Distributed Systems I

Software Architecture

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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

Going forward

Investigating architectures that are *distributed*.

Distributed Systems Series

Distributed I *Reliability* and *scalability* of *stateless* systems.

Distributed II *Complexities* of *stateful* systems.

Distributed III *Hard problems* in distributed systems.

What are the benefits?

- Improved *reliability*
- Improved *scalability*
- Improved *latency*

Some systems are inherently distributed.

What are the drawbacks?

- Increased *complexity*
- Increased *attack vector*
- Increased *latency*
- Introduce *consistency* problems

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

§ *Fallacies*

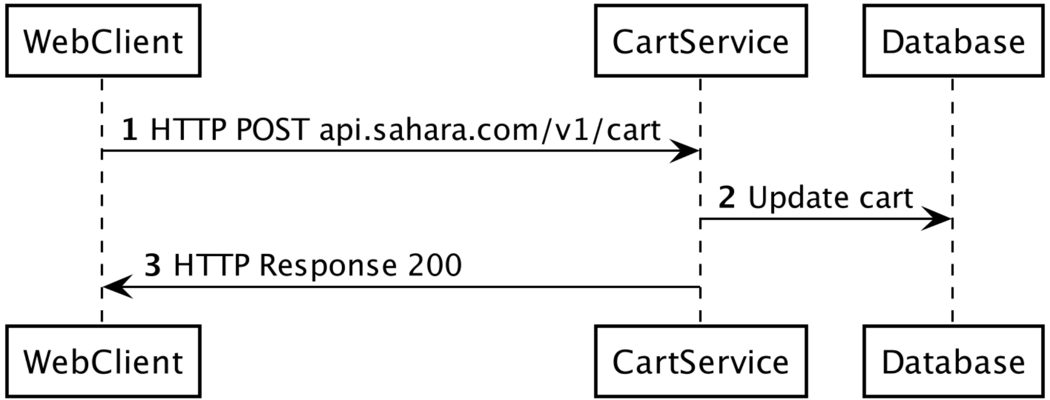
A few reasons for complexity

The Fallacies of *Distributed Computing*.

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

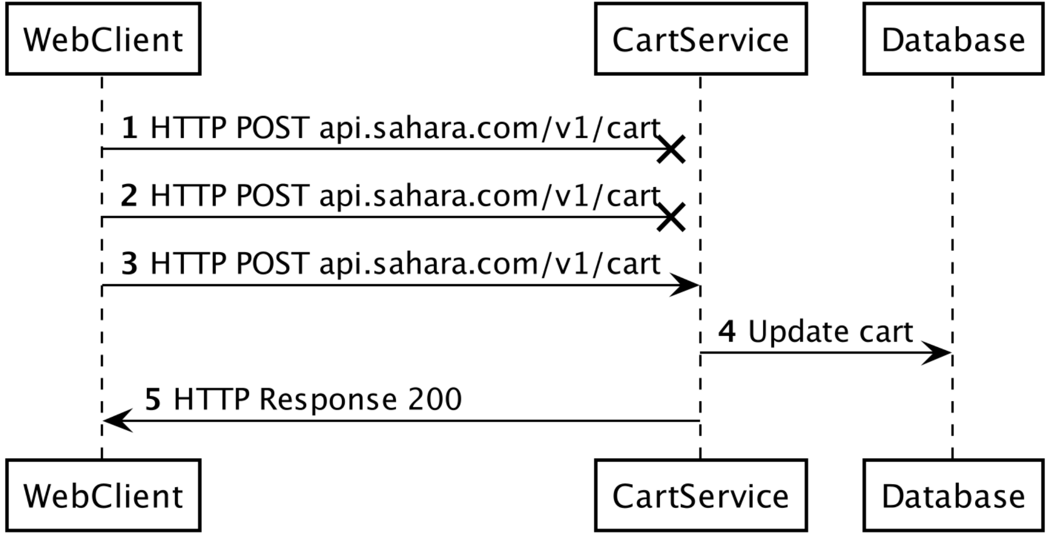
Fallacy #1

The network is reliable.

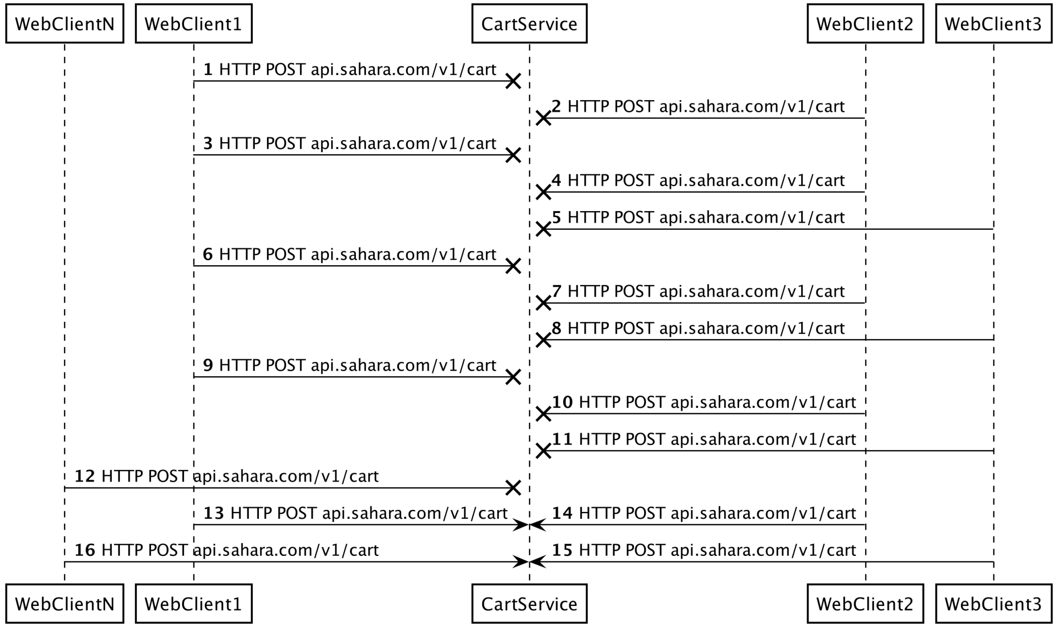


Success: Send request to add item to cart.

Failure 1: Request not received by server (CartService).



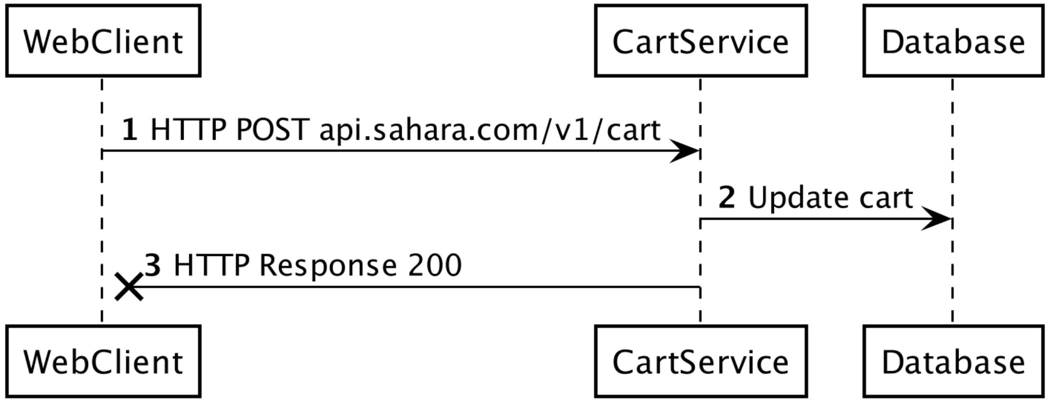
Failure 1: *Solution* resend request?



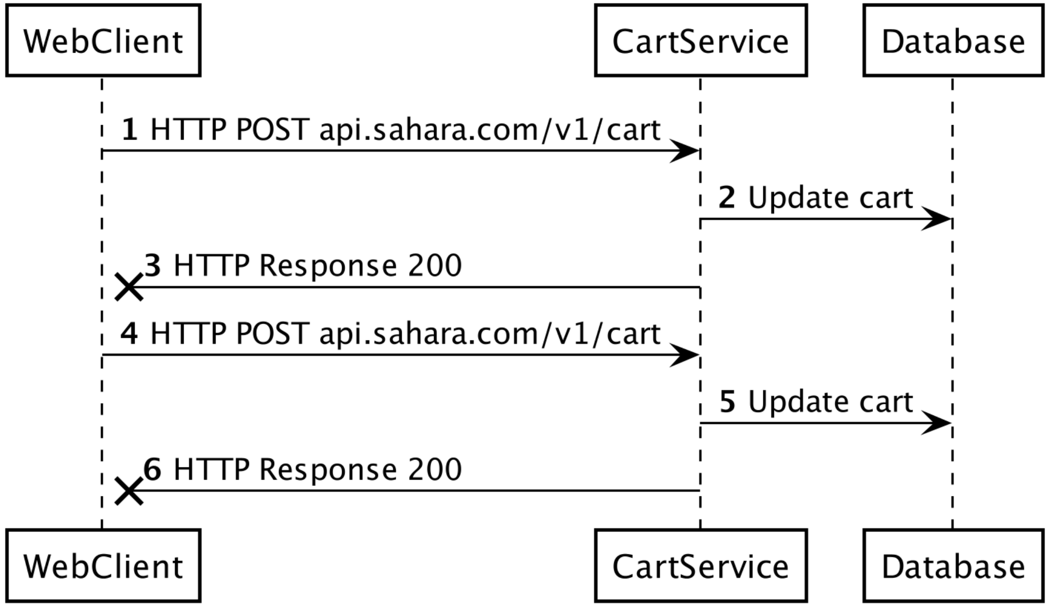
If the service goes down and all clients are re-trying, the service is in for a shock when it comes back, we solve this with *exponential backoff*.

Exponential Backoff

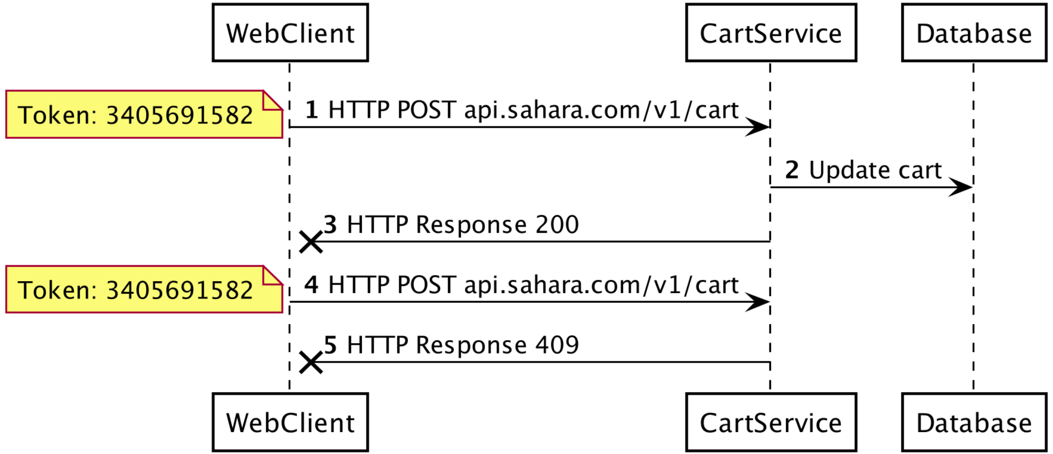
```
retries = 0
do:
    status = service.request()

    if status != SUCCESS:
        retries += 1
        wait(2 ** retries)
while (status != SUCCESS and retries < MAX_RETRIES)
```



Failure 2: Response not received.



- Failure 1's *solution* of resending request leads to:
- Duplicate actions, problem for ordering/payments.



Solution: Use tokens to prevent duplicates.

Fallacy #2

Latency is zero.

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.

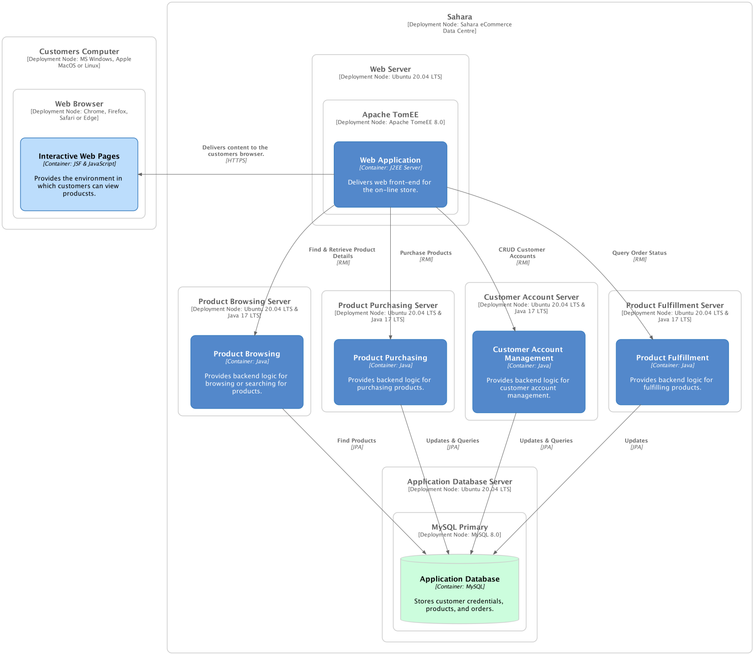
Similar to previous fallacy, be mindful, distributed calls clog up network.

Definition 1. Stamp Coupling

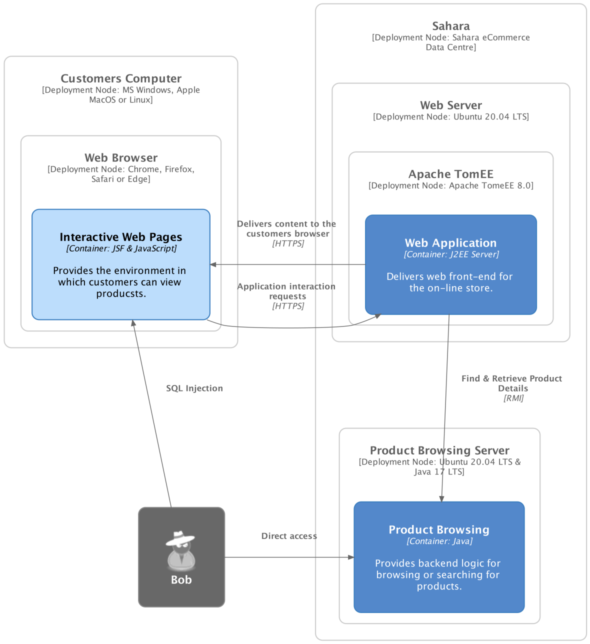
Components which share a composite data structure.

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 just makes this easier.
- Don't rely on static IPs.
- Don't assume consistent latency.

Fallacy #6

There is only one administrator.

- Things spontaneously break.
- Who can help you?

Fallacy #7

Transport cost is zero.

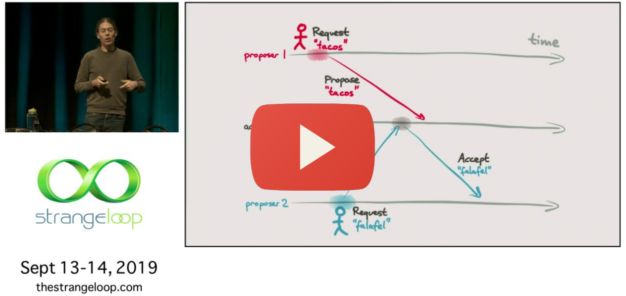
Remember

Distributed systems are *hard*.

The choice to use them should be *well considered*.

Can often introduce more problems than they solve.

When you need to, maybe prove it?



- Presentation: Proving correctness of distributed systems.
- by Dr. Martin Kleppmann, University of Cambridge.
- Using Isabelle – See CSS research sub-group.

`https://youtube.com/watch?v=7w4KC6i9Yac`

Or, more realistically,

Use existing algorithms and software.

Distributed Systems Series

Distributed I *Reliability* and *scalability* of *stateless* systems.

Distributed II Complexities of stateful systems.

Distributed III Hard problems in distributed systems.

Stateless Does *not* utilise *persistent data*.

Stateful Does utilise *persistent data*.

Question

What makes software *reliable*?

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 1950s.

Problem

Individual computers fail *all the time*.

10-50 years hard-drive lifetime. 10,000 disks will fail daily. Google last had 2.5 million servers.

Solution

Spread the risk of faults over *multiple computers* or *nodes*.

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.

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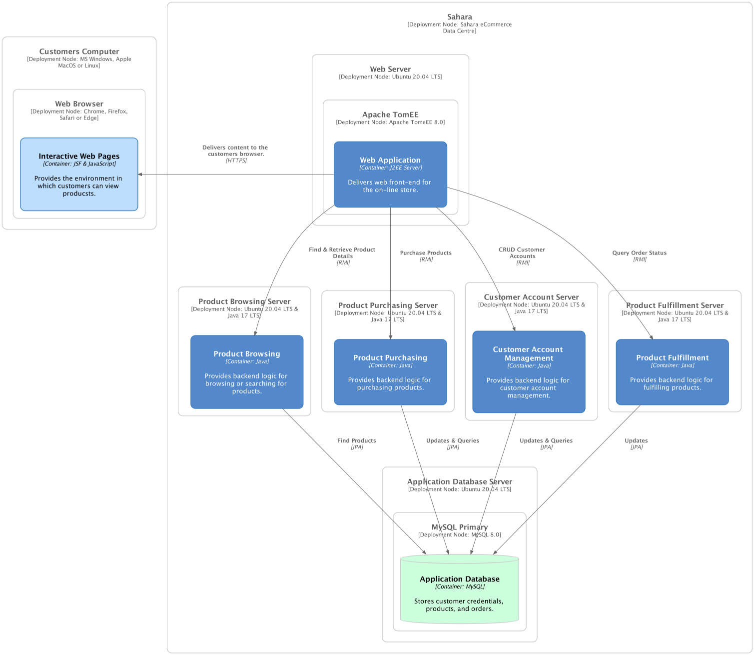
Adding *100* computers reduces the risk by *100*.



- 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?

Question

Who has used *auto-scaling*?

Auto-scaling terminology

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

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Scaling Policy How to determine the desired capacity.

Minimum/Maximum Capacity *Hard limits* on the minimum and maximum number of instances.

What we really want

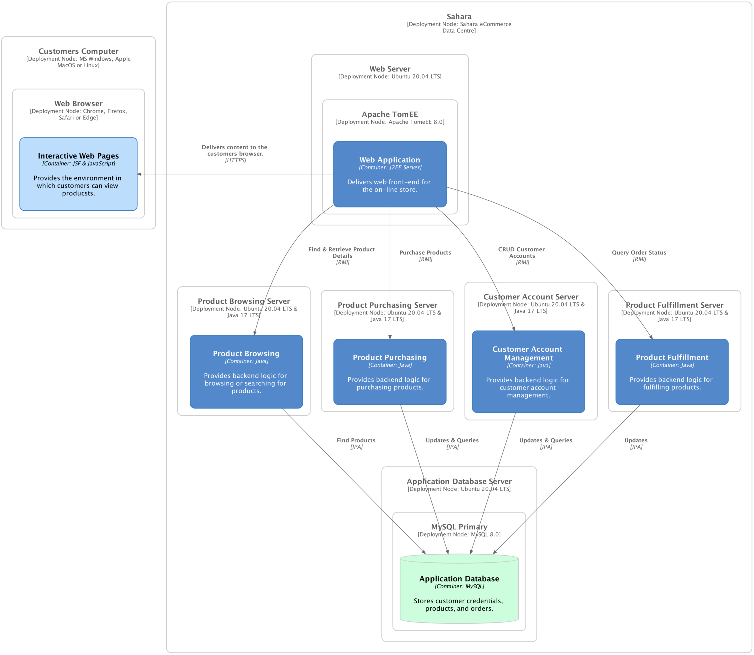
Desired Capacity Amount of *healthy* instances we want to have in an auto-scaling group.

Health check

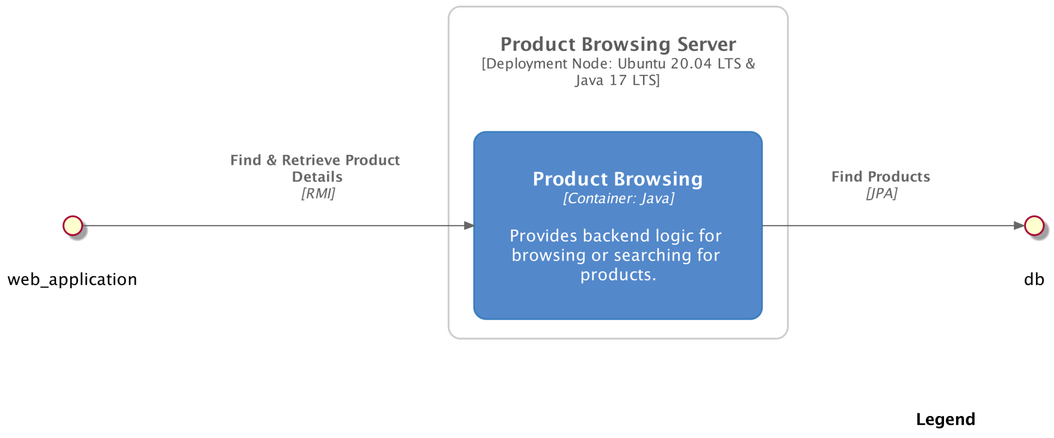
Mechanism to determine whether an instance is *healthy*.

Auto-scaling

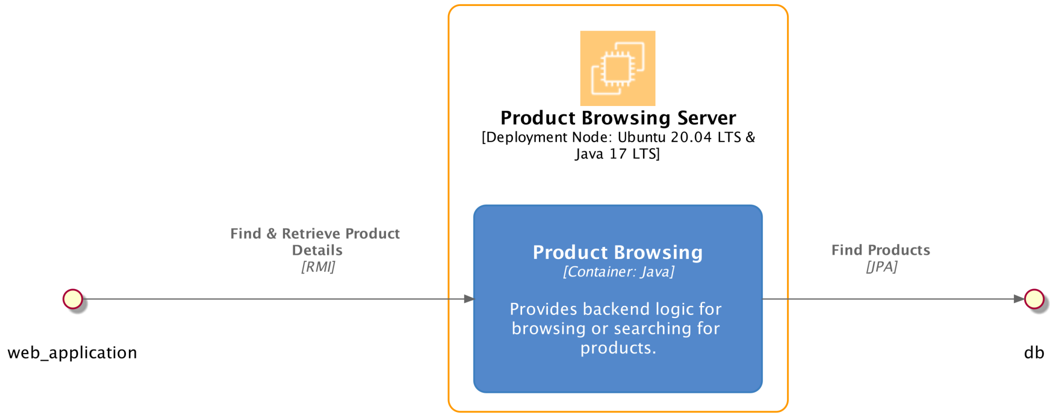
An example



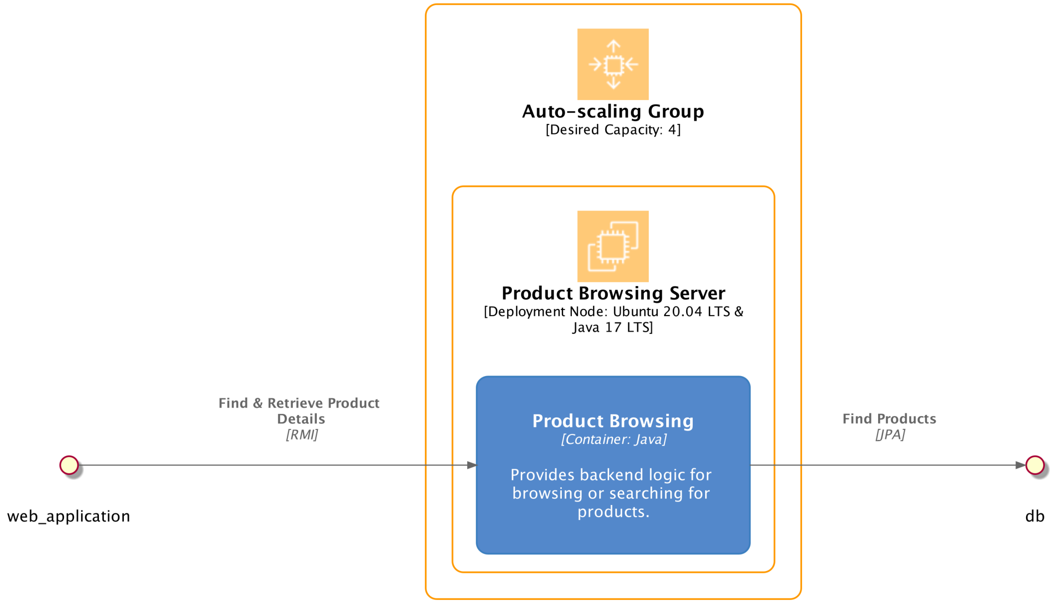
Product Browsing service keeps going down



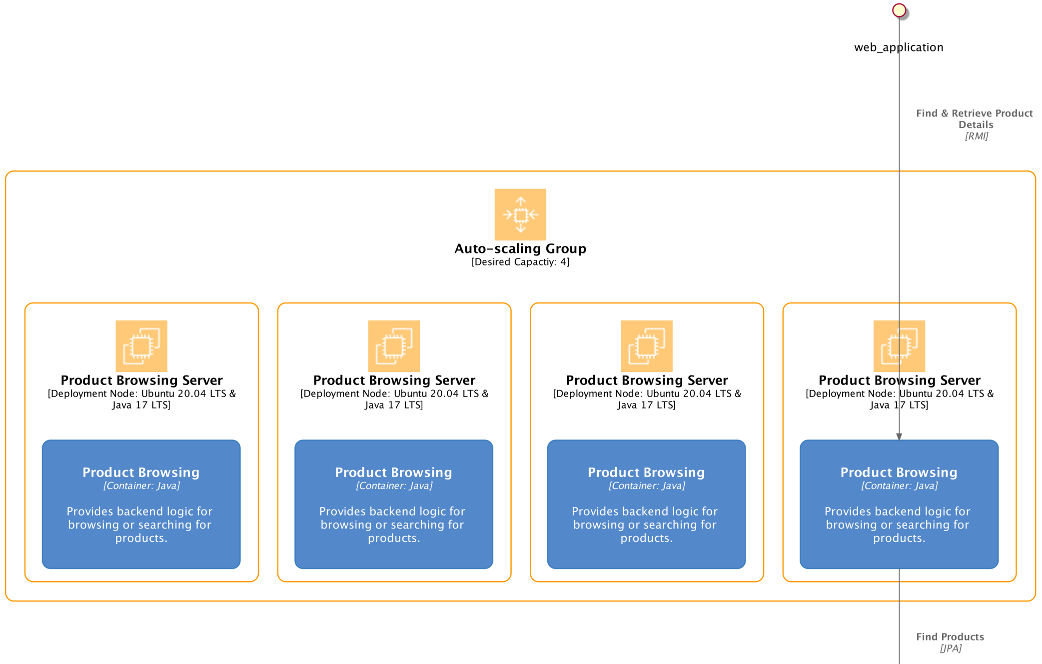
We might expect product browsing to have a much higher load than other services


Product Browsing Server
[Deployment Node: Ubuntu 20.04 LTS & Java 17 LTS]
Product Browsing
[Container: Java]
Provides backend logic for browsing or searching for products.
Find & Retrieve Product Details
[RMI]
Find Products
[JPA]
web_application
db

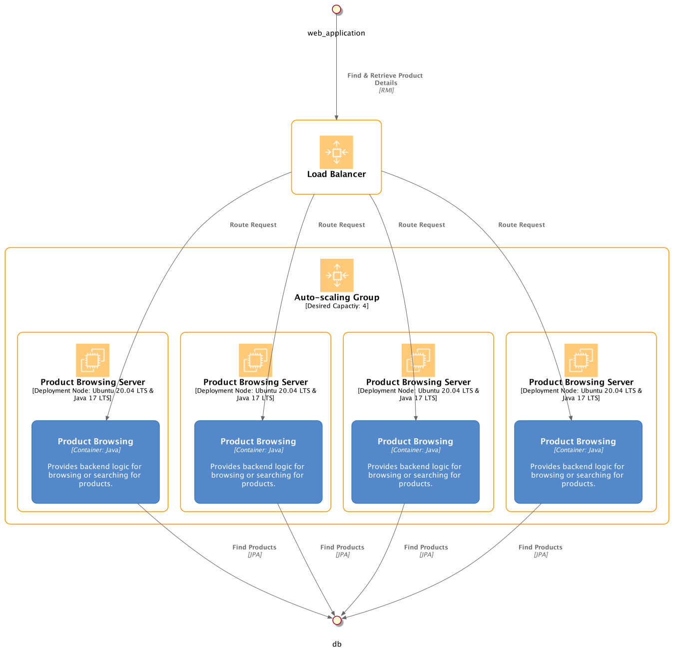
Legend



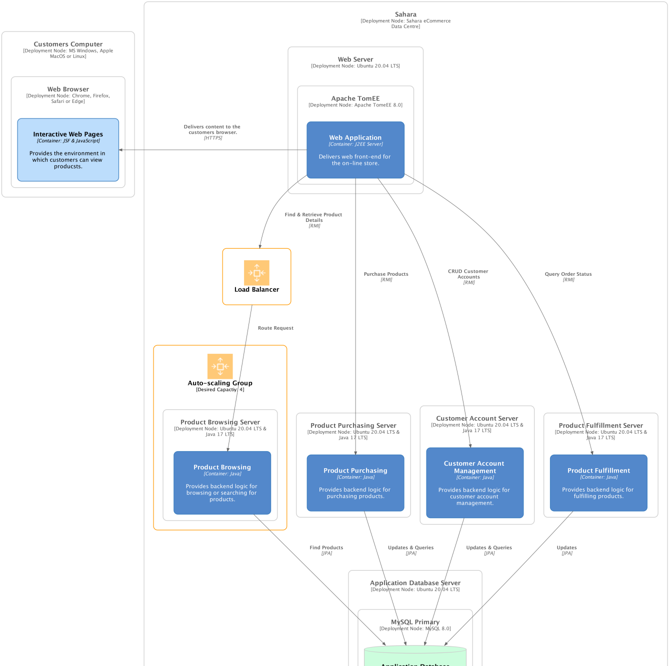
Use an auto-scaling group to replicate the service



What’s the problem?



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


Sahara
[Deployment Node: Sahara eCommerce Data Centre]
Customers Computer
[Deployment Node: MS Windows, Apple MacOS or Linux]
Web Browser
[Deployment Node: Chrome, Firefox, Safari or Edge]
Interactive Web Pages
[Container: JSF & JavaScript]
Provides the environment in which customers can view producsts.
Delivers content to the customers browser.
[HTTPS]
Web Server
[Deployment Node: Ubuntu 20.04 LTS]
Apache TomEE
[Deployment Node: Apache TomEE 8.0]
Web Application
[Container: J2EE Server]
Delivers web front-end for the on-line store.
Find & Retrieve Product Details
[RMI]
Load Balancer
Purchase Products
[RMI]
CRUD Customer Accounts
[RMI]
Query Order Status
[RMI]
Route Request
Auto-scaling Group
[Desired Capactiy: 4]
Product Browsing Server
[Deployment Node: Ubuntu 20.04 LTS & Java 17 LTS]
Product Browsing
[Container: Java]
Provides backend logic for browsing or searching for products.
Product Purchasing Server
[Deployment Node: Ubuntu 20.04 LTS & Java 17 LTS]
Product Purchasing
[Container: Java]
Provides backend logic for purchasing products.
Customer Account Server
[Deployment Node: Ubuntu 20.04 LTS & Java 17 LTS]
Customer Account Management
[Container: Java]
Provides backend logic for customer account management.
Product Fulfillment Server
[Deployment Node: Ubuntu 20.04 LTS & Java 17 LTS]
Product Fulfillment
[Container: Java]
Provides backend logic for fulfilling products.
Find Products
[JPA]
Updates & Queries
[JPA]
Updates & Queries
[JPA]
Updates
[JPA]
Application Database Server
[Deployment Node: Ubuntu 20.04 LTS]
MySQL Primary
[Deployment Node: MySQL 8.0]

In Summary

- Simplicity
- Reliability
- Scalability

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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