

Distributed Computing I

Software Architecture

Brae Webb

March 27, 2023



Mathias Verrae
@mathiasverraes

There are only two hard problems in distributed systems: 2. Exactly-once delivery 1. Guaranteed order of messages 2. Exactly-once delivery

Lecture Goal: Balance a healthy love-hate relationship with distributed systems

Previously in CSSE6400...

Service-based Architecture

Re-visiting service-based architectures from last lecture

Previously in CSSE6400...

Simplicity For a distributed system



Modularity Services



Extensibility New services



Deployability Independent services



Testability Independent services



Security API layer



Reliability Independent services



Interoperability Service APIs



Scalability Coarse-grained services



Concluded on these attributes

Previously in CSSE6400...

Simplicity For a distributed system



Reliability Independent services



Scalability Coarse-grained services



Let's revisit these attributes

Previously in CSSE6400...

Simplicity *For a distributed system*



This condition is doing a lot of work

Previously in CSSE6400...

Simplicity



We'll look at a few reasons that distributed systems are *fundamentally* quite challenging

\S Fallacies

Question

What is a *fallacy*?

Definition 1. Fallacy

Something that is believed or assumed to be true
but is not.

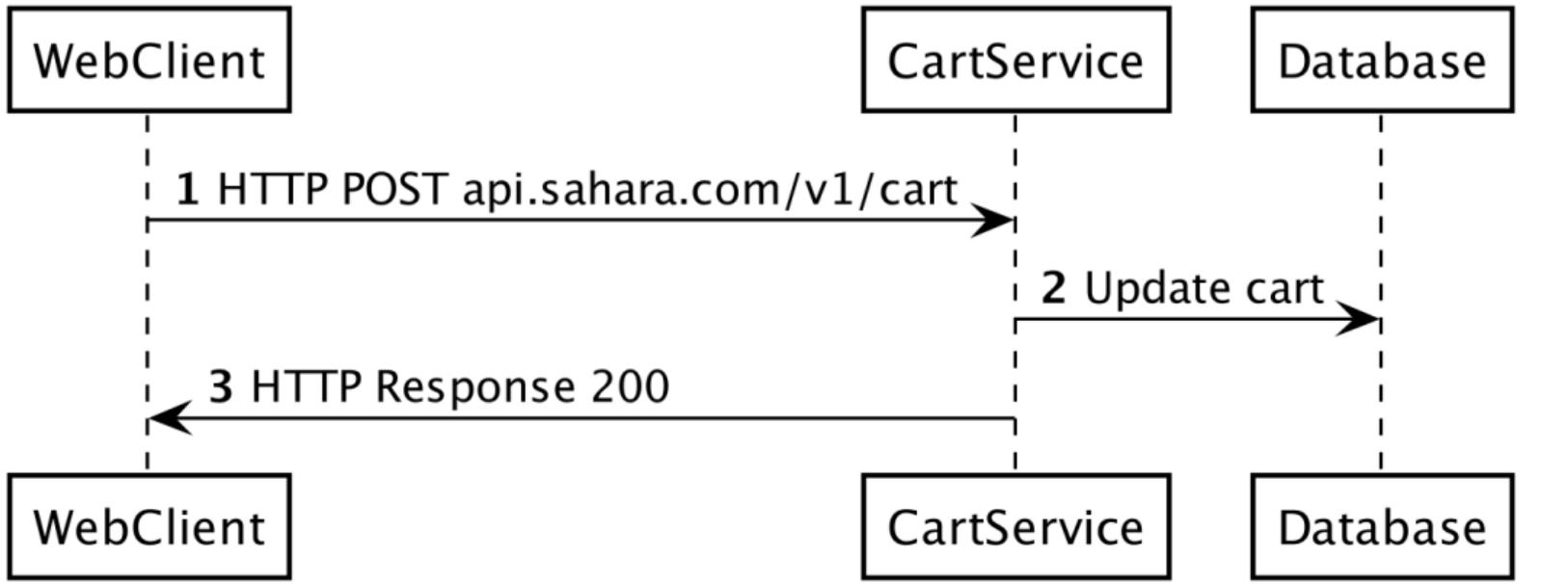
A few reasons for complexity

The Fallacies of *Distributed Computing*

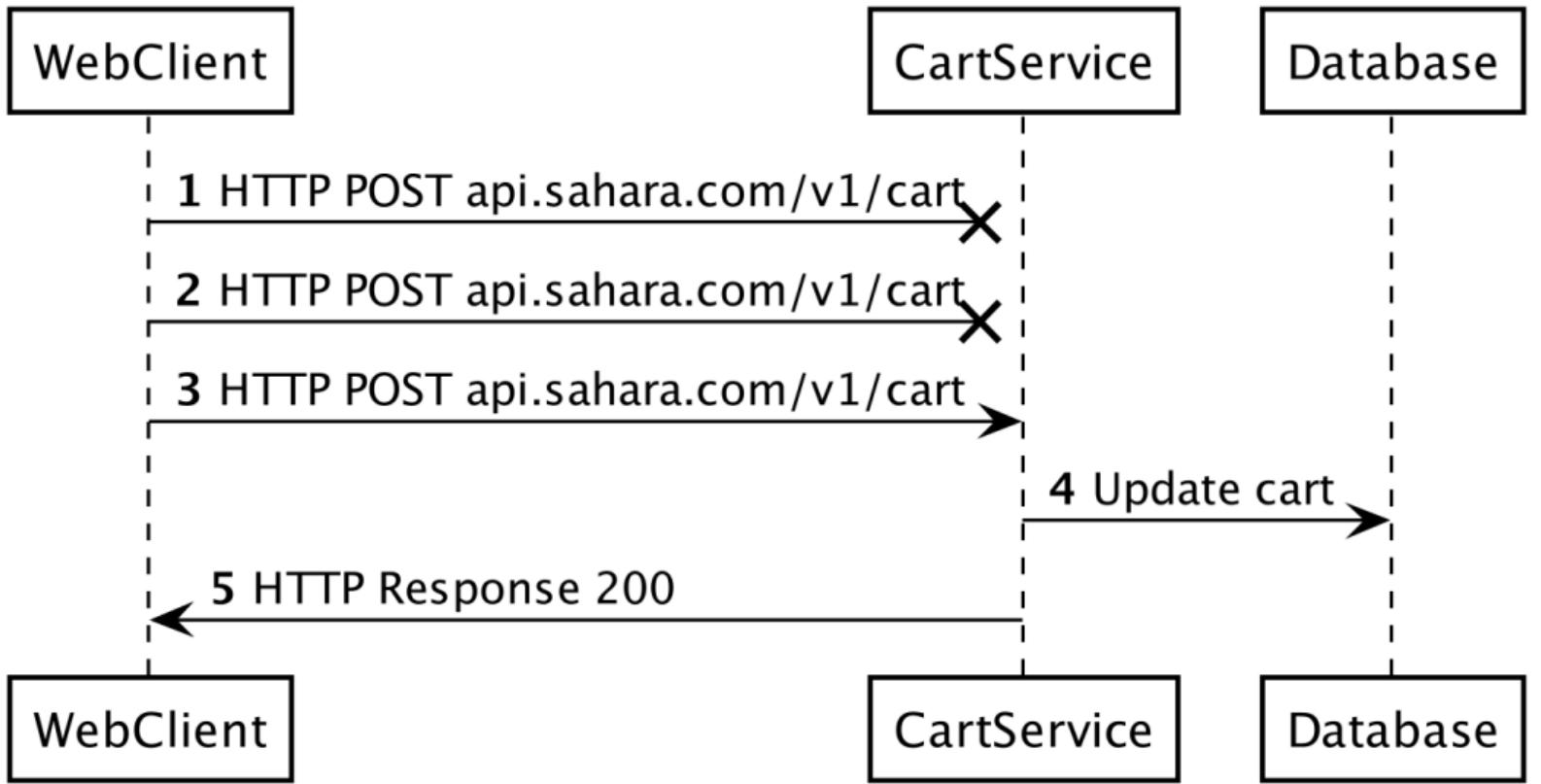
Sun Microsystems in 1994, primarily accredited to Peter Deutsch
(doy-ch)

Fallacy #1

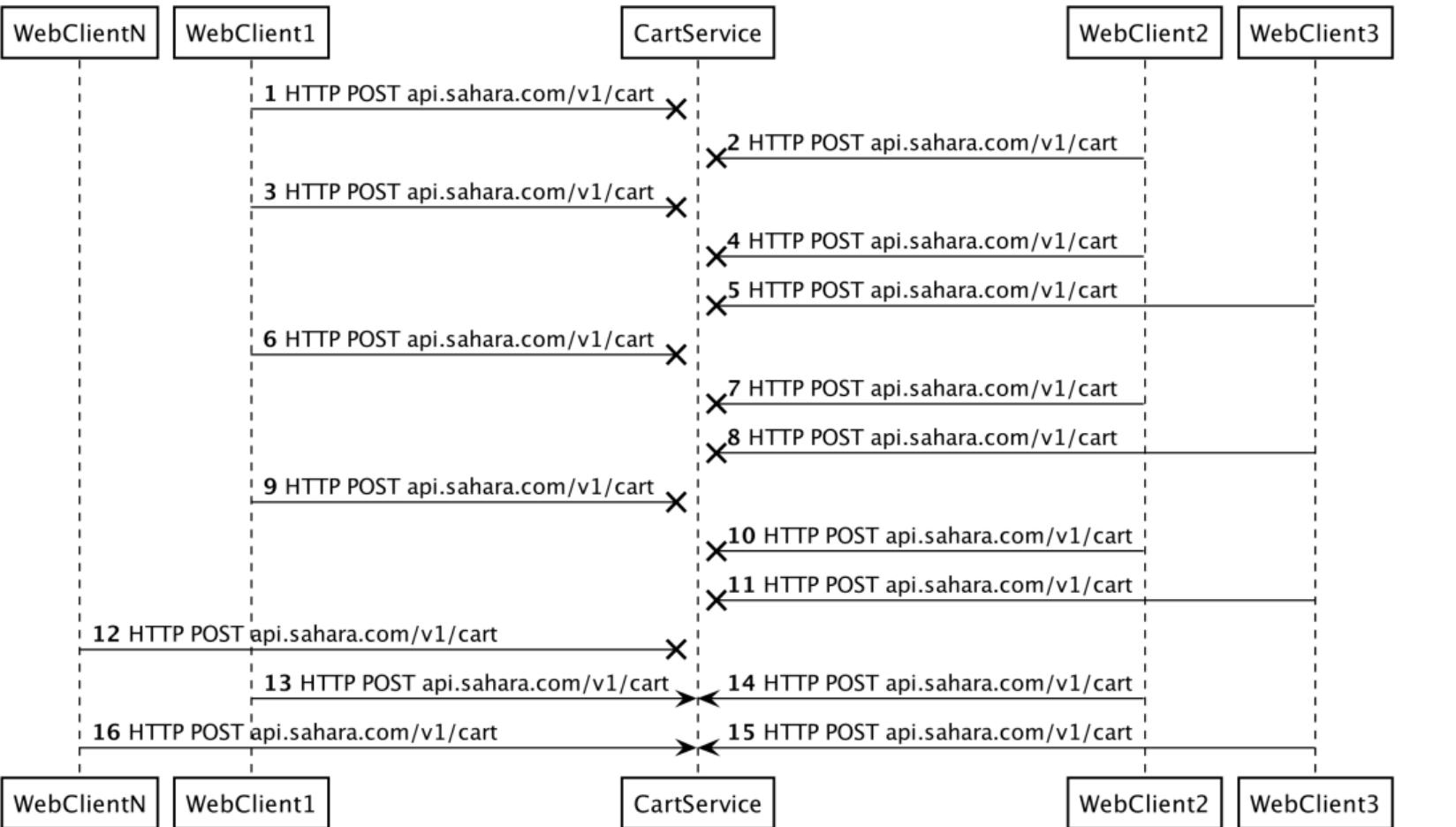
The network is reliable







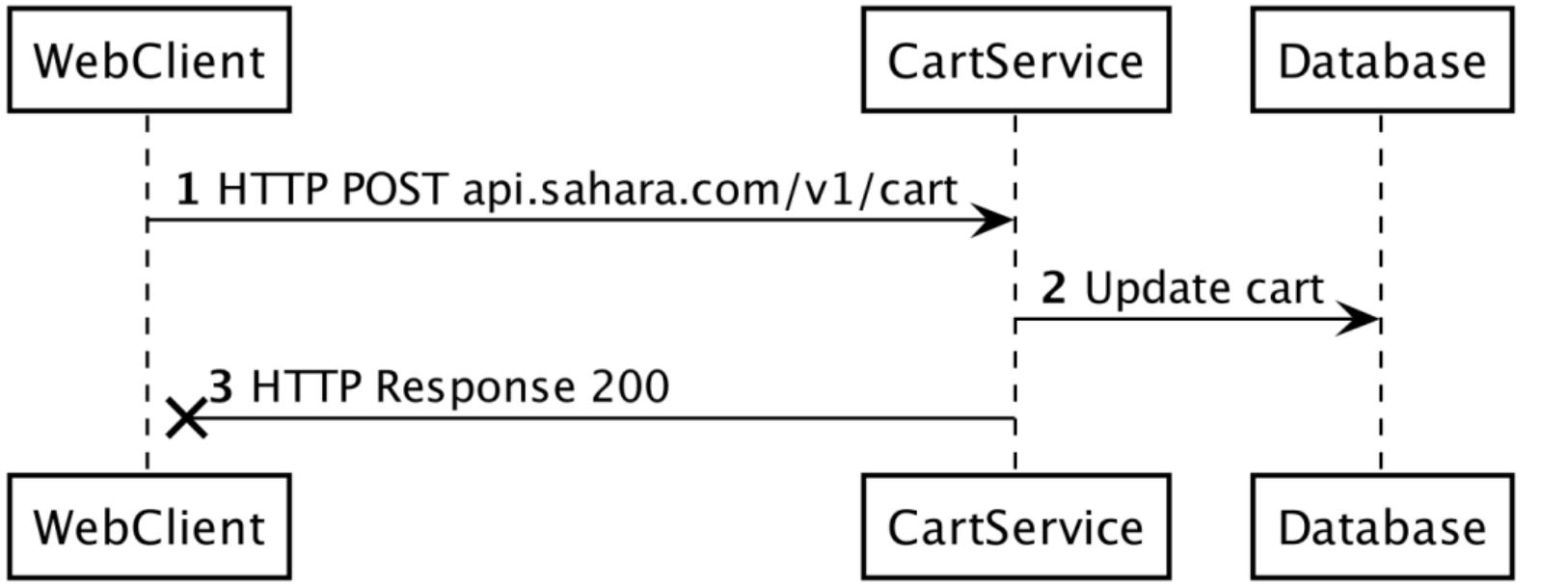
Solve it by resending it

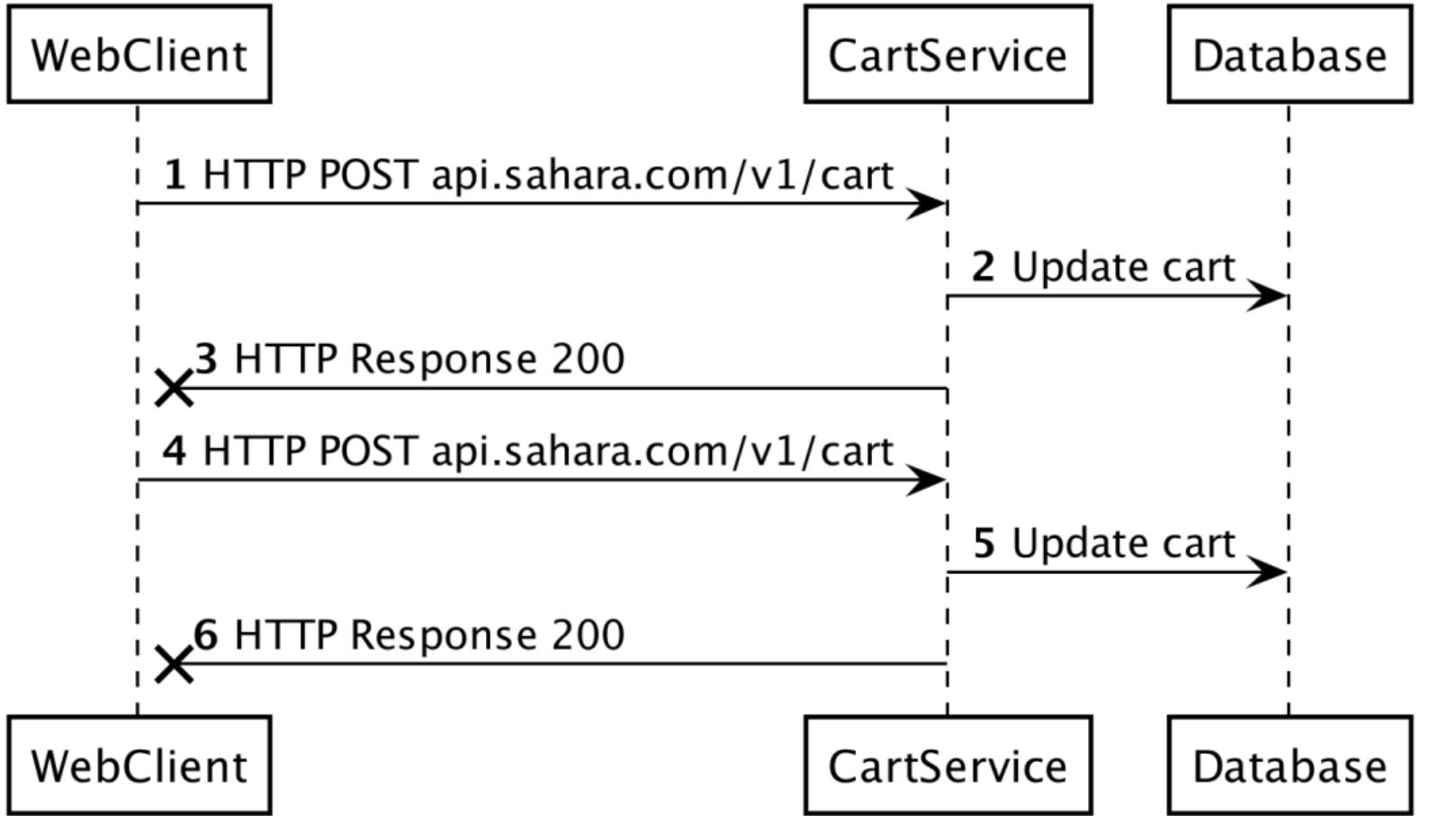


If the service goes down and all clients are re-trying, the service is in for a shock when it comes back, we solve this with *exponential backoff*

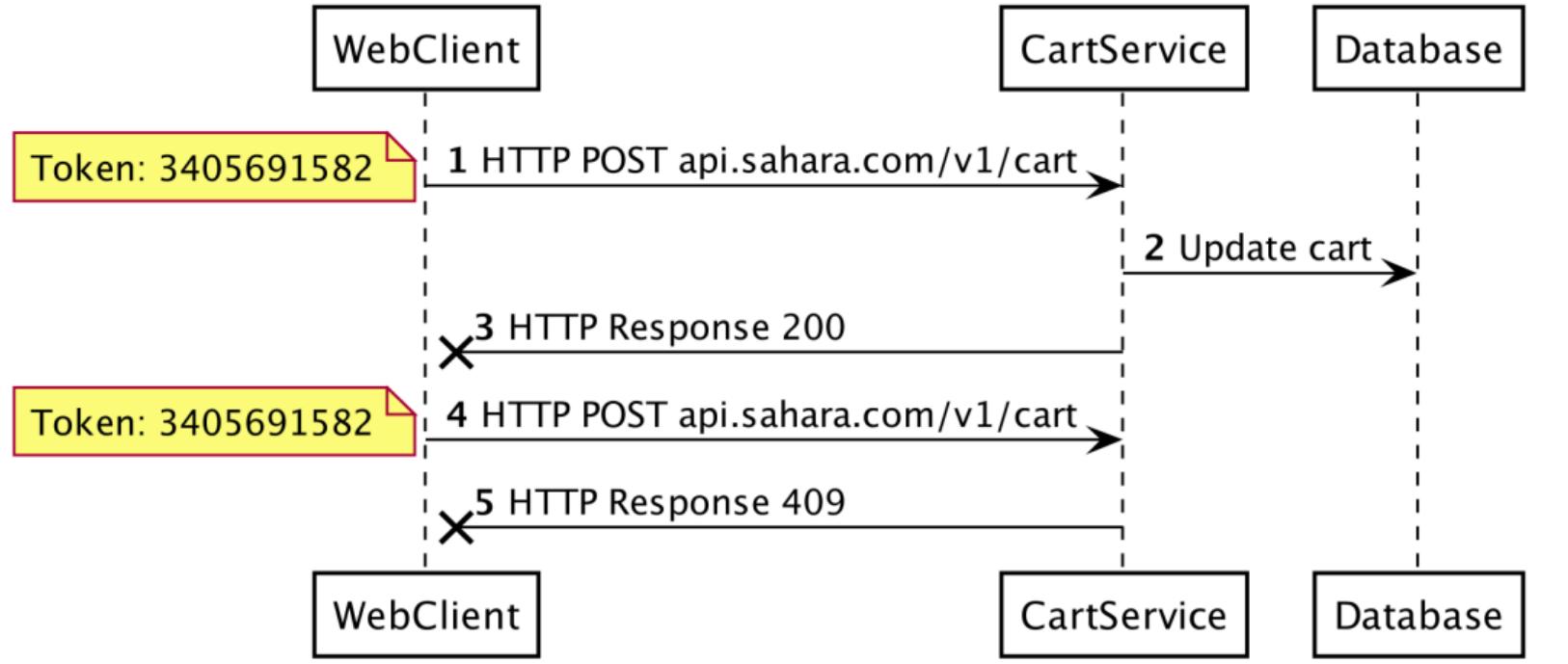
Exponential backoff

```
1  retry = True
2  do:
3      status = service.request()
5
5      if status != SUCCESS:
6          wait(2 ** retries)
7      else:
8          retry = False
9  while (retry and retries < MAX_RETIRES)
```





Causes duplicate actions, problem for ordering/payments



Use tokens to prevent duplicates.

Fallacy #2

Latency is zero

Network Statistics

Home to UQ

Home to us-east-1

EC2 to EC2

Network Statistics

Home to UQ 20.025ms

Home to us-east-1

EC2 to EC2

Network Statistics

Home to UQ 20.025ms

Home to us-east-1 249.296ms

EC2 to EC2

Network Statistics

Home to UQ 20.025ms

Home to us-east-1 249.296ms

EC2 to EC2 0.662ms

Be mindful when designing distributed systems. Network call much slower than local call.

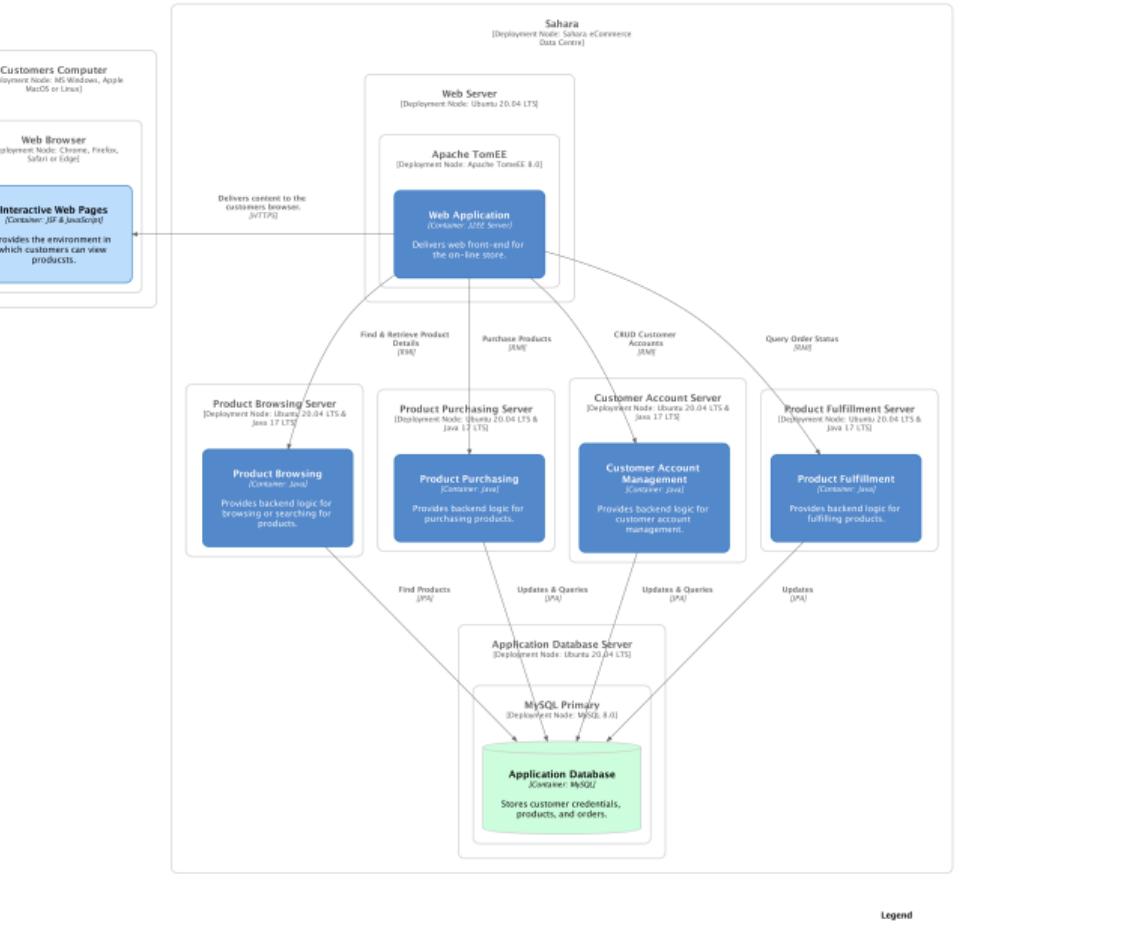
Fallacy #3

Bandwidth is infinite

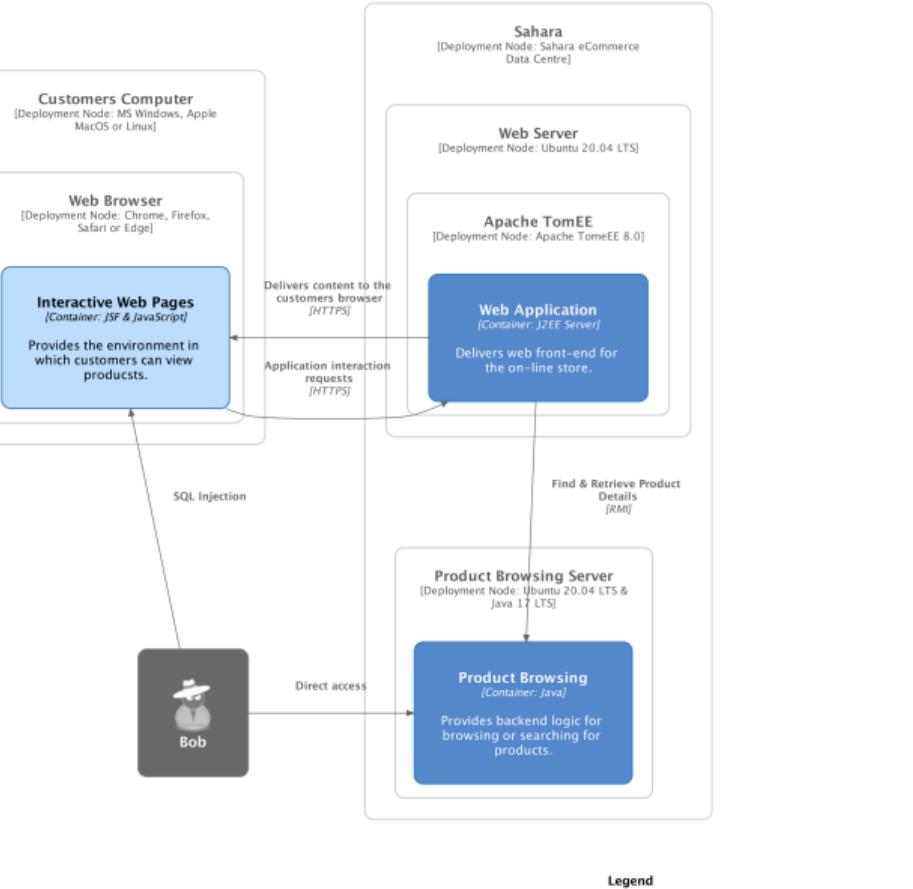
Similar to previous fallacy, be mindful, distributed calls clog up network.

Fallacy #4

The network is secure



Authentication only occurs when entering Sahara data centre



Bad actor gets access via one insecure node, network is compromised. Practice defence in depth.

Fallacy #5

The topology never changes

Topology changes all the time, cloud has just made this easier.
Don't rely on static IPs. Don't assume consistent latency.

Fallacy #6

There is only one administrator

Scenario

- Deployments are banned on the weekend.

Scenario

- Deployments are banned on the weekend.
- Sunday night users start complaining.

Scenario

- Deployments are banned on the weekend.
- Sunday night users start complaining.
- There have been no deployments since Friday.

Scenario

- Deployments are banned on the weekend.
- Sunday night users start complaining.
- There have been no deployments since Friday.
- You can still access the system.

Scenario

- Deployments are banned on the weekend.
- Sunday night users start complaining.
- There have been no deployments since Friday.
- You can still access the system.
- Who do you talk to?
Things spontaneously break. Who can help you?

Fallacy #7

Transport cost is zero

Remember

Distributed systems are *hard*.

Remember

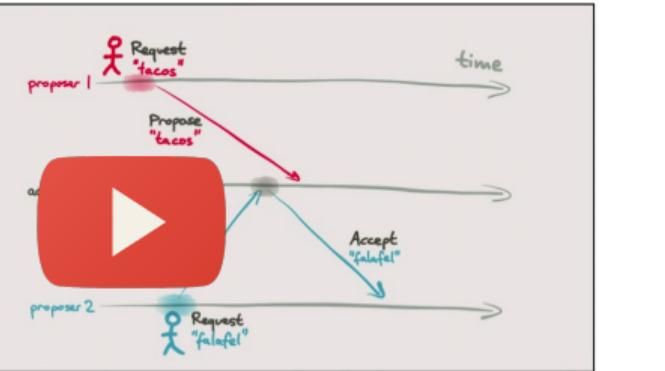
Distributed systems are often *not your friend*.

Can often introduce more problems than they solve

When you need to, prove it



Sept 13-14, 2019
thestrangeloop.com



Programming Research Group at Oxford in 1982

Previously in CSSE6400...

Simplicity For a distributed system



Reliability Independent services



Scalability Coarse-grained services



Previously in CSSE6400...

Reliability Independent services



Question

What makes software *reliable*?

Perhaps software that always works?

'Working' software

Satisfies the functional requirements

Definition 2. Reliable Software

Continues to work, even when things go wrong.

Definition 3. Fault

Something goes wrong.

Death, taxes, and computer system failure are all inevitable to some degree.

Plan for the event.

- Howard and LeBlanc

Reliable software is

Fault *tolerant*

John von Neumann built fault tolerant hardware in the 50s.

Problem

Individual computers fail *all the time*

10-50 years hard-drive lifetime. 10,000 disks will fail daily.

Solution

Spread the risk of faults over *multiple computers*

Spreading Risk

If you have software that works with *just one* computer, spreading the software over *two* computers *halves* the risk that your software will fail.

Spreading Risk

If you have software that works with *just one* computer, spreading the software over *two* computers *halves* the risk that your software will fail.

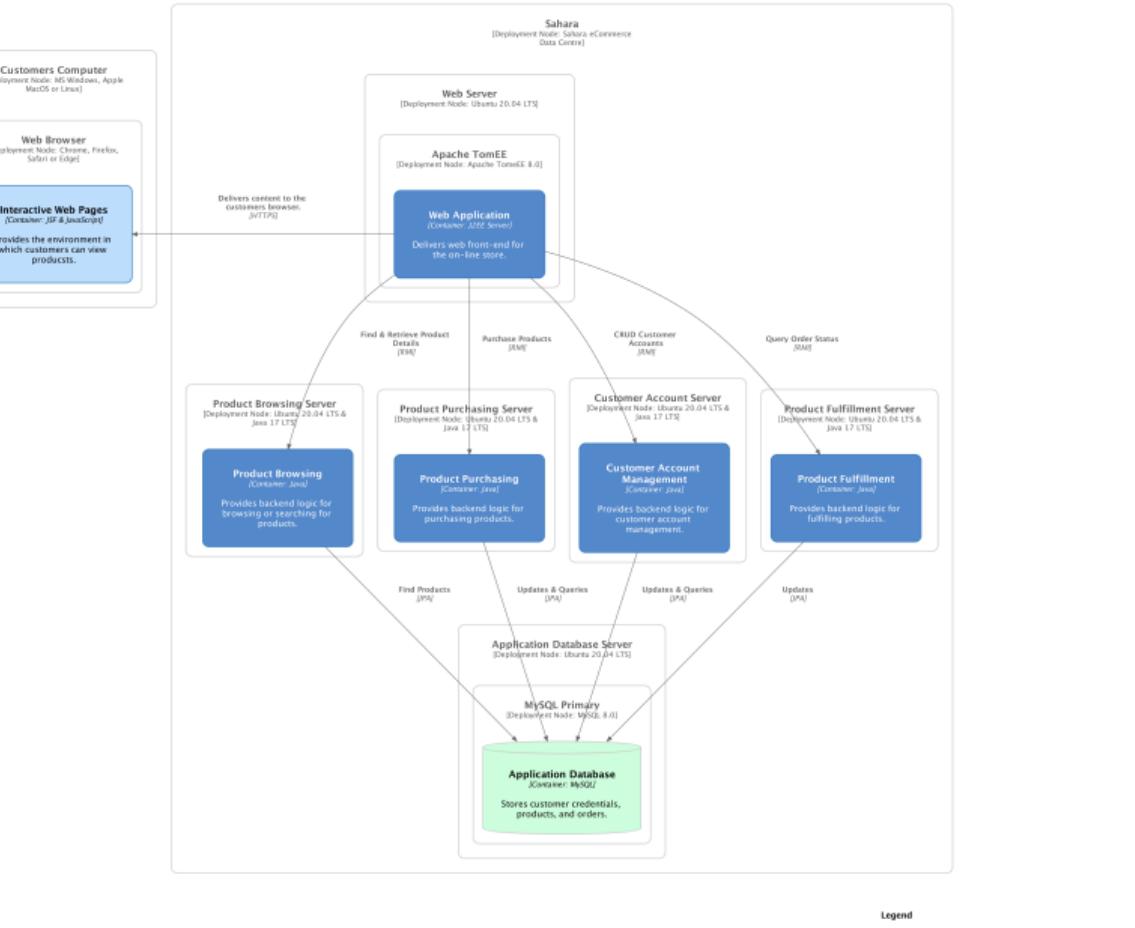
Adding *100* computers reduces the cuts the risk by *100*.

Spreading Risk

If you have software that works with *just one* computer, spreading the software over *two* computers *halves* the risk that your software will fail.

Adding *100* computers reduces the cuts the risk by *100*.

Of course, there are other reasons you might want run software on multiple computers.



- Why is this software somewhat reliable?
- Any individual service can go down and the rest still work.
- Can we do better?
- Can a service go down but have that service still work?

Previously in CSSE6400...

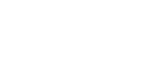
Simplicity For a distributed system



Reliability Independent services



Scalability Coarse-grained services



Previously in CSSE6400...

Scalability Coarse-grained services



Question

Who has used *auto-scaling*?

Auto-scaling Terminology

Auto-scaling group A *collection of instances* managed by auto-scaling.

Auto-scaling Terminology

Auto-scaling group A *collection of instances* managed by auto-scaling.

Capacity Amount of instances *currently* in an auto-scaling group.

Auto-scaling Terminology

Auto-scaling group A *collection of instances* managed by auto-scaling.

Capacity Amount of instances *currently* in an auto-scaling group.

Desired Capacity Amount of instances *we want to have* in an auto-scaling group.

Auto-scaling Terminology

Auto-scaling group A *collection of instances* managed by auto-scaling.

Capacity Amount of instances *currently* in an auto-scaling group.

Desired Capacity Amount of instances *we want to have* in an auto-scaling group.

Scaling Policy How to determine the desired capacity.

Auto-scaling Terminology

Auto-scaling group A *collection of instances* managed by auto-scaling.

Capacity Amount of instances *currently* in an auto-scaling group.

Desired Capacity Amount of instances *we want to have* in an auto-scaling group.

Scaling Policy How to determine the desired capacity.

Minimum/Maximum Capacity *Hard limits* on the minimal and maximum amount of instances.

What we really want

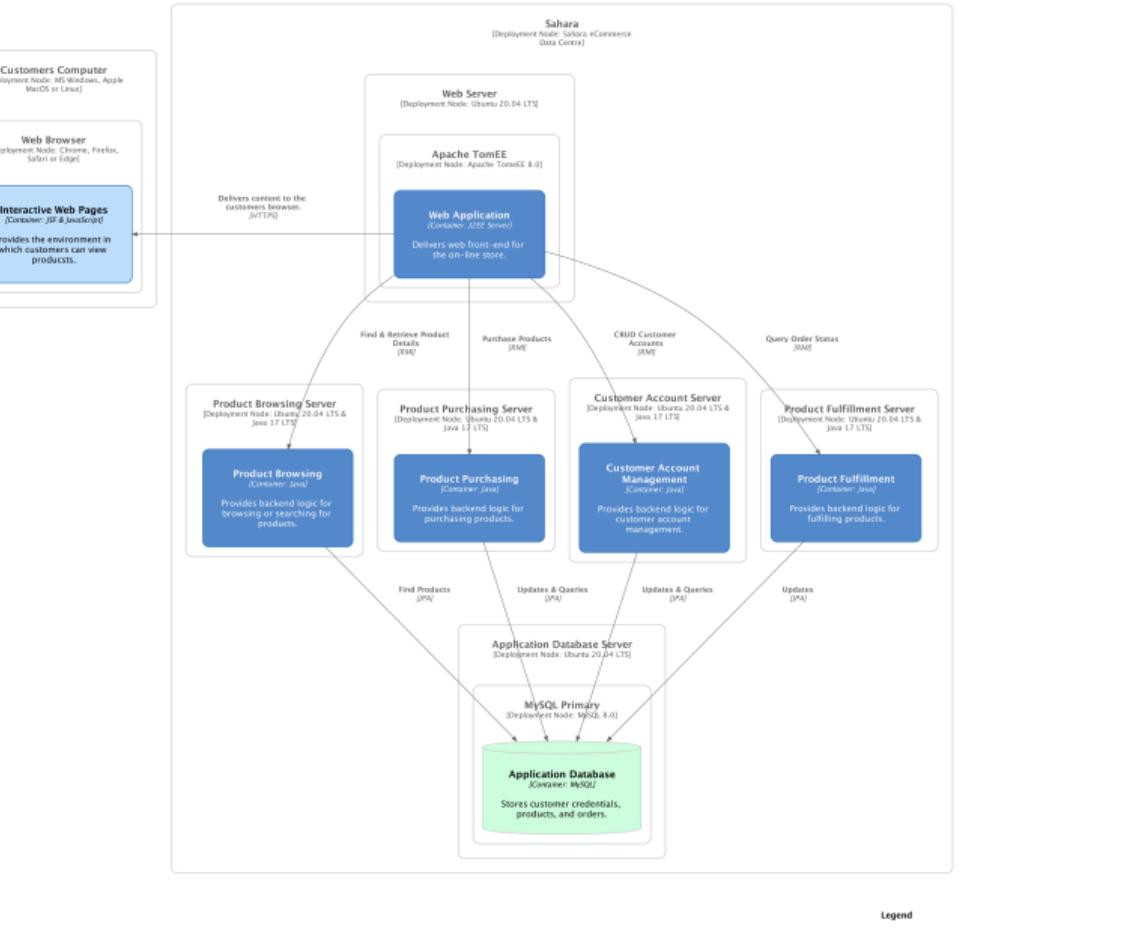
Desired Capacity Amount of *healthy* instances we want to have in an auto-scaling group.

Health check

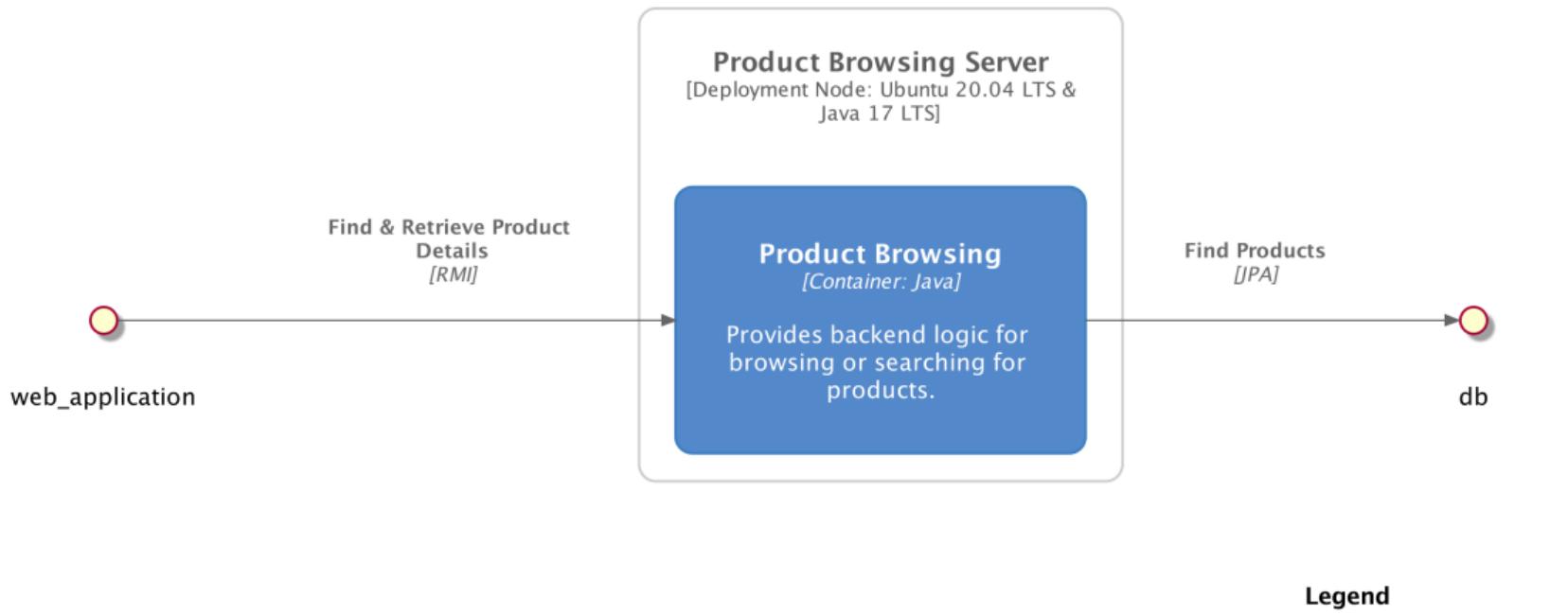
User defined method to determine whether an instance is *healthy*.

Auto-scaling

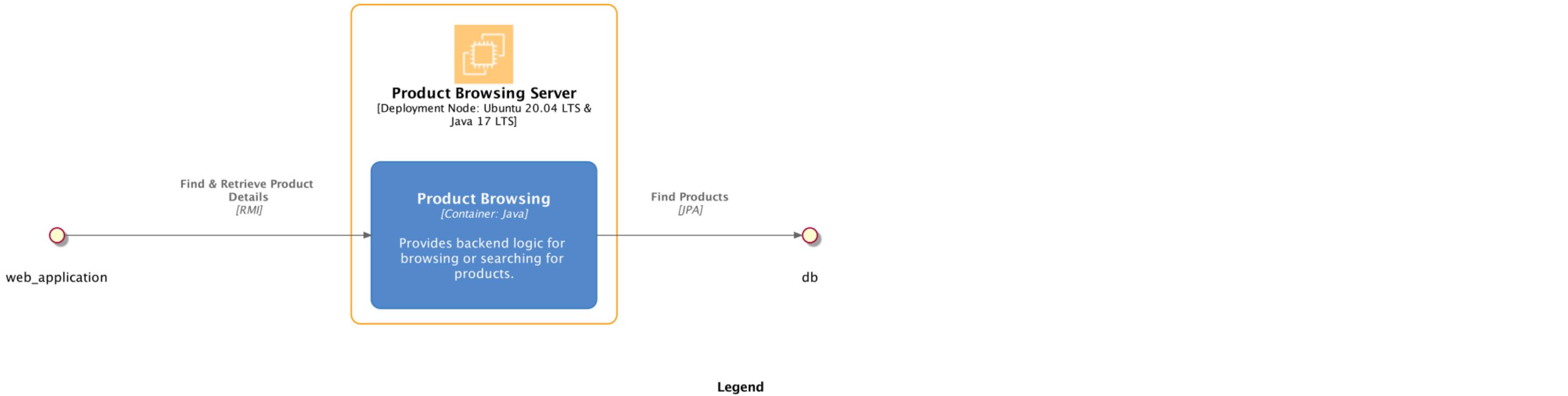
An example

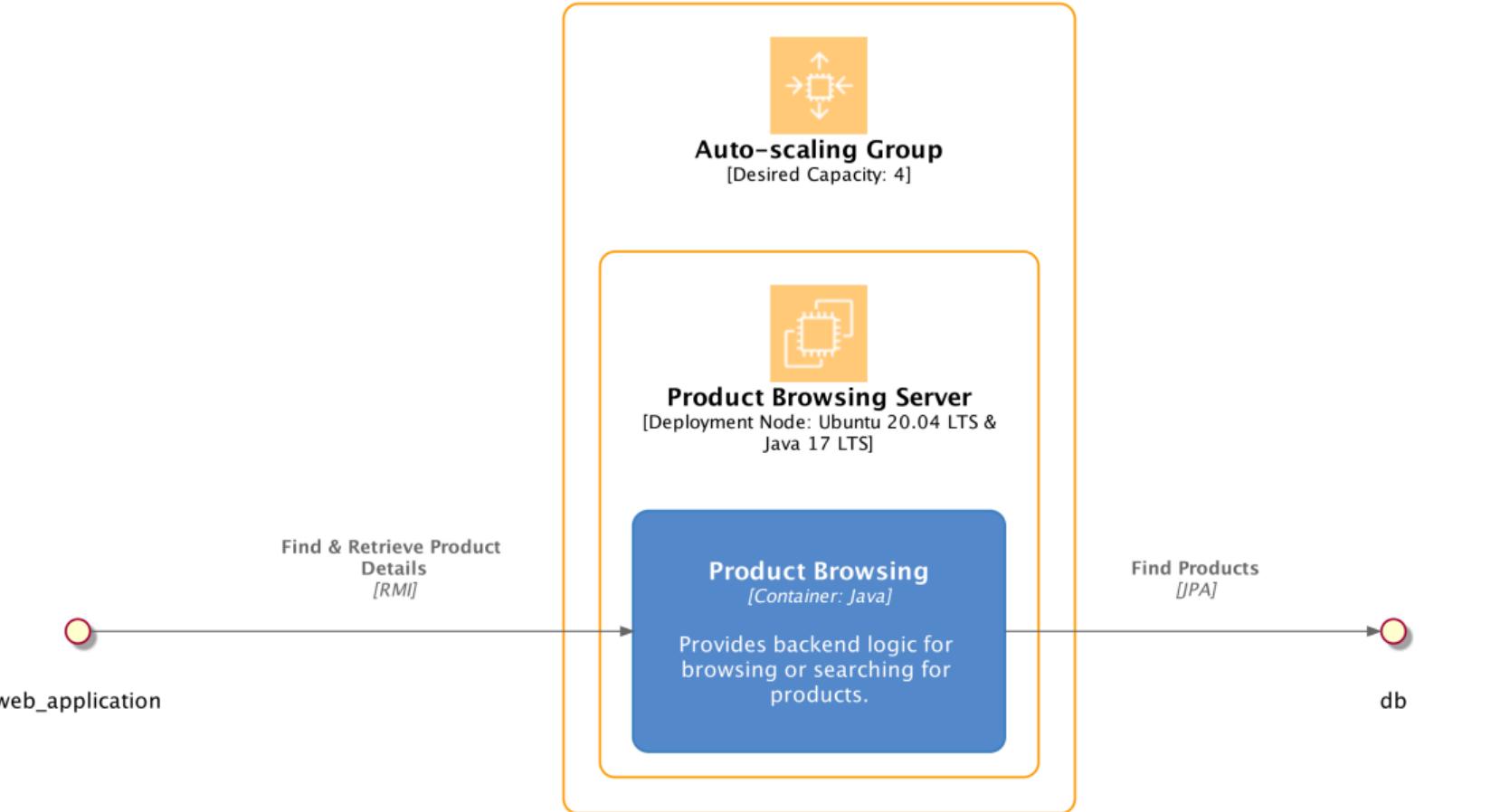


Product service keeps going down

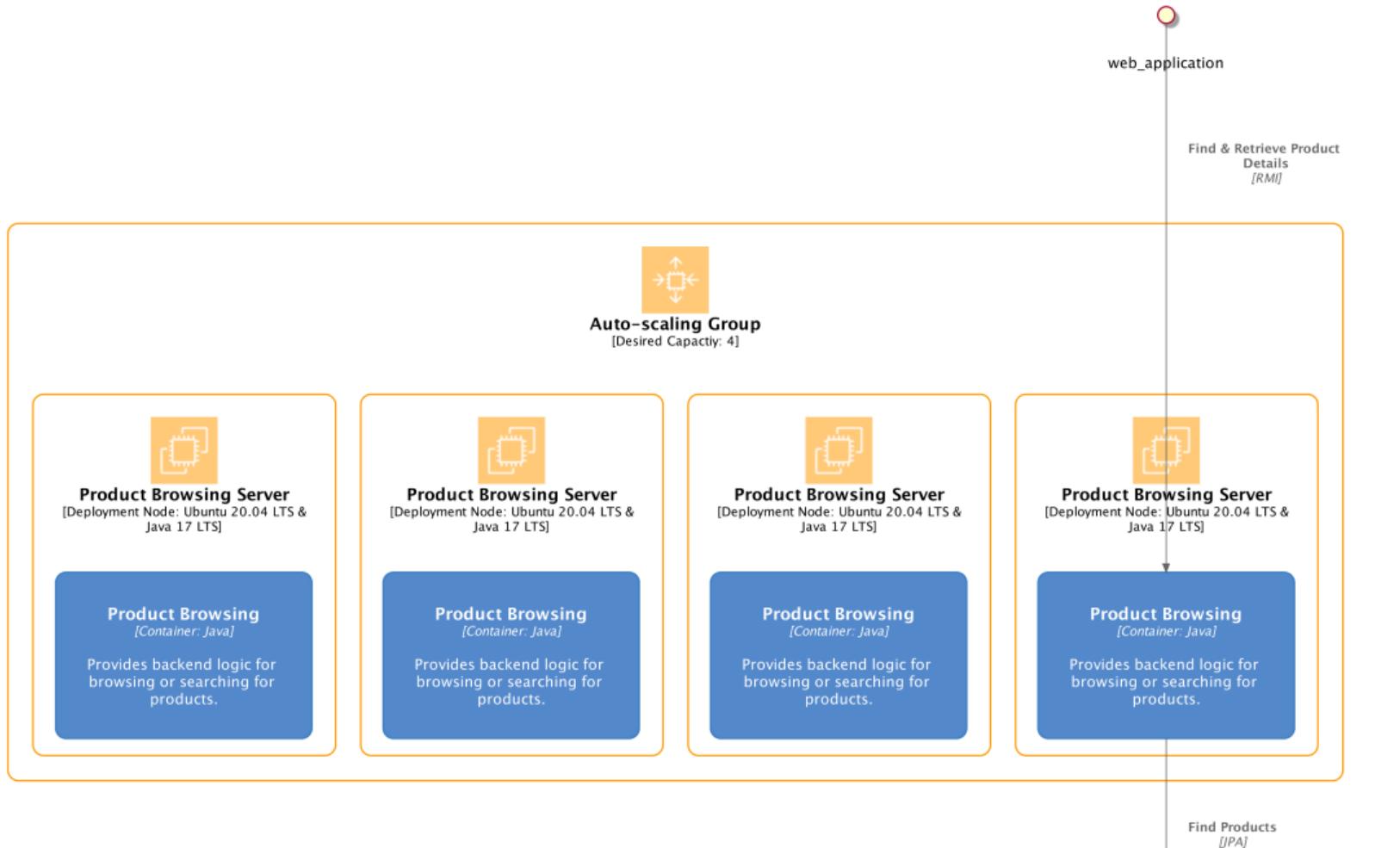


We might expect product service to have a much higher load than other services

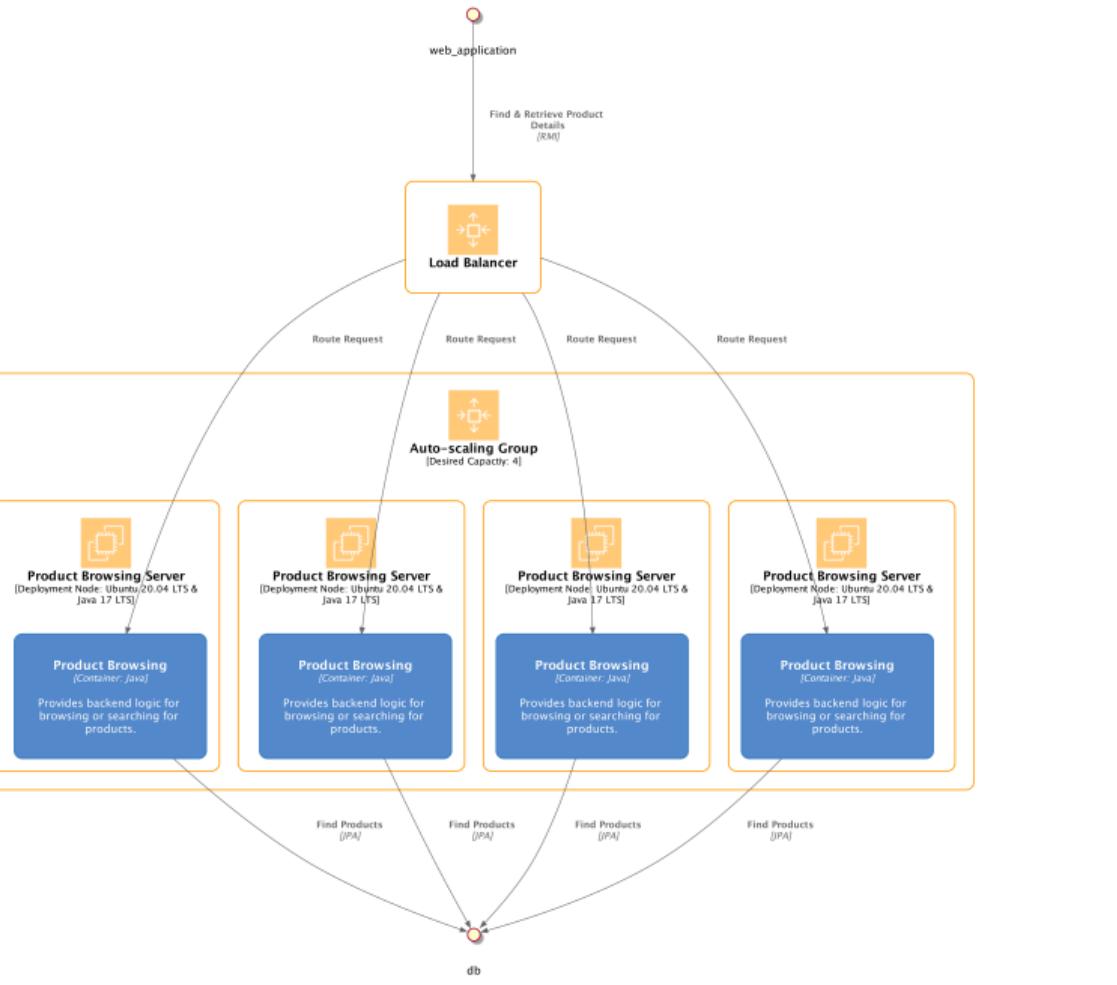




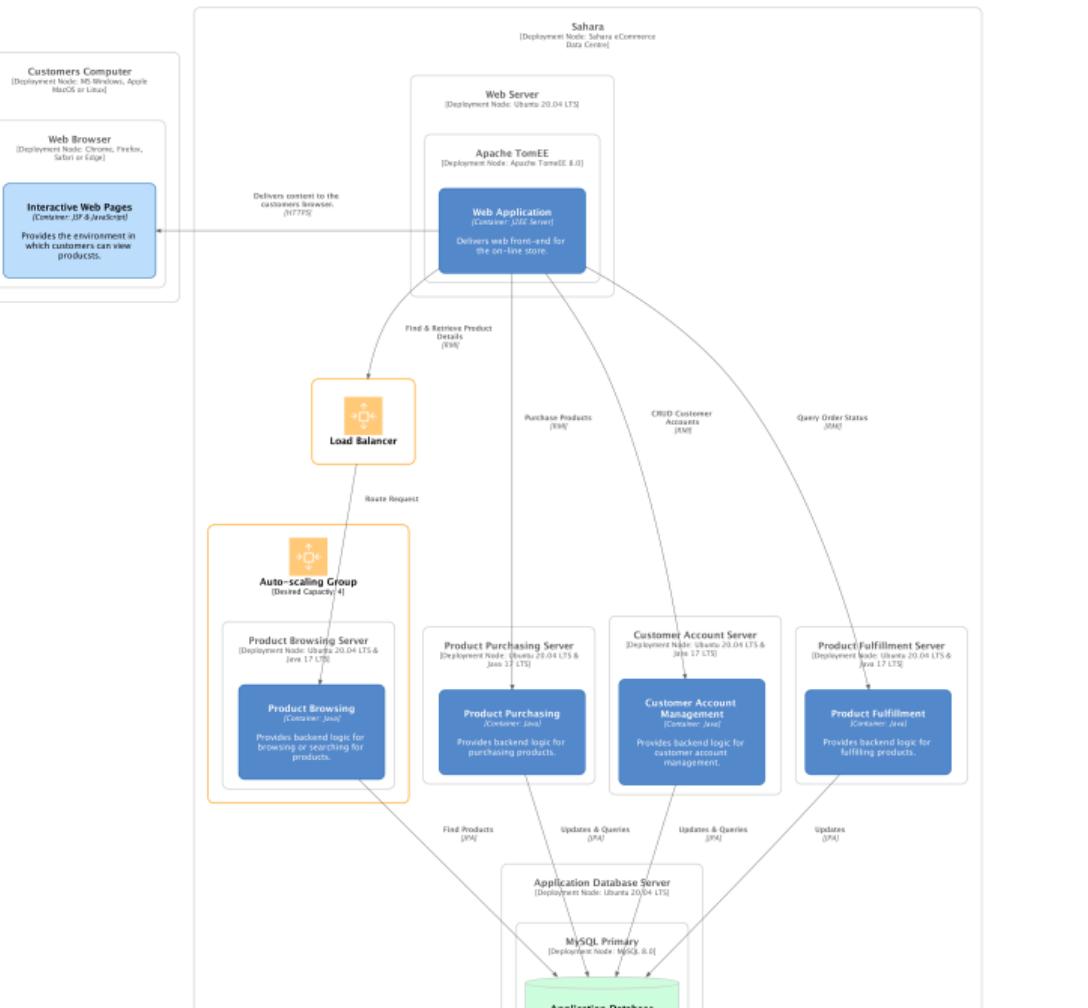
Use an auto-scaling group to replicate the service



What's the problem?



Traffic was all sent through the one instance, load balancer routes to all



In Summary

Simplicity

Reliability

Scalability

In Summary

Simplicity *Minimal network communication* (compared to other distributed systems), less impacted by fallacies.

Reliability

Scalability

In Summary

Simplicity *Minimal network communication* (compared to other distributed systems), less impacted by fallacies.

Reliability Traffic is spread to various services, still *partially operational* if one goes down. Auto-scaling allows for *basic replication*.

Scalability

In Summary

Simplicity *Minimal network communication* (compared to other distributed systems), less impacted by fallacies.

Reliability Traffic is spread to various services, still *partially operational* if one goes down. Auto-scaling allows for *basic replication*.

Scalability Auto-scaling and load balancing allows *individual services to scale*. However, the *database is a bottle-neck*.

database is a bottle-neck is foreshadowing