

# Distributed Systems I

## *Software Architecture*

Brae Webb & Richard Thomas

March 24, 2025



**Mathias Verras**  
@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 dis-  
tributed 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

```
1  retries = 0
2  do:
3      status = service.request()
5
5      if status != SUCCESS:
6          retries += 1
7          wait(2 ** retries)
8  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.

*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.

*Definition 0.* Stamp Coupling

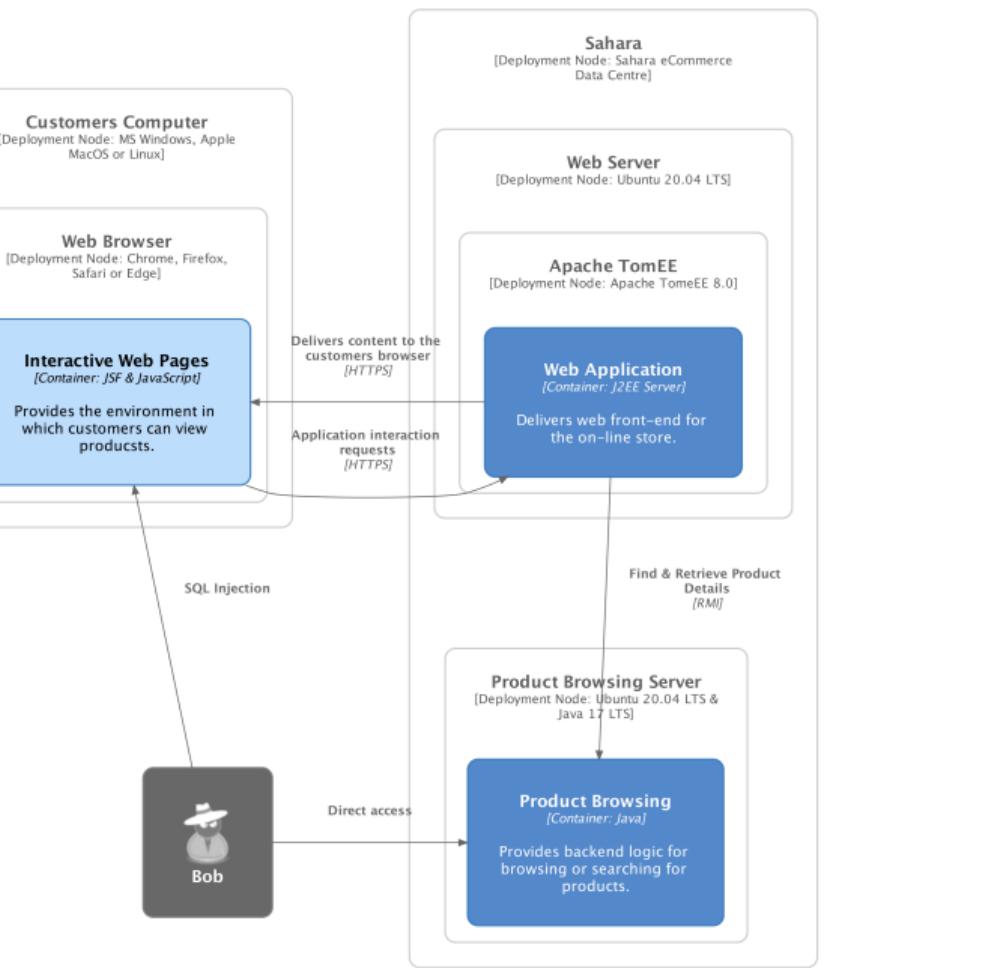
Components which share a composite data structure.

*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*.

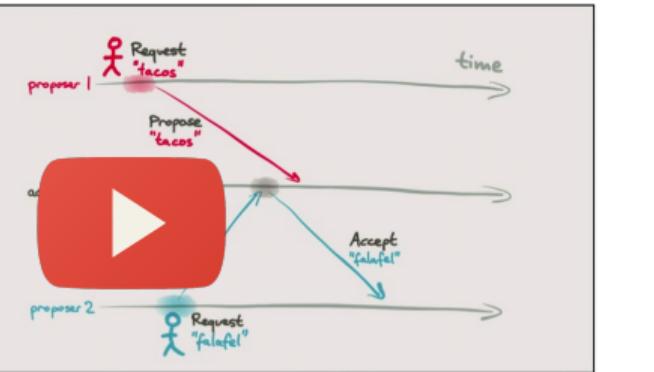
The choice to use them should be *well considered*.

Can often introduce more problems than they solve.

*When you need to, maybe prove it?*



Sept 13-14, 2019  
[thestrangeloop.com](http://thestrangeloop.com)



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

*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 vs. Stateful Systems*

Stateless Does *not* utilise *persistent data*.

Stateful Does utilise *persistent data*.

*Question*

What makes software *reliable*?

*Definition 0.* Reliable Software

Continues to work, even when things go wrong.

*Definition 0.* 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.

### *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 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.

### *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 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





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