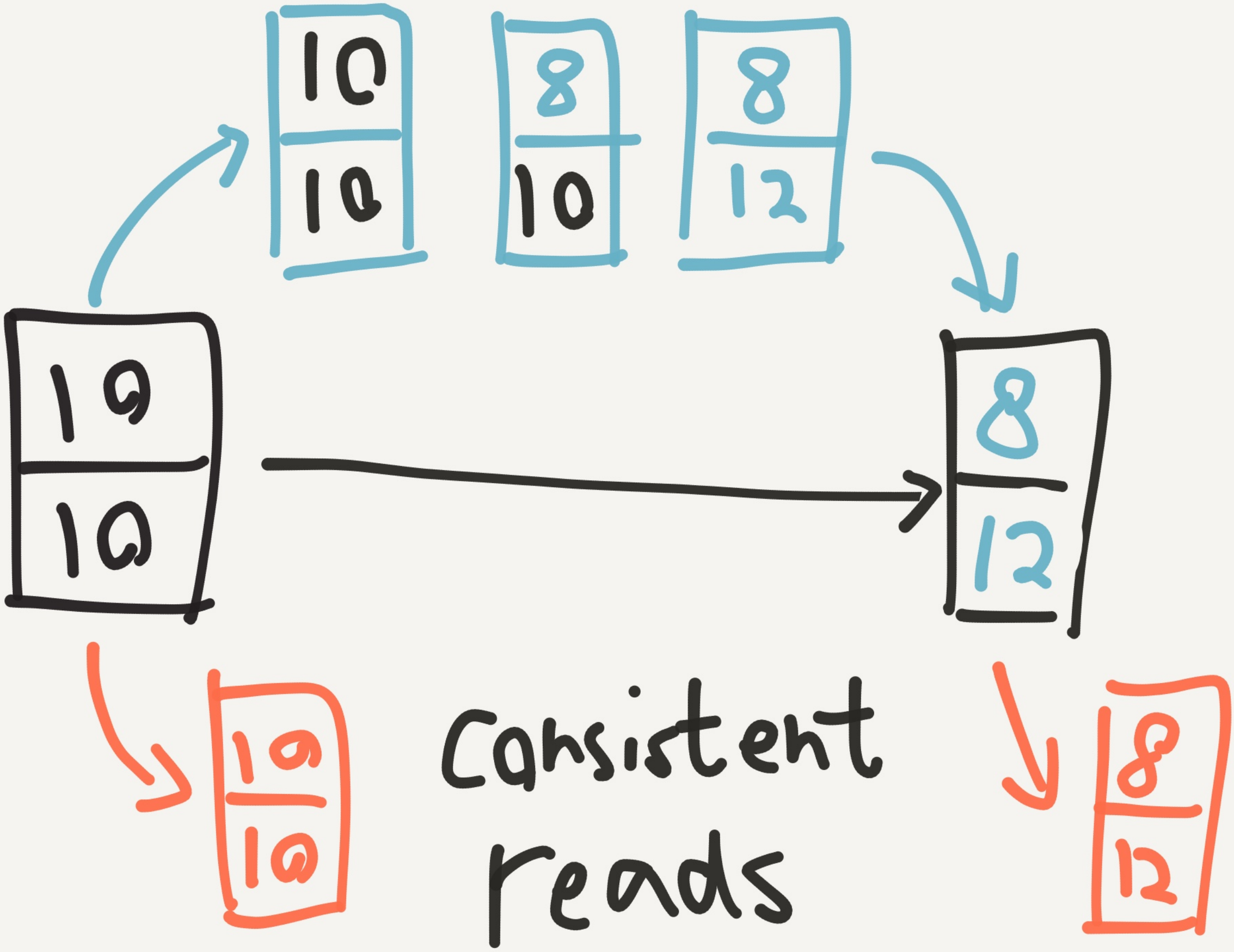
Consider 2 bank accounts...




10
10
8
10
8
12
10
10
8
12
8
12
10
10
10
5
15
5



Transfers must serialize

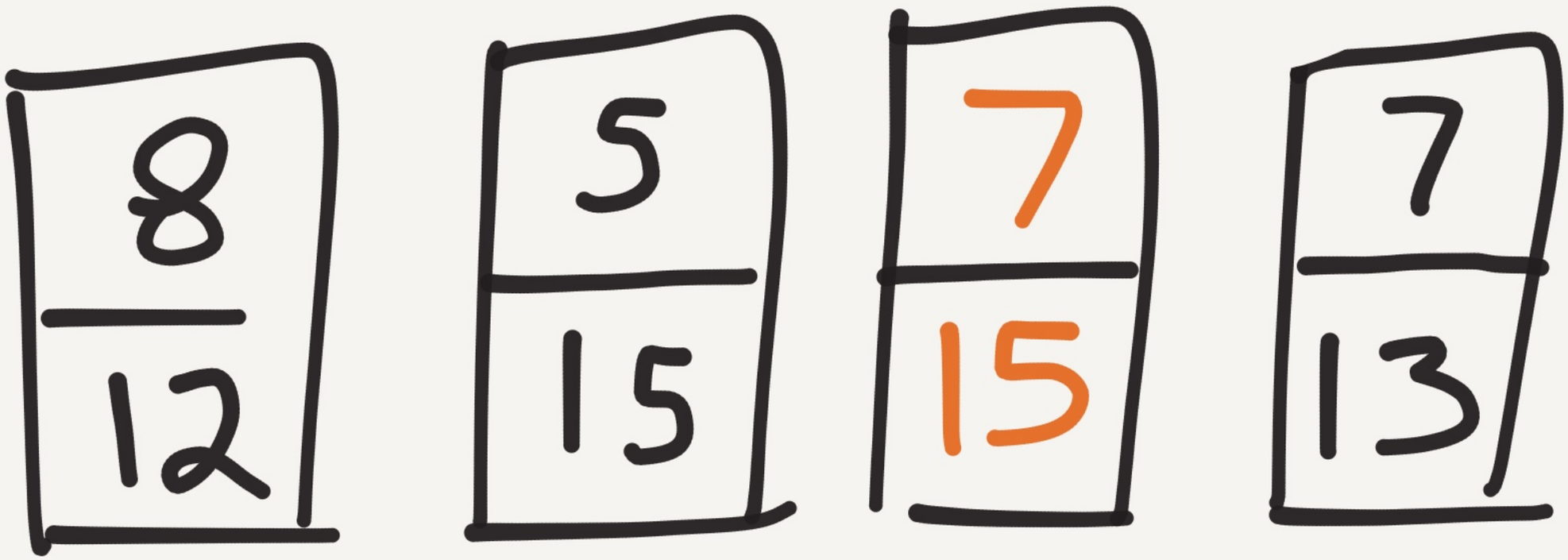

10
10
8
10
8
12
10
10
8
12
10
10
8
12
Consistent reads

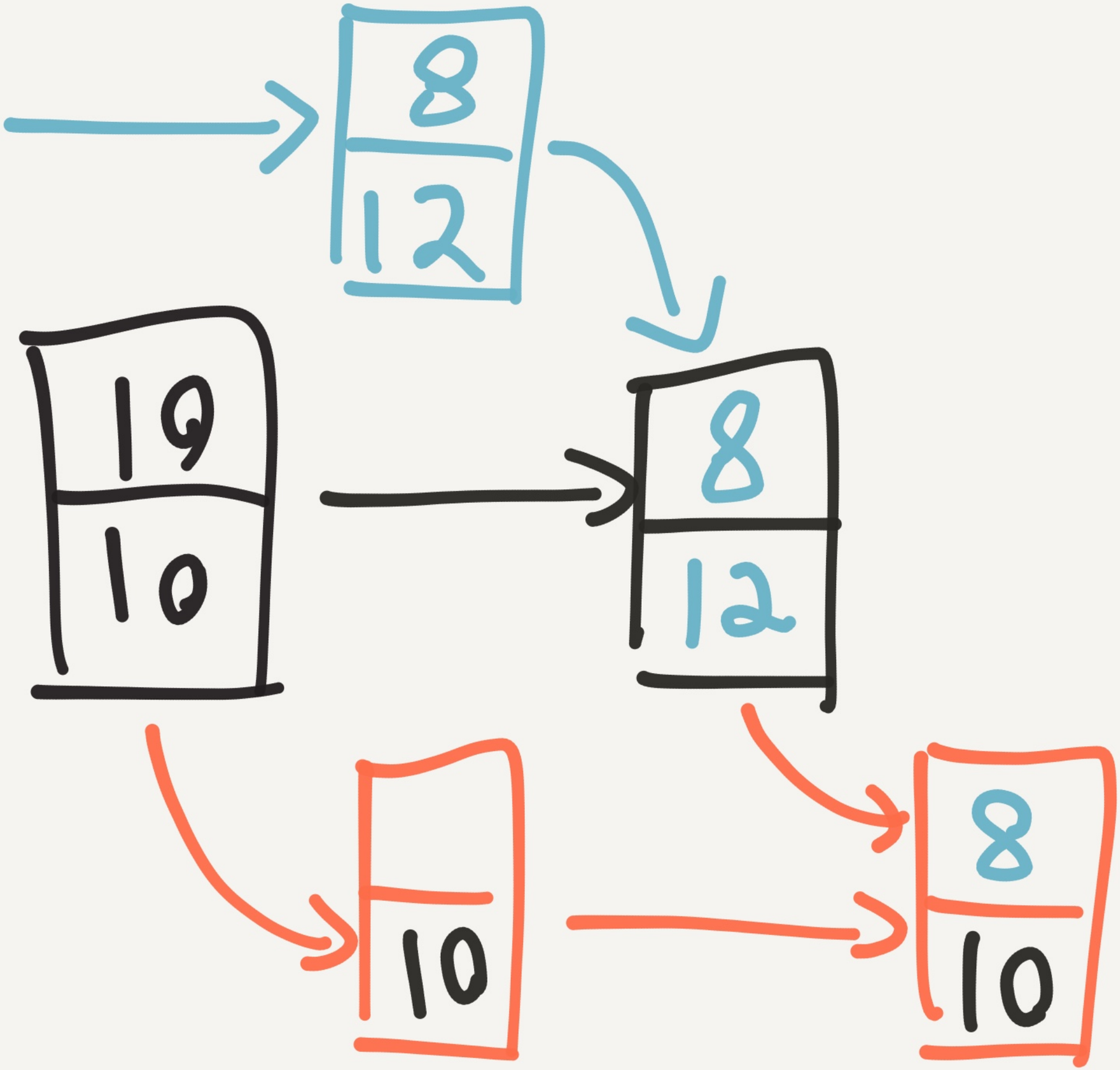
$\Rightarrow$ Sum of accts is always a CONSTANT

OR IS

IT?

Inconsistent Reads




8
12
19
10
8
12
10
8
10

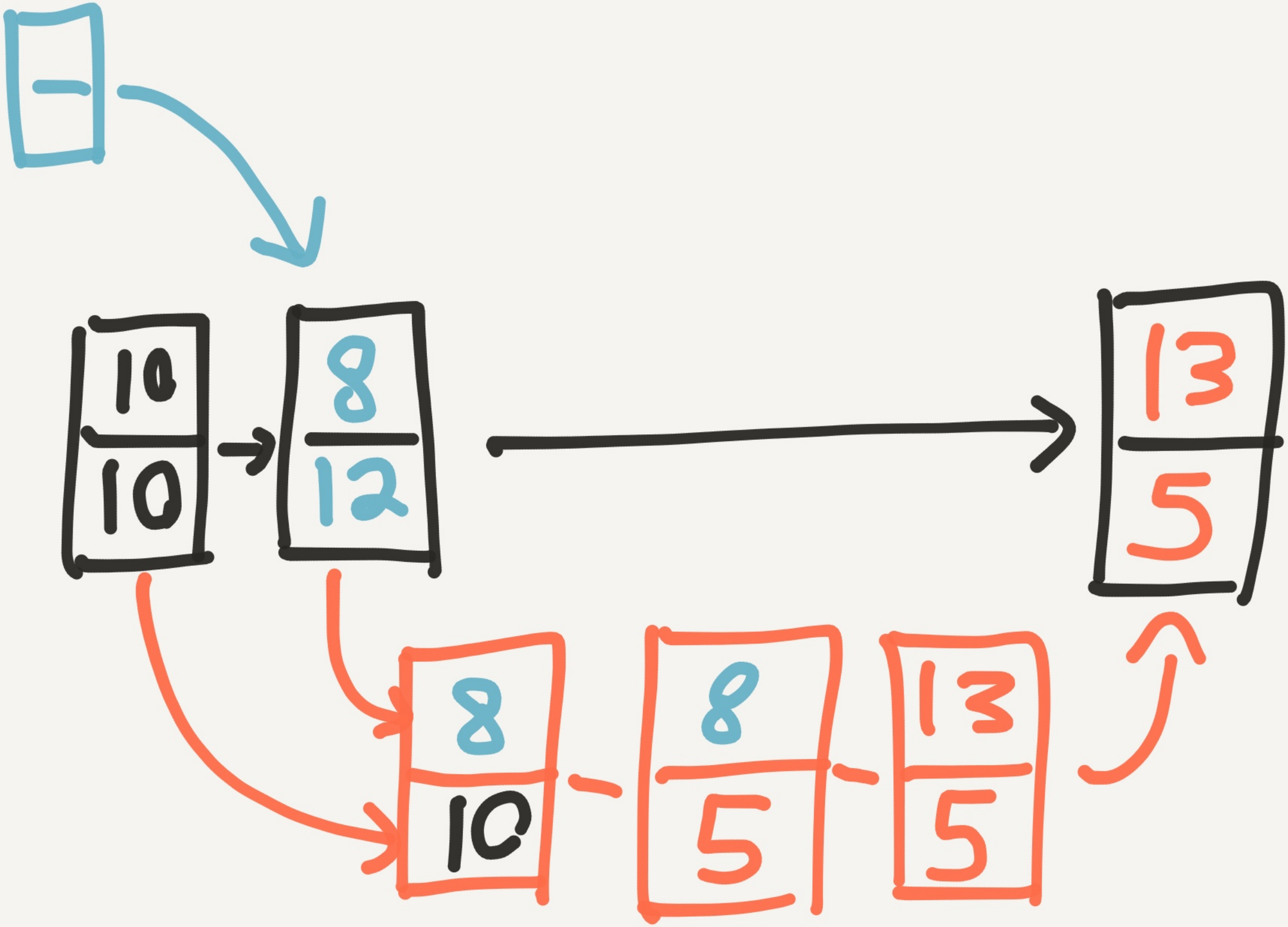
A5A

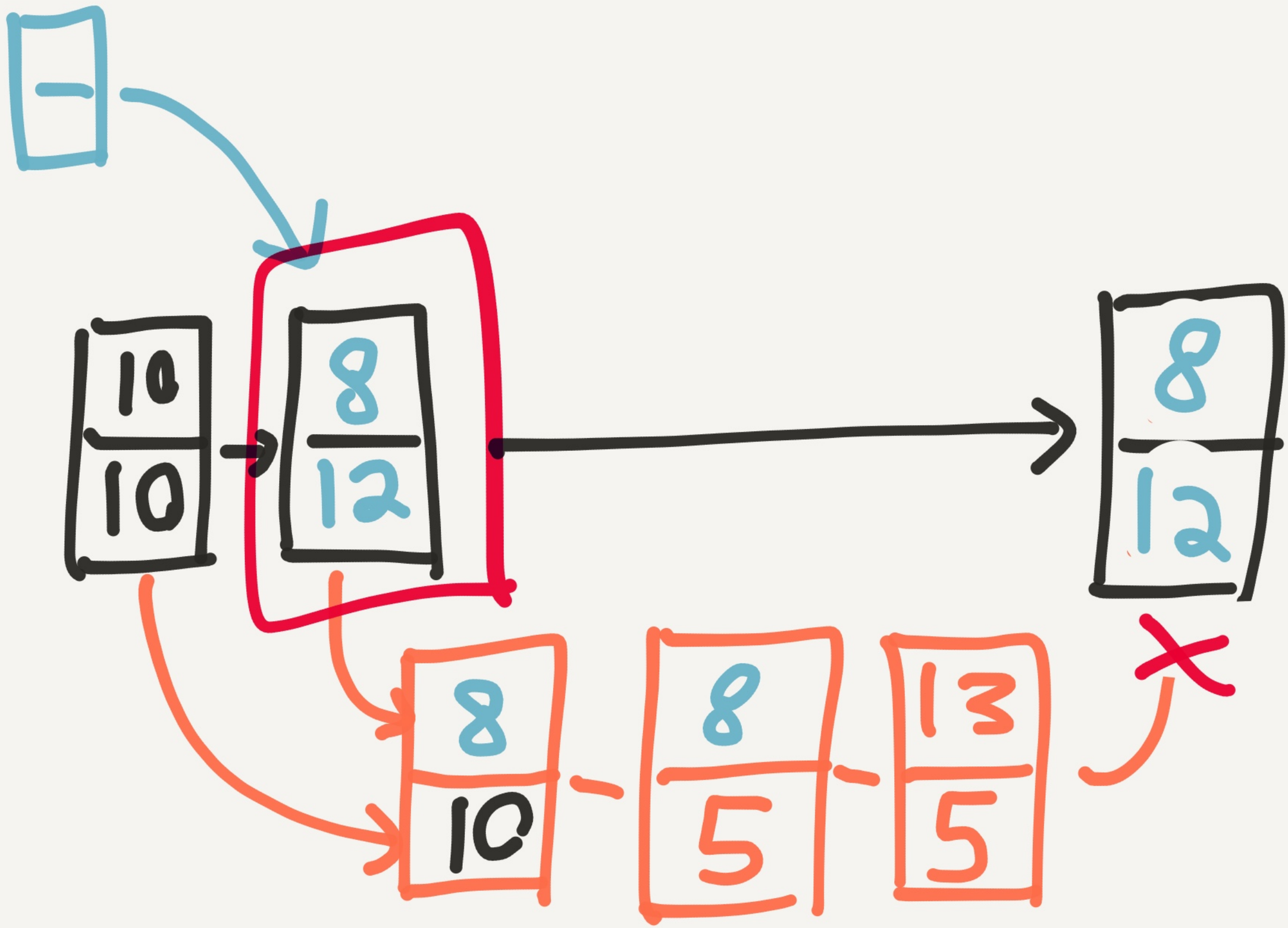
READ SKEW

Read Skew
breaks SI
invariants

IT GETS

WORSE


-
10
10
8
12
13
5
8
10
8
5
13
5


10
10
8
12
8
12
8
10
8
5
13
5

Galera engineers:

"first committer wins rule is not honored by galera certification"

$\neg$ first-committer-wins

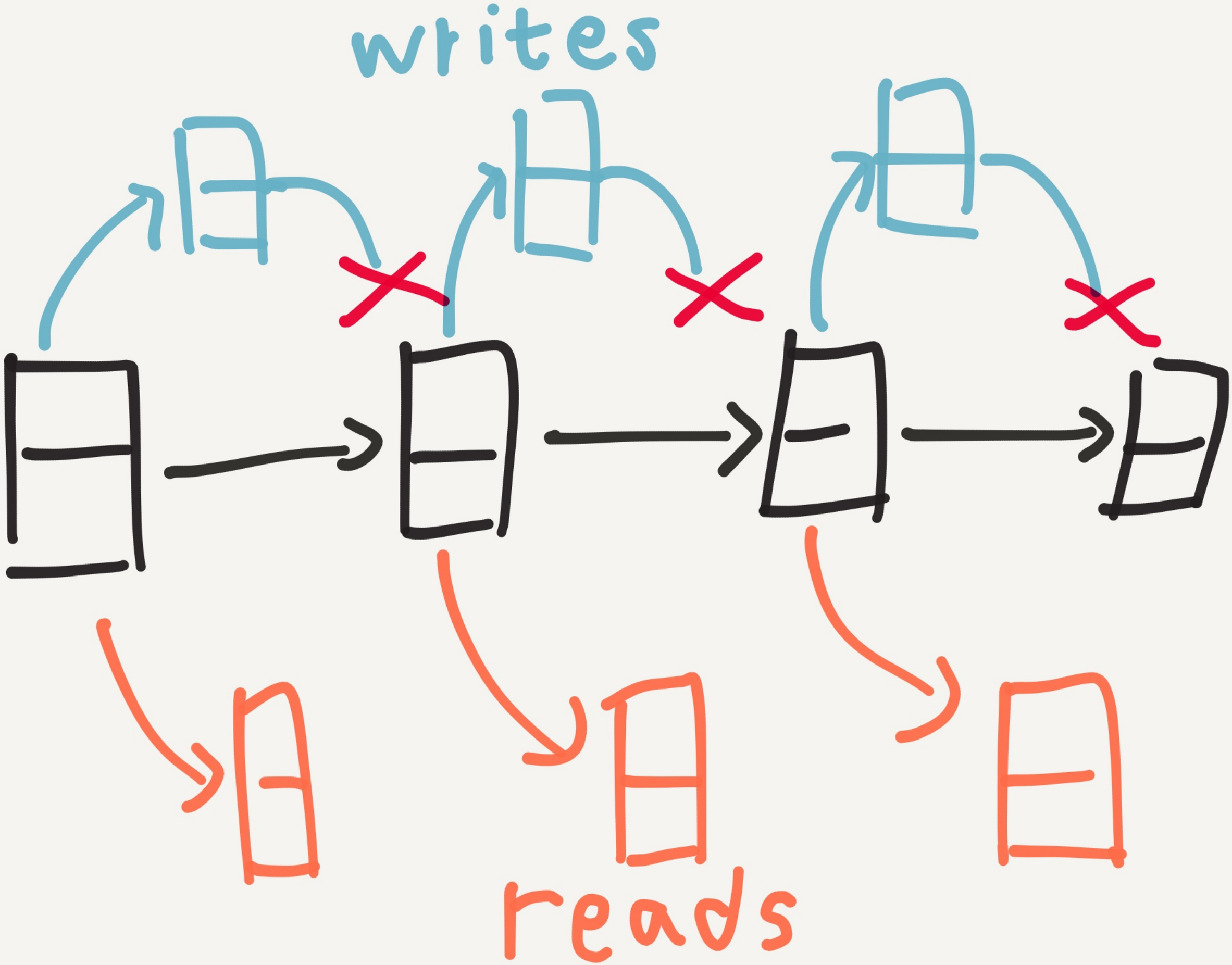
$\Rightarrow \neg$ SI

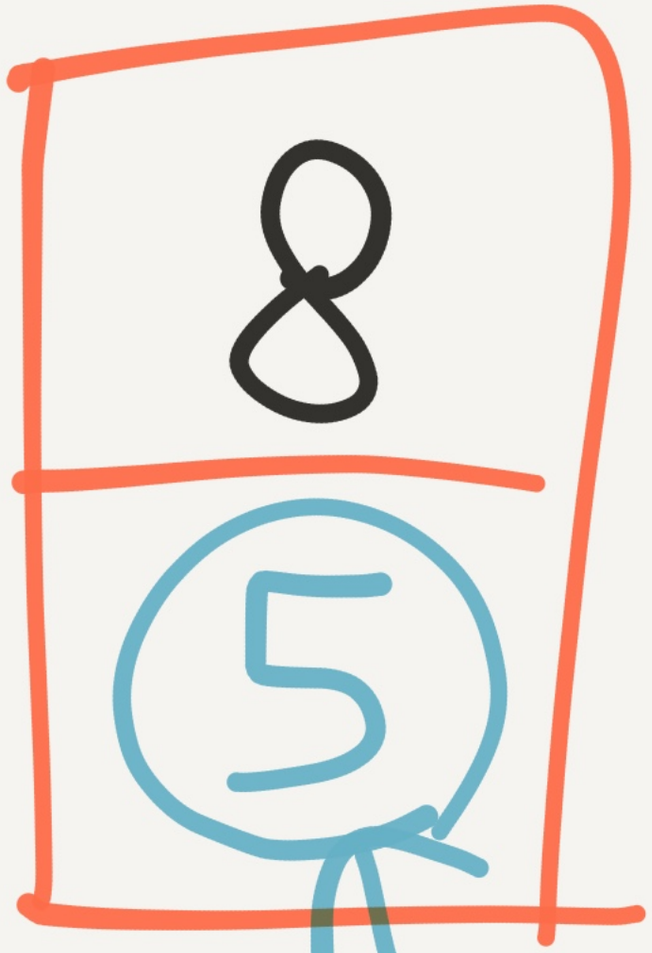
Docs are lying

Not all is

LOST

Galera does not allow Dirty Read


writes
reads



(we never see this)

from abarted transaction

1SR ✗

RR ?

SI ✗

RC ✓

RU ✓

If your app
works with RC,
it might be ok.

RC is a pretty weak property.

Allows those inconsistent reads!

Galera might support SI

someday...

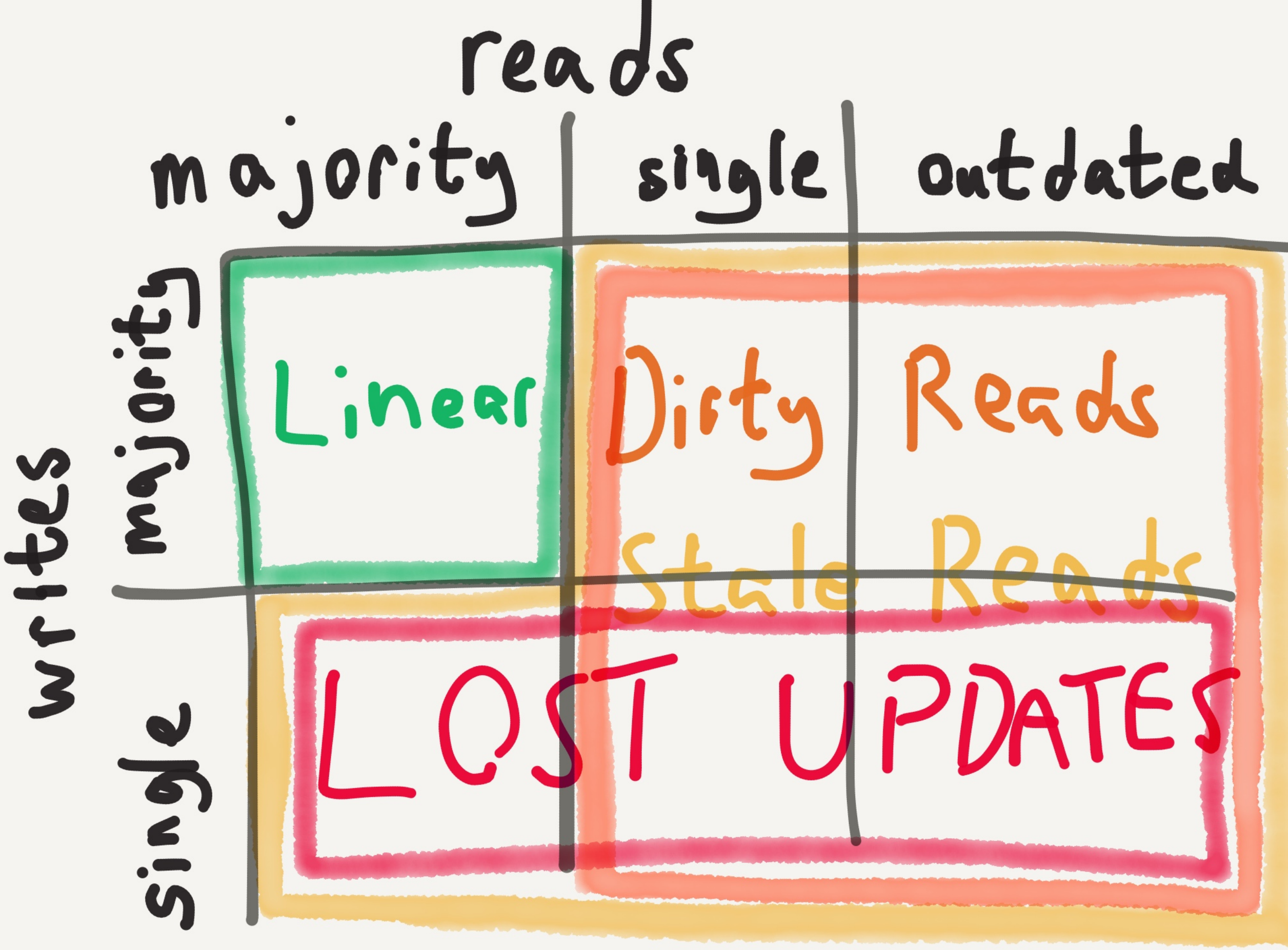
RethinkDB

- Document Store
- Like MongoDB
- Linearizable on 1 Key
- No multi-doc txns

Now uses

to offer

consensus!


reads
majority
single
outdated
writes
majority
single
Linear
Dirty
Reads
Stale Reads
LOST UPDATES

During Partitions,

- brief latency spike
- brief downtime
- Recovery in ~10 s

Outdated reads always available

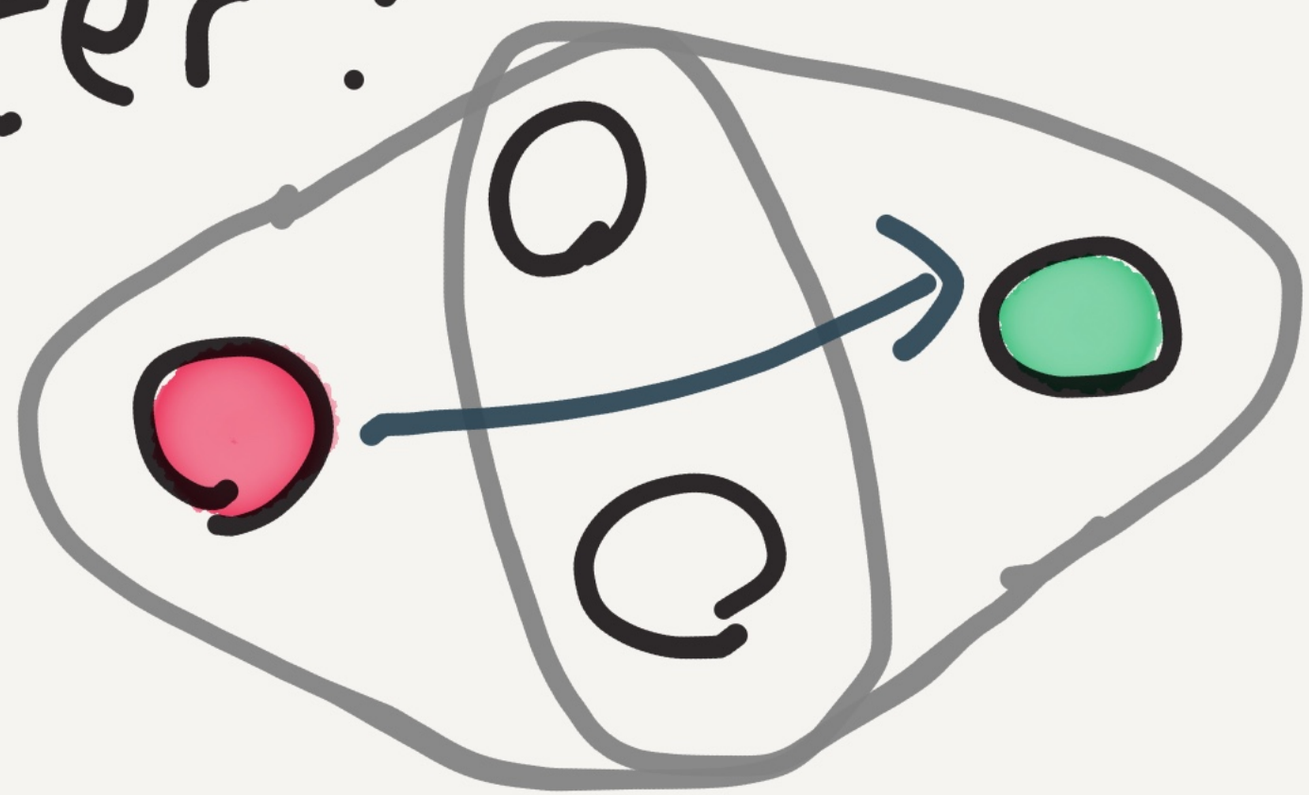
All other ops require a majority connected

Majority/Majority

PASSED

We have to go Deeper

What if... we rebalanced the cluster?



Still passes. Ok.

Let's rebalance during partitions

lost update!

3 write 0

17 cas 3→0

time →

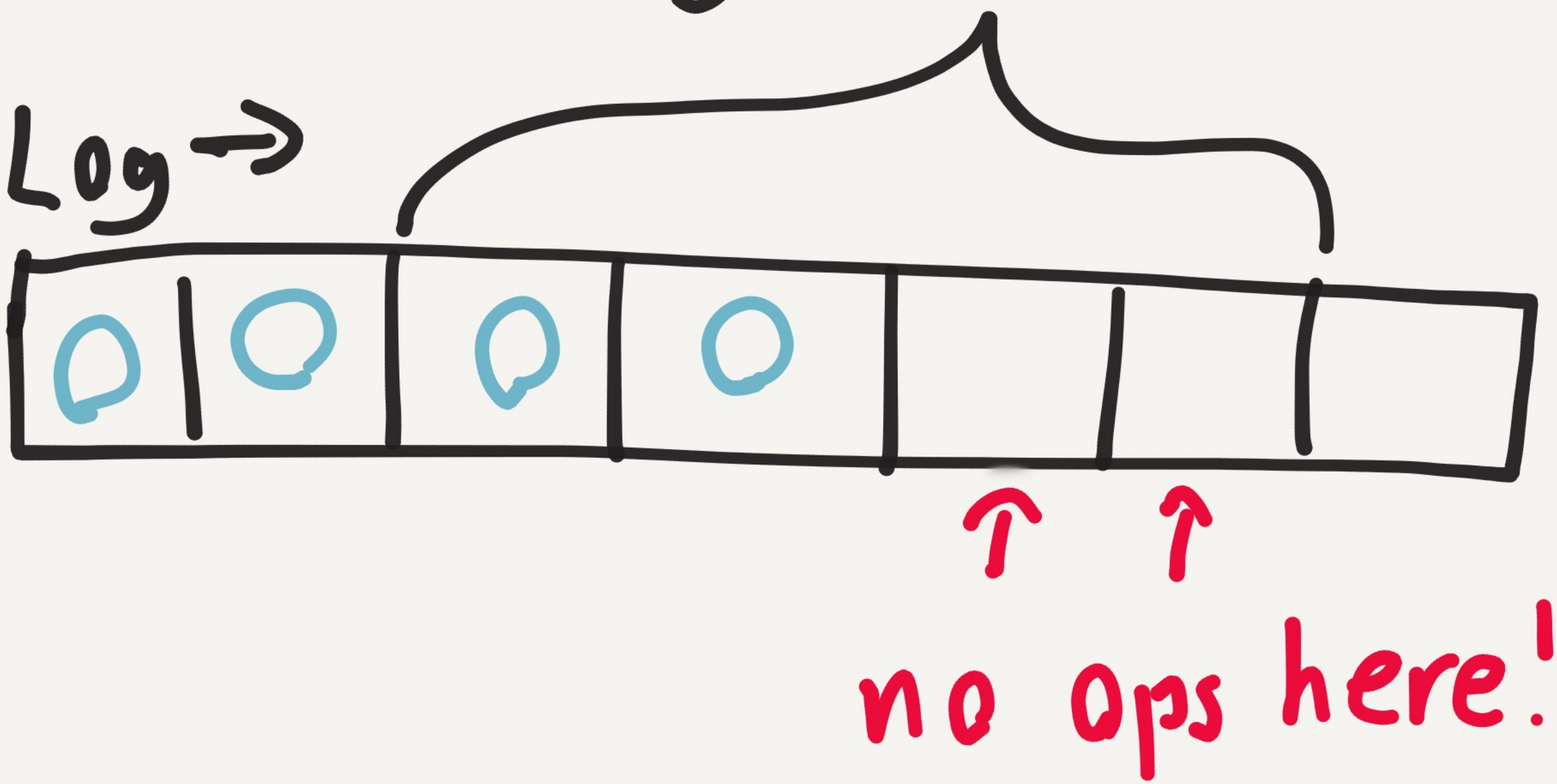
"Guarantee failed:

[index <= get_latest_index]

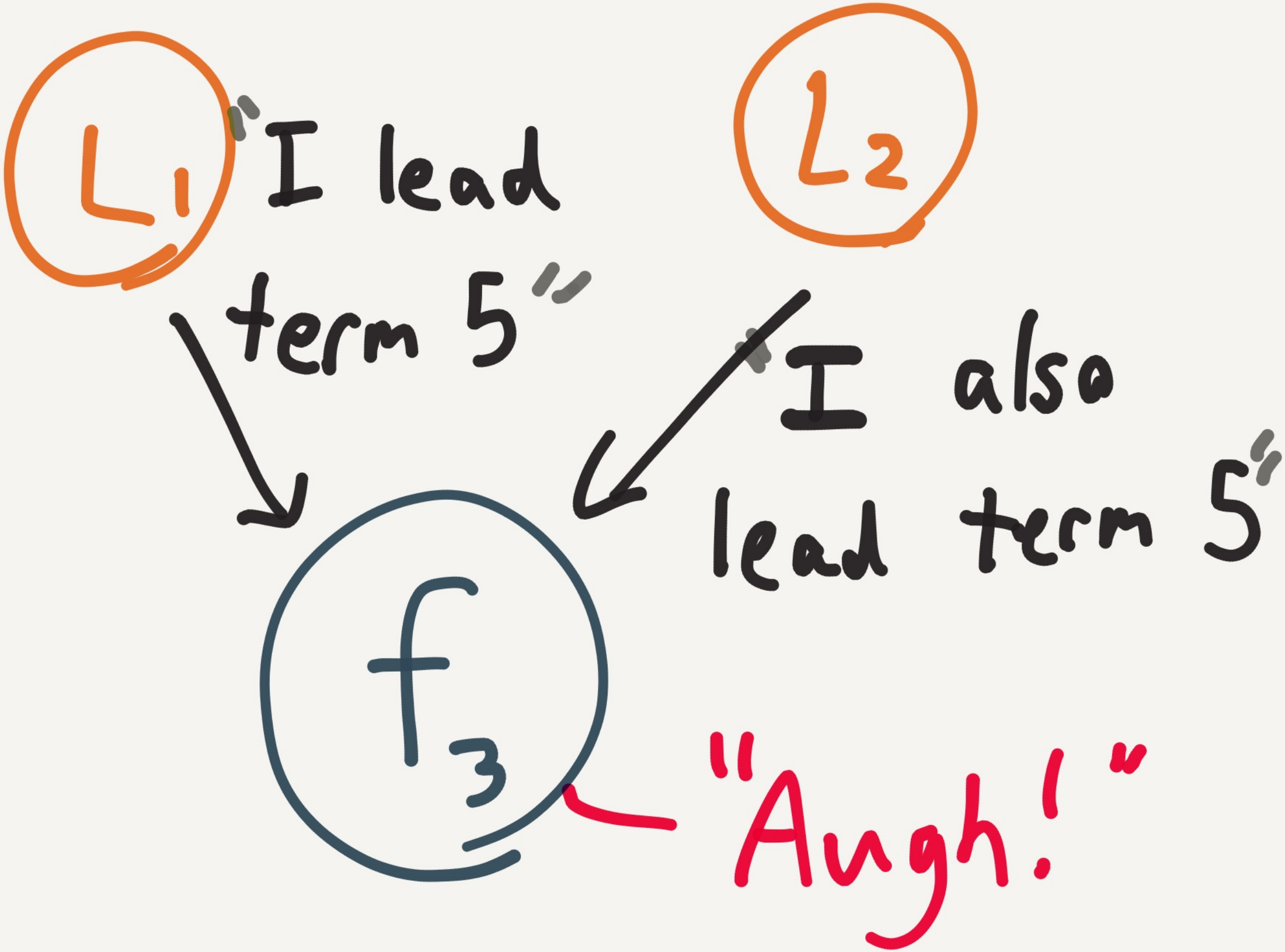
the log doesnt go

forward this far"

Leader: "please apply this range to your SM"



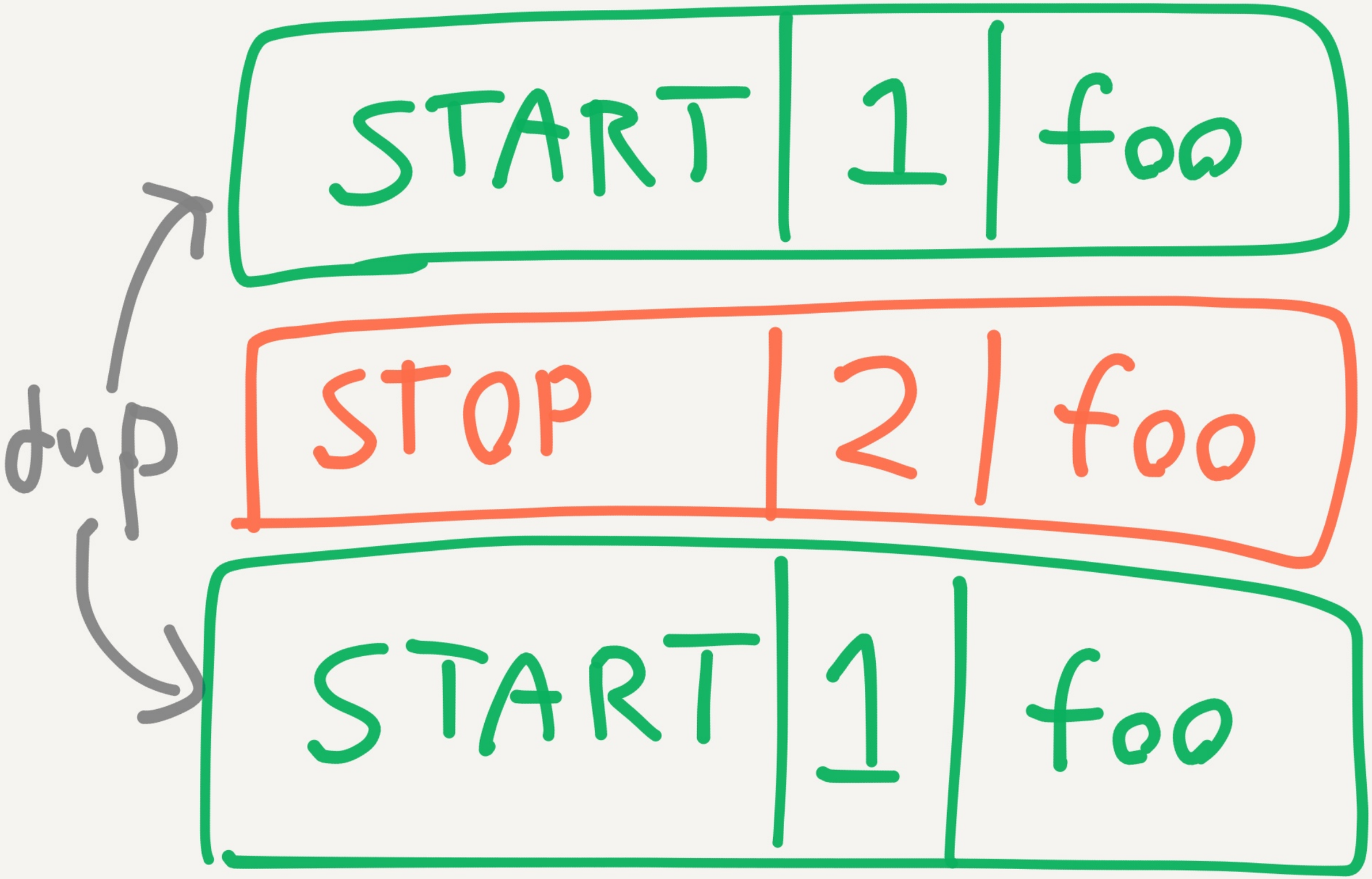
"Guarantee failed:
[current_term_leader_id
== request_leader_id]"

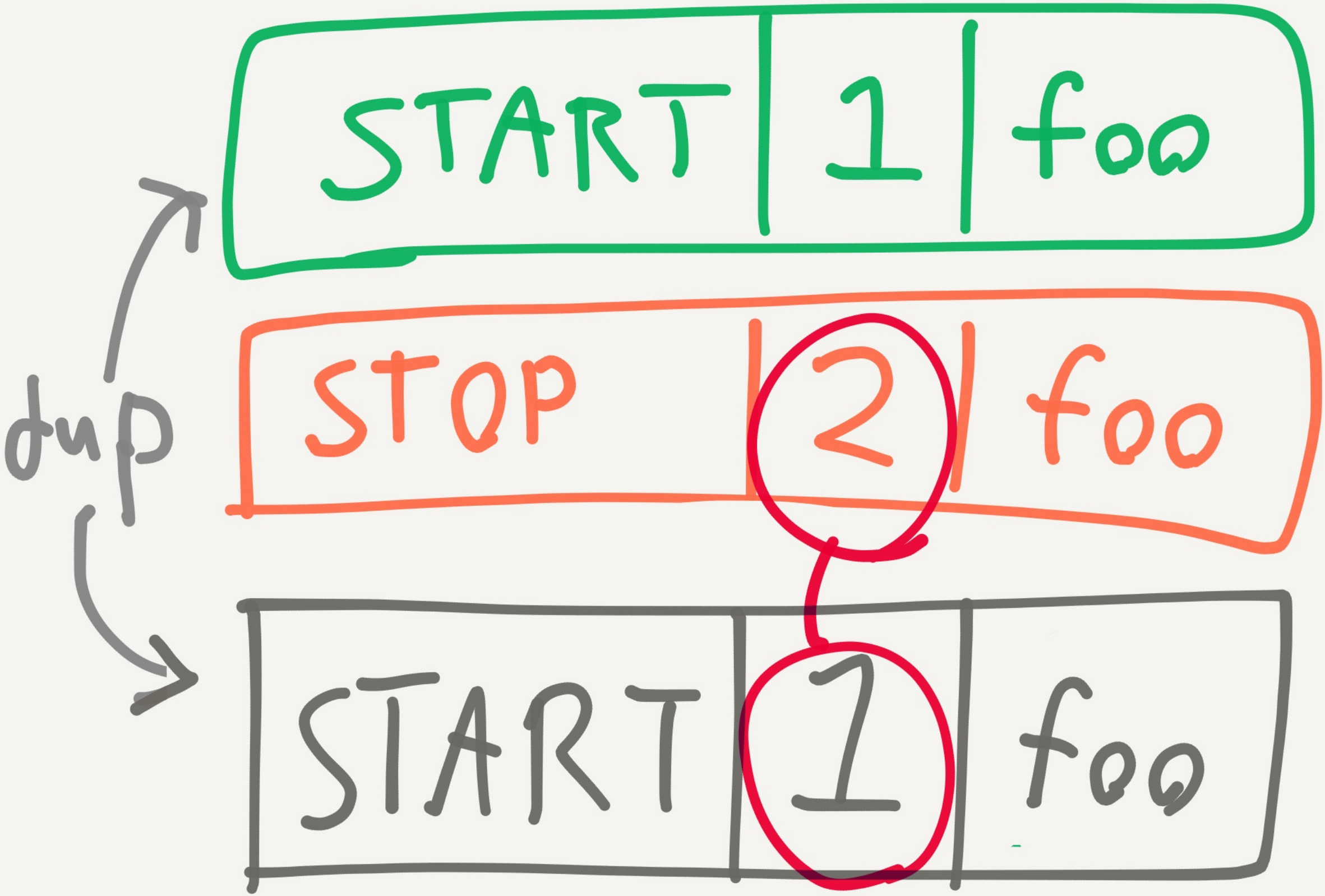

L_1
"I lead term 5"
L_2
"I also lead term 5"
f_3
"Augh!"

seq #

raft ID

START	1	foo
STOP	2	foo


START
1
foo
STOP
2
foo
dup
START
1
foo


START
1
foo
STOP
2
foo
dup
START
1
foo

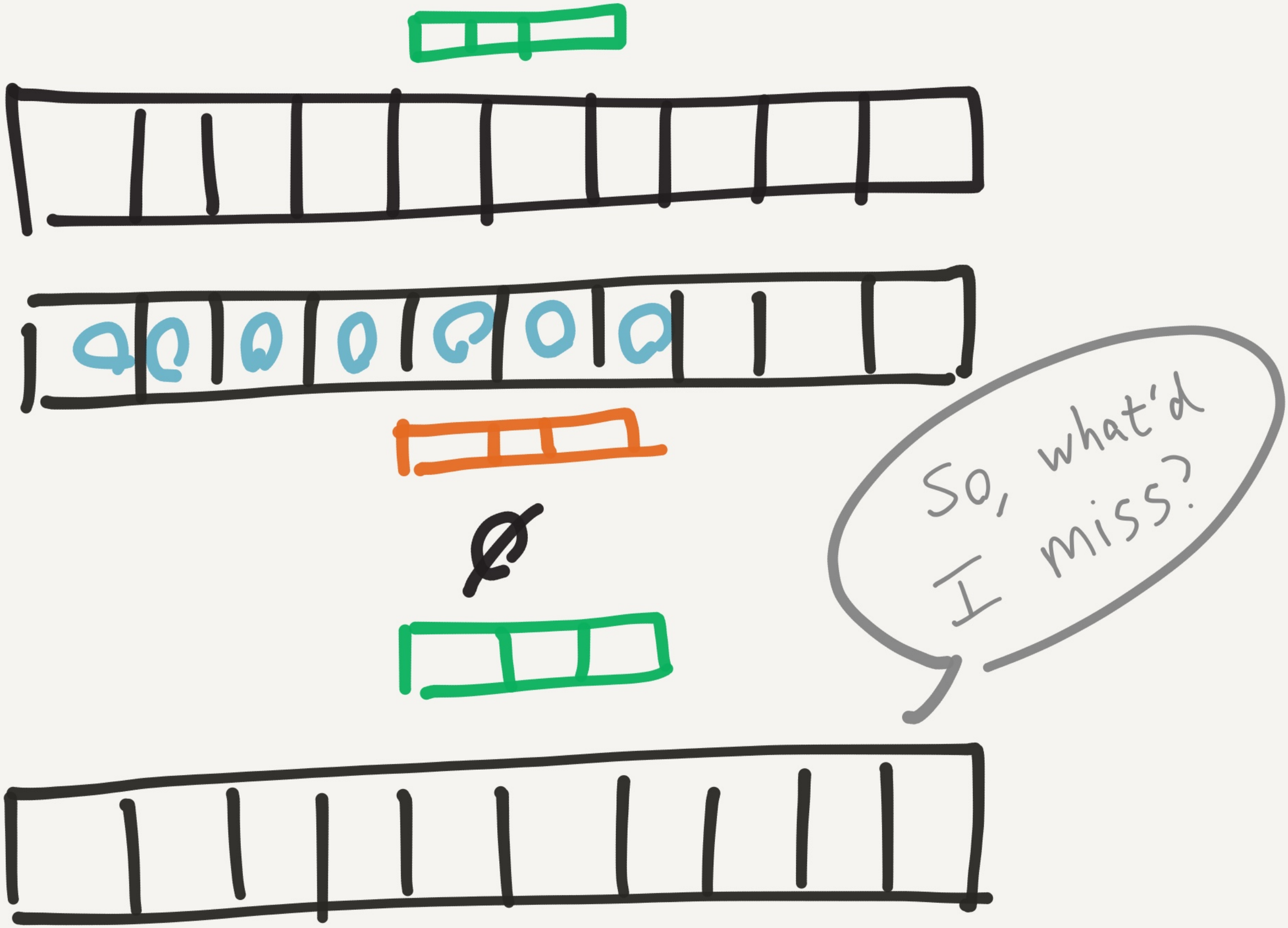
...mostly.

#4668

In version 2.1.0,
seq #s set to
MAX_INT.

Workaround:

Always process ACTIVE messages


So, what'd I miss?

Patches in 2.2.4 & 2.1.6

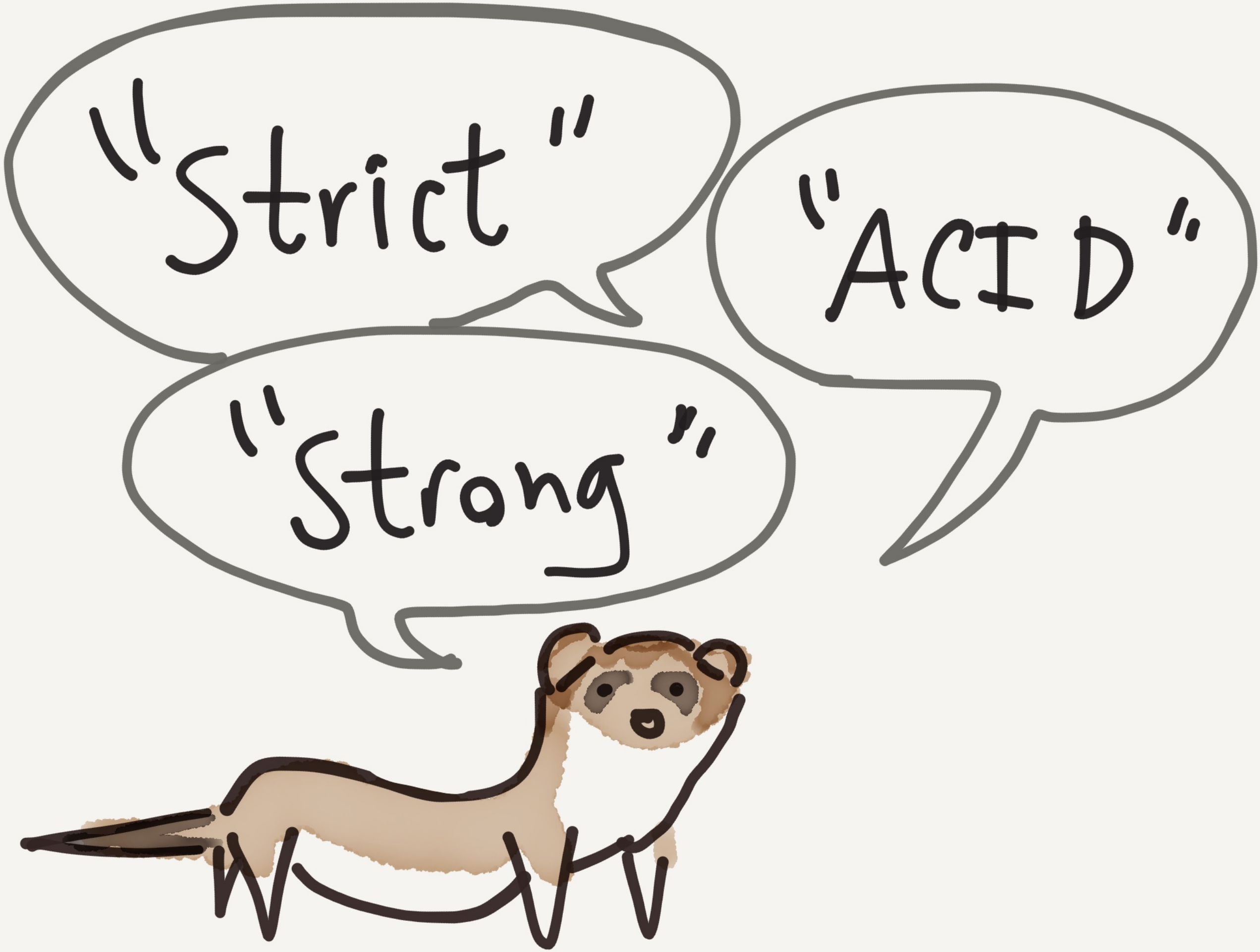
Recap

Read the docs!
CAREFULLY

Then test it

for

YOURSELF


"Strict"
"ACID"
"Strong"

Be Formal

&

Be Specific!

Figure out the

Invariants

<u>your</u> system needs

How much

can you tolerate?

Consider your failure modes

Process Crash

```
#kill -9 1234
```

Node failure

- AWS terminate
- Physical power switch

Clock Skew

```
# date 10280000
# faketime ...
```

GC/IO Pause

```
# killall -s STOP foo
# killall -s CONT foo
```

Network Partition

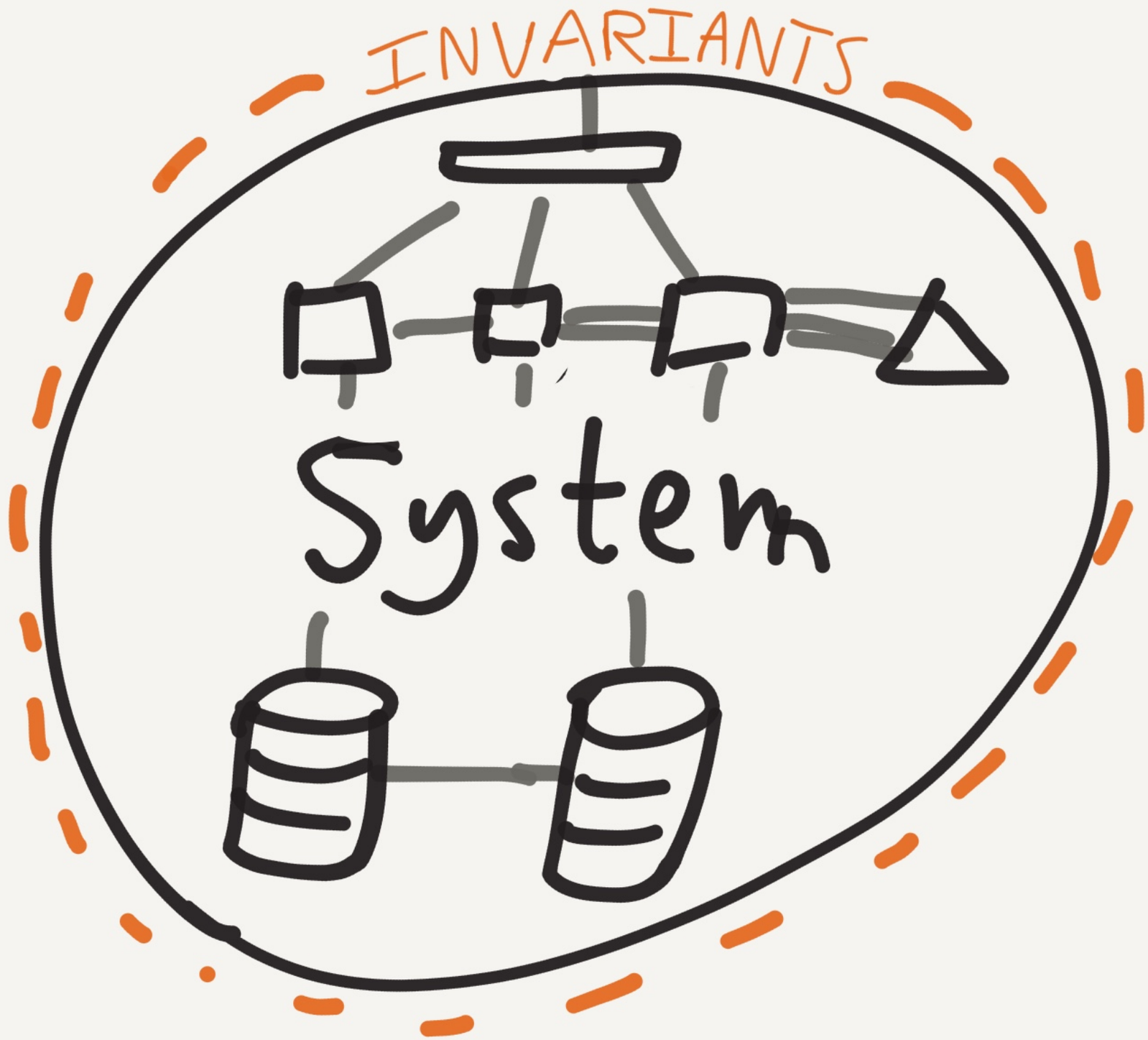
```
# iptables -j DROP

# tc qdisc ... delay ...
                drop ...
```

Test your Systems

end ——— to ——→ end

vs.



- Property testing
- High-level invariants
- With distsys failure modes

Thanks

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Thanks!

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Michael Lucy

Slava Alchmechet

Thanks!

Codership

Mesos (sphere)?

Thanks!

Stripe

RethinkDB

funded work

http://jepsen.io