# Distributed Computing I

*Software Architecture*

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March 20, 2023

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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

*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

## § *Fallacies*

*Question*

What is a *fallacy*?

*Definition 1.* Fallacy

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

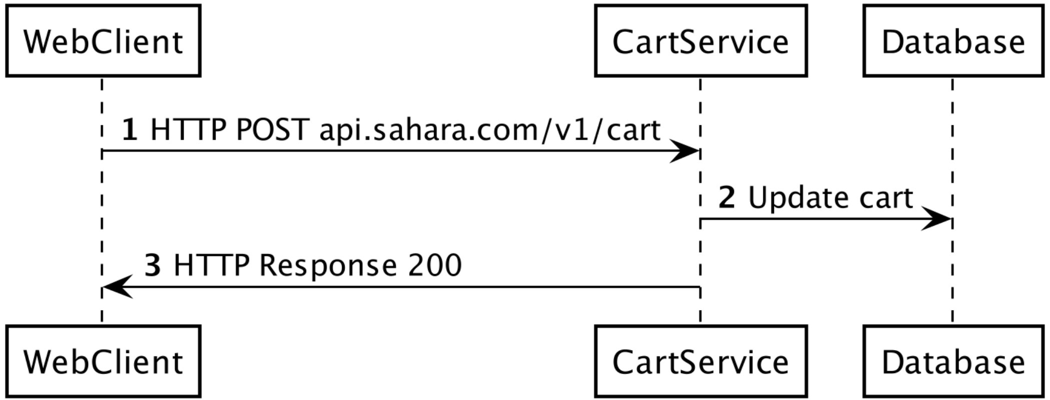
*A few reasons for complexity*

# The Fallacies of *Distributed Computing*

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

*Fallacy #1*

# The network is reliable


WebClient
CartService
Database
1 HTTP POST api.sahara.com/v1/cart
2 Update cart
3 HTTP Response 200
WebClient
CartService
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1 HTTP POST api.sahara.com/v1/cart
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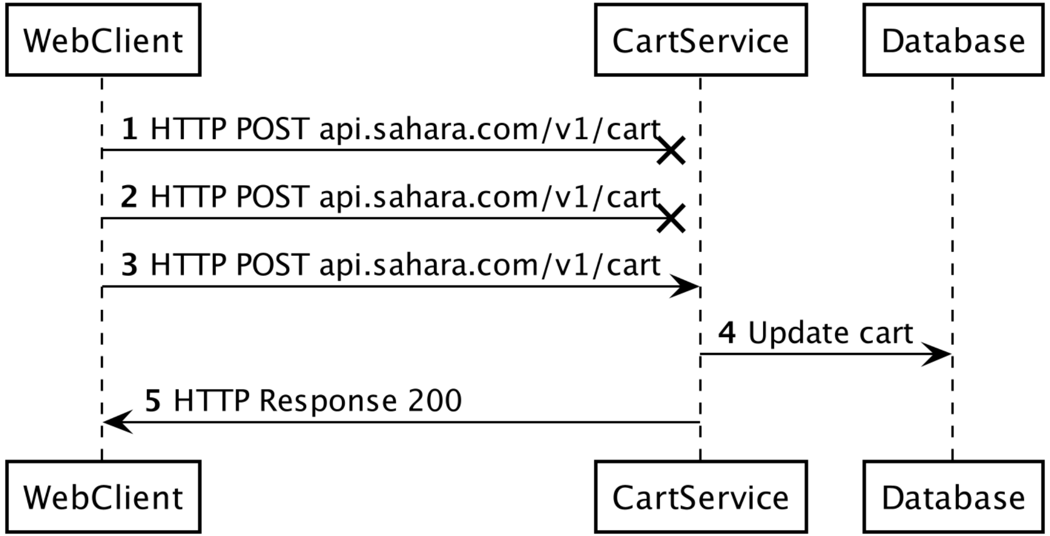
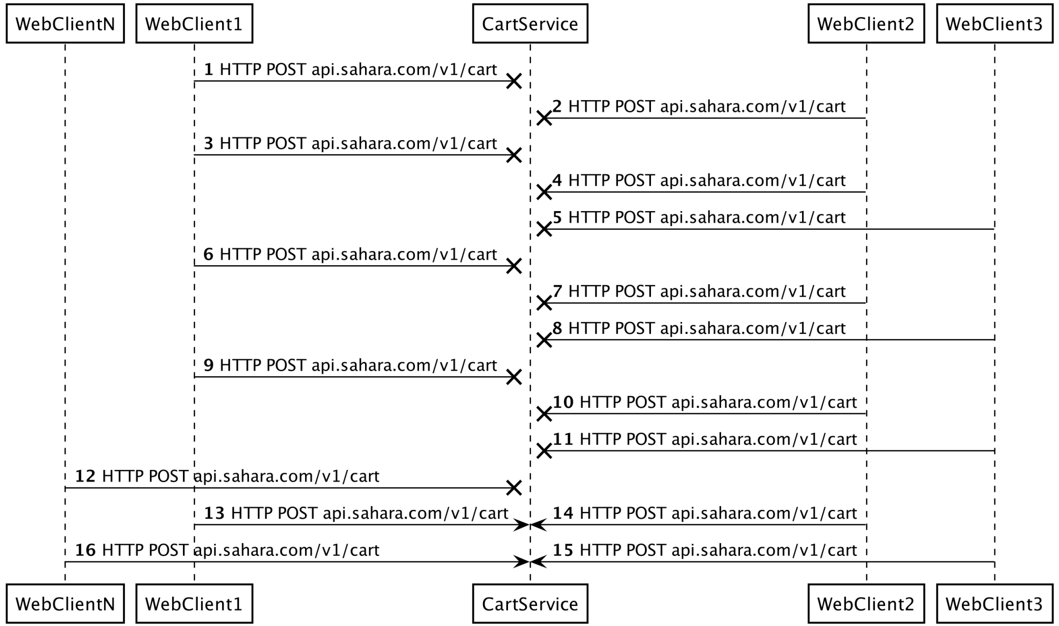



Solve it by resending it

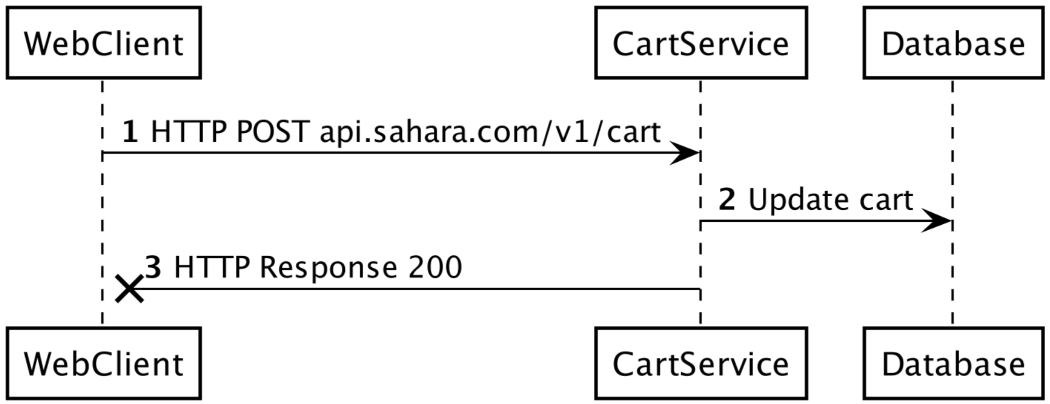



If the service goes down and all clients are re-trying, the service is in for a shock when it comes back, we solve this with *exponential backoff*

# Exponential backoff

```
retry = True
do:
    status = service.request()

    if status != SUCCESS:
        wait(2 ** retries)
    else:
        retry = False
while (retry and retries < MAX_RETIRES)
```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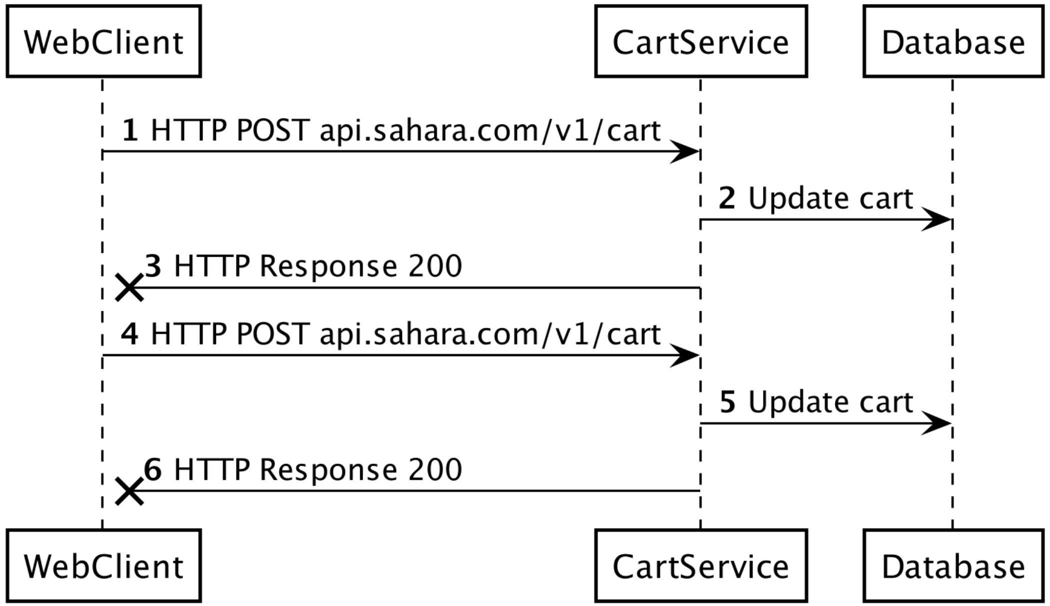
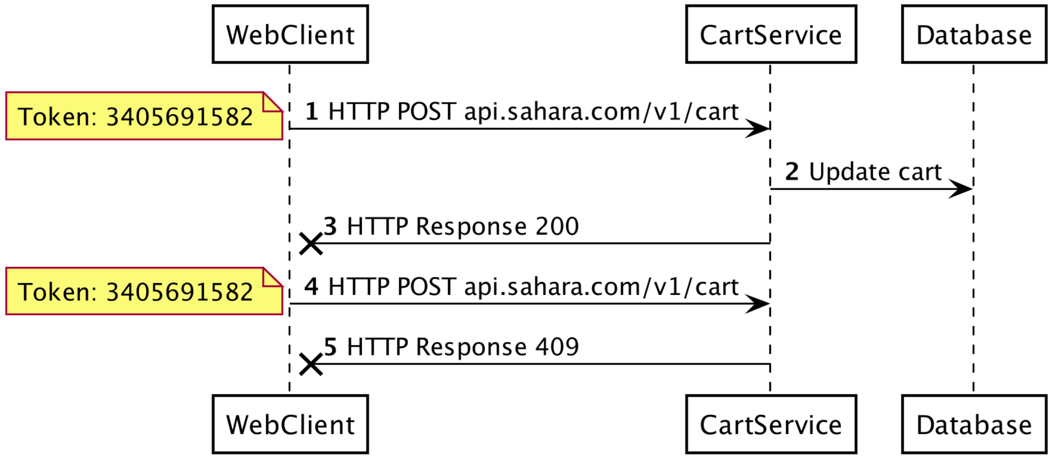



Causes duplicate actions, problem for ordering/payments




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 then local call.

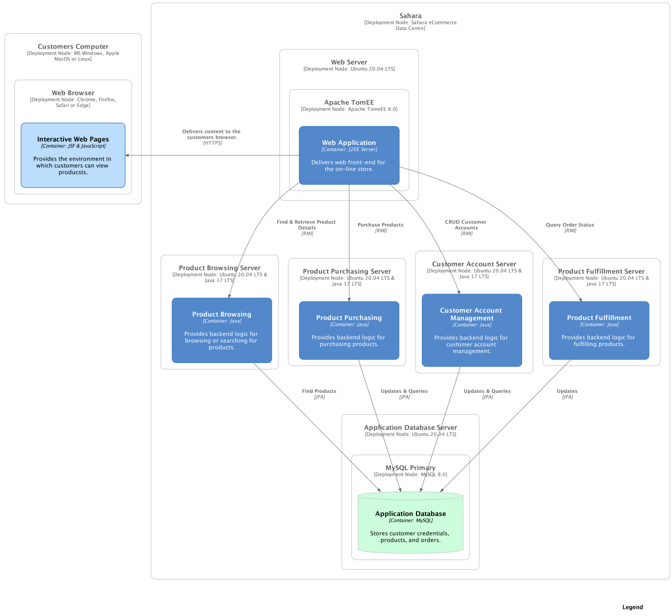
*Fallacy #3*

# Bandwidth is infinite

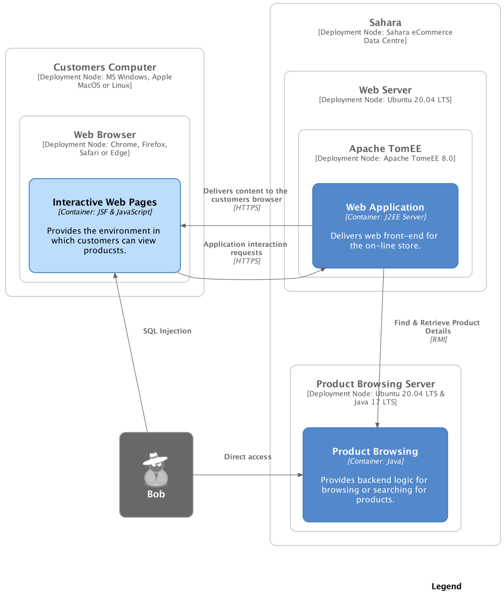
Similar to previous fallacy, be mindful, distributed calls clog up network.

*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.

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- Sunday night users start complaining.

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- 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 spontaniously break. Who can help you?

*Fallacy #7*

# Transport cost is zero

*Remember*

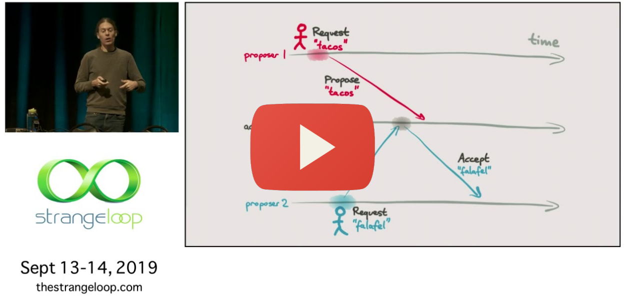
Distributed systems are *hard*.

*Remember*

Distributed systems are often *not your friend*.

Can often introduce more problems than they solve

## *When you need to, prove it*




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

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.

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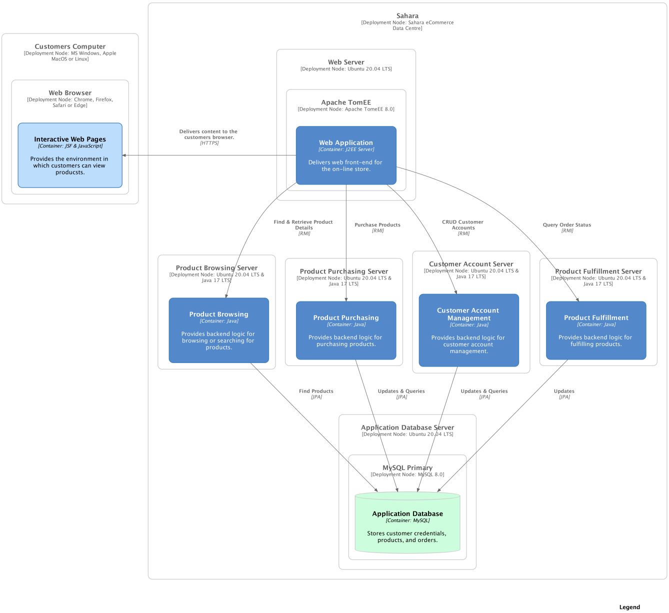
Adding *100* computers reduces the cuts the risk by *100*.

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

*Auto-scaling Terminology*

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**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.

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Scaling Policy How to determine the desired capacity.

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: 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*

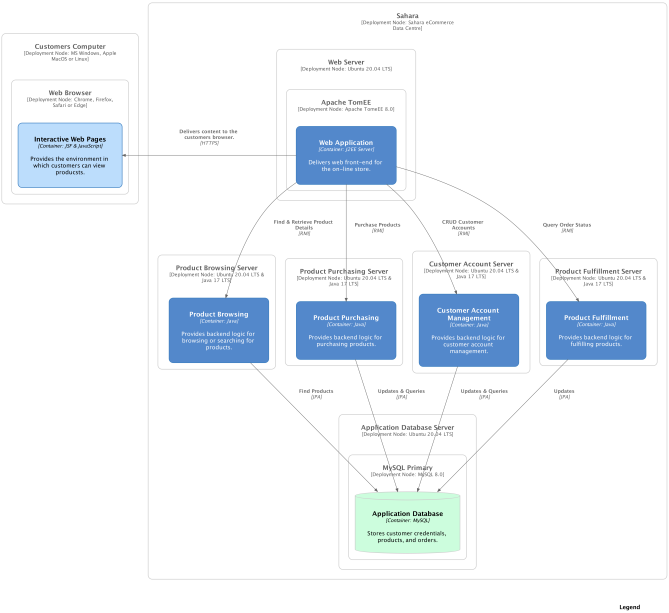
Desired Capacity Amount of *healthy* instances we want to have in an auto-scaling group.

*Health check*

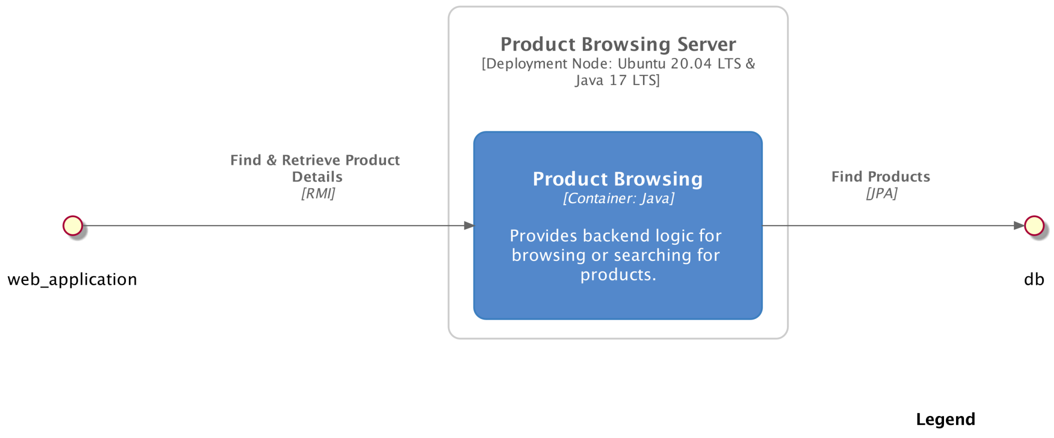
User defined method to determine whether an instance is *healthy*.

*Auto-scaling*

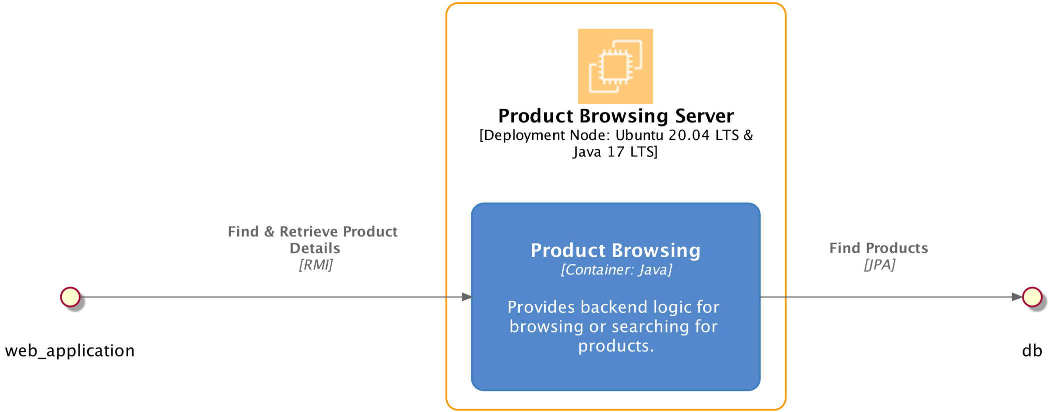
# An example



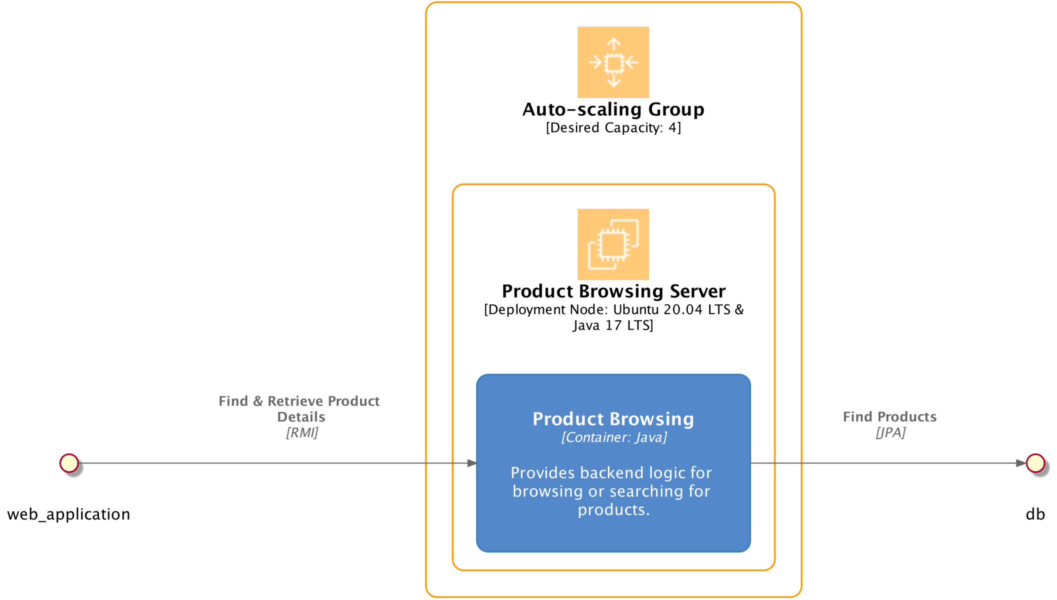

# Product service keeps going down



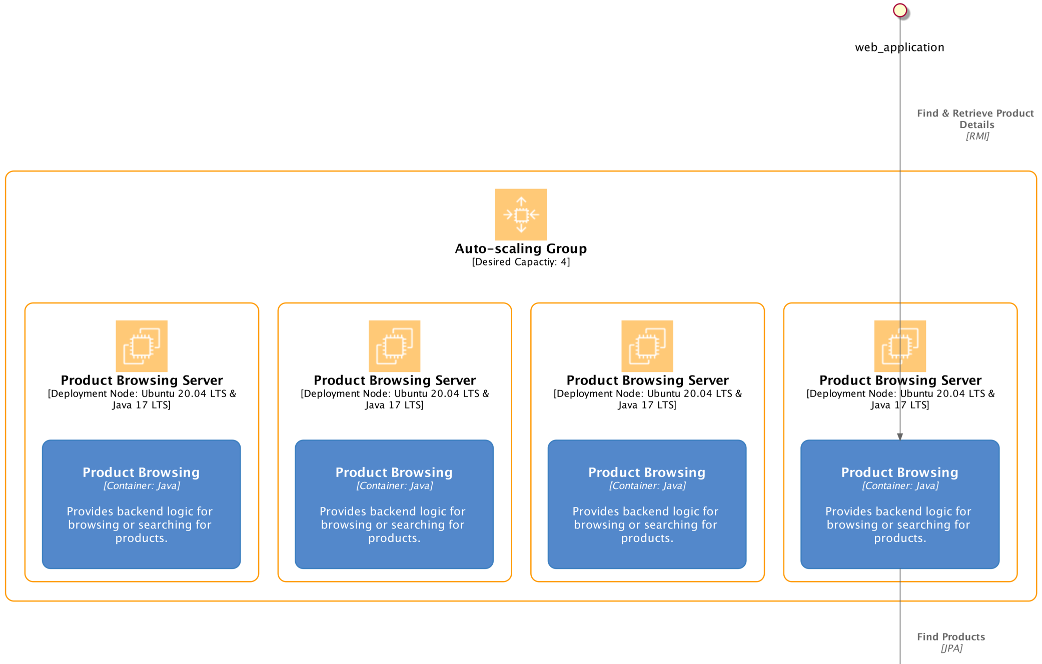

We might expect product service to have a much higher load than other services


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

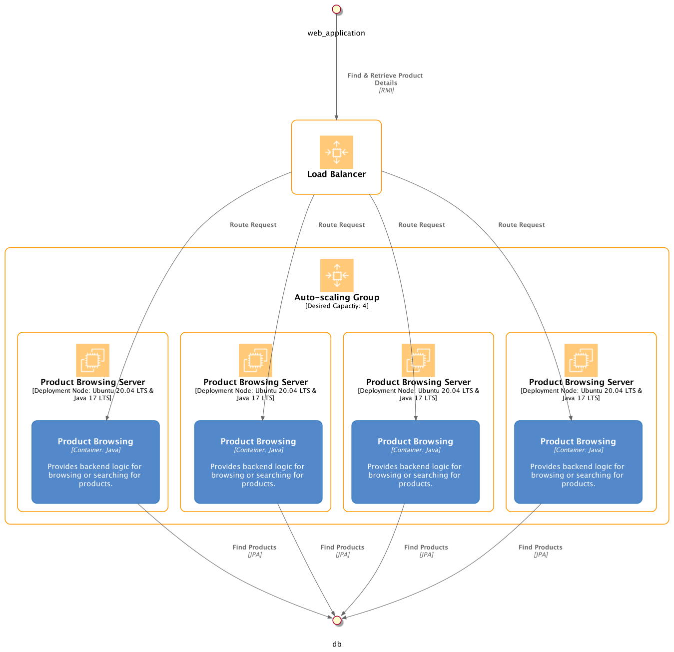
**Legend**



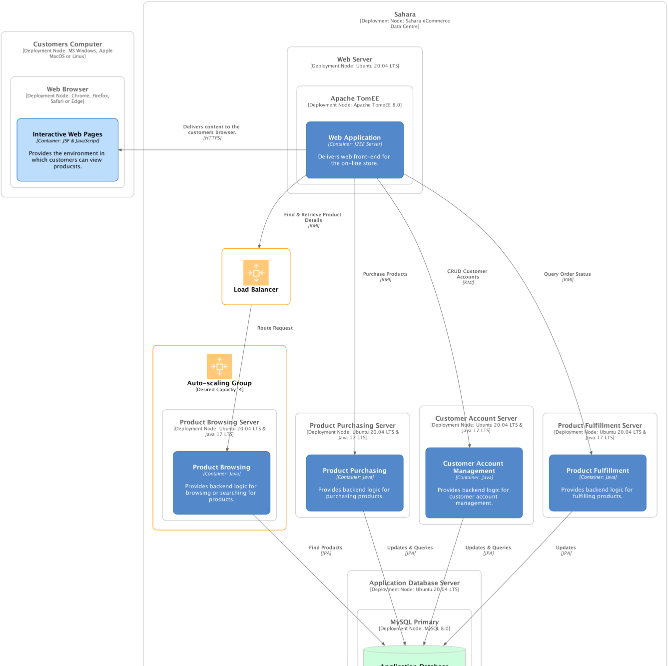

Use an auto-scaling group to replicate the service




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]
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[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

# 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